

From Digital Financial Inclusion to Human Development in ASEAN: The Mediating Role of Sustainability Performance

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Abstract

Digital financial inclusion has become increasingly important for sustainable development, yet how it contributes to human development remains less clear, particularly in ASEAN economies. This study examines whether sustainability performance (ESG) mediates the relationship between digital financial inclusion and human development. Using panel data from eight ASEAN countries over 2015–2024, the study constructs a multidimensional Digital Financial Services Index (DFSI) and applies fixed-effects regression models selected through the Hausman test. The results show that digital financial inclusion has a positive and significant effect on ESG performance, while traditional financial development measures, including financial access and financial depth, are not significant. ESG performance is positively associated with human development. The mediation analysis further shows that the indirect effect of digital financial inclusion on human development through ESG is positive and statistically significant. In contrast, the direct effect becomes insignificant once ESG is included. These findings suggest that digital finance contributes to human development mainly through stronger sustainability performance. The study highlights the importance of developing digital financial systems that support both sustainability objectives and broader human development outcomes.

Keywords: Digital financial inclusion, ESG performance, Human development, Mediation analysis, Sustainability

Abstrak

Inklusi kewangan digital telah menjadi semakin penting bagi pembangunan mampan, namun bagaimanakah ia menyumbang kepada pembangunan manusia kekal kurang jelas, khususnya dalam ekonomi ASEAN. Kajian ini meneliti sama ada prestasi kelestarian (ESG) mengantarai hubungan antara inklusi kewangan digital dengan pembangunan manusia. Menggunakan data panel daripada lapan buah negara ASEAN sepanjang tahun 2015–2024, kajian ini membina Indeks Perkhidmatan Kewangan Digital (DFSI) pelbagai dimensi dan mengaplikasikan model regresi kesan tetap yang dipilih melalui ujian Hausman. Dapatan kajian menunjukkan bahawa inklusi kewangan digital mempunyai kesan positif dan signifikan terhadap prestasi ESG, manakala ukuran pembangunan kewangan tradisional, termasuk akses kewangan dan

kedalaman kewangan, adalah tidak signifikan. Prestasi ESG dikaitkan secara positif dengan pembangunan manusia. Analisis pengantaraan seterusnya menunjukkan bahawa kesan tidak langsung inklusi kewangan digital terhadap pembangunan manusia melalui ESG adalah positif dan signifikan secara statistik, manakala kesan langsung menjadi tidak signifikan selepas ESG diperkenalkan. Sebaliknya, kesan langsung menjadi tidak signifikan sebaik sahaja ESG dimasukkan. Dapatan ini menunjukkan bahawa kewangan digital menyumbang kepada pembangunan manusia terutamanya melalui prestasi kelestarian yang lebih kukuh. Kajian ini menyerlahkan kepentingan membangunkan sistem kewangan digital yang menyokong kedua-dua objektif kelestarian dan hasil pembangunan manusia yang lebih luas.

1. INTRODUCTION

The expansion of financial systems has long been viewed as a key driver of economic and social progress. This belief has been strengthened in ASEAN economies by the rapid growth of mobile banking, digital payment systems, and access to financial services over the past ten years. But even with these changes, progress in human development across the region is still uneven and, in some cases, surprisingly small (Wang et al., 2024). Evidence from Human Development Index (HDI) trends between 2015 and 2024 reveals persistent divergence across ASEAN economies: high-income countries maintain consistently elevated levels, while middle- and lower-income countries experience only modest improvements, particularly in the post-pandemic period. Highlighting structural vulnerabilities in translating economic and financial expansion into sustained human development gains. This pattern indicates that financial development does not automatically lead to human development; instead, its effects depend on deeper structural mechanisms (Awdeh et al., 2023).

Recent empirical evidence suggests that the relationship between financial development and welfare outcomes is neither linear nor uniform. For instance, some studies indicate an inverse relationship between financial development and economic growth, and a positive

correlation between financial development and income disparity across ASEAN nations (Wahyudi et al., 2024). While financial inclusion and digital finance can expand economic participation, their developmental impact varies significantly across countries depending on institutional quality, digital readiness, and governance structures (Ozili, 2024; Parvez et al., 2023). In ASEAN specifically, digital financial services have improved access but have not consistently translated into equitable development outcomes, reflecting disparities in adoption and effectiveness (Bajwa et al., 2025). These findings challenge the conventional assumption that expanding financial systems automatically enhances societal well-being.

A central limitation in the literature lies in the aggregation of financial development into broad indicators, which obscures the distinct roles of financial access, digital financial inclusion, and financial depth (Chisadza & Biyase, 2023; Pavon, 2021). This disaggregation is crucial for understanding how specific components of financial infrastructure contribute to human development outcomes. More importantly, existing research has largely overlooked the mechanisms through which financial development influences human development, focusing instead on direct relationships that assume a linear transmission (Mani et al., 2024). Specifically, further research is warranted to examine the

causal mechanisms underlying the observed relationships among technology, innovation, financial development, human development, and economic well-being (Vojinović et al., 2024).

This study argues that the missing link lies in the sustainability orientation of financial systems, captured through environmental, social, and governance (ESG) performance. However, the influence of financial development on sustainability outcomes may not be uniform across its different dimensions (Guo & Naseer, 2025). In particular, digital financial inclusion may play a more critical role compared to traditional indicators such as financial access and financial depth (Drago et al., 2025). Financial systems influence not only the level of investment but also the allocation of resources between sustainable and unsustainable activities (Nauman et al., 2024). Emerging evidence suggests that improvements in digital financial systems can enhance ESG outcomes by promoting transparency, enabling responsible financial practices, and supporting long-term investments (Guo et al., 2025). At the same time, ESG performance is increasingly recognised as an important factor in improving overall well-being, including human development (Barykin et al., 2022). However, its role as a pathway through which digital financial inclusion influences human development remains poorly understood, particularly in ASEAN countries (Khoi & Dinh, 2025).

The ASEAN region provides a unique context for examining this relationship due to its diversity in financial systems, digital infrastructure, and sustainability practices. While countries such as Singapore and Malaysia have advanced financial ecosystems, others are still in earlier stages of financial and digital development. This heterogeneity suggests that financial

development may yield different outcomes depending on how effectively it is aligned with sustainability-oriented practices. Consequently, financial expansion may be development-enhancing only when improvements in ESG performance accompany it; otherwise, its impact may be limited or uneven.

Grounded in Financial Intermediation Theory and Sustainable Development Theory, this study reconceptualises the finance–development nexus by incorporating sustainability performance as a mediating mechanism. It addresses three research questions: (i) how financial access, digital financial inclusion, and financial depth influence ESG performance in ASEAN countries; (ii) whether ESG performance contributes to human development; and (iii) whether ESG mediates the relationship between financial development and human development.

By reframing financial development as a conditional driver of human development, this study advances a more nuanced understanding of how financial systems contribute to societal progress. It further provides new empirical evidence from ASEAN economies and introduces a multidimensional Digital Financial Services Index (DFSI) to capture digital financial inclusion more comprehensively.

2.0 LITERATURE REVIEW

2.1 Financial Development and Human Development

The interplay between financial development and human development has garnered significant attention in academic and policy discourse due to its implications for sustainable growth and societal well-being (Zainuri et al., 2023). Financial development, characterised by the expansion and efficiency of financial

institutions and markets, is widely recognised as a driver of human development, which encompasses improvements in education, health, and overall quality of life (Afolabi et al., 2023, p. 202). However, this relationship is inherently complex, with evidence suggesting both direct and indirect pathways of influence. Recent empirical studies indicate that financial development does not automatically improve human development outcomes; rather, its impact depends on factors such as institutional quality, inclusiveness, and the distribution of financial access, which determine how effectively financial resources are translated into broader societal benefits (Kamalu & Ibrahim, 2023, p. 34).

A growing body of literature highlights that financial development can positively influence human development by improving access to financial services, thereby empowering individuals and marginalised groups (Mani et al., 2024). For instance, Ofosu-Mensah Ababio et al. (2021) find that financial inclusion, measured by access to savings, credit, and insurance, significantly enhances human development in frontier economies. Similarly, in Southeast Asia, financial inclusion has been shown to expand access to economic opportunities and support development outcomes, although its effectiveness remains conditional on structural and institutional factors (Vo et al., 2021). These findings underscore the role of financial systems in facilitating investments that enhance human capabilities and improve welfare.

Despite these positive associations, the relationship is not universally robust. In certain contexts, financial development exhibits a negligible or limited impact on human development. For example, evidence from Nigeria suggests that while financial indicators such as credit supply and money

supply are statistically significant, their long-term effects on human development remain minimal, reflecting inefficiencies in financial intermediation (Afolabi et al., 2023, p. 208). Similarly, in India, financial development has been found to negatively affect economic growth, with human development emerging as a more critical determinant of progress (Kumar & Batra, 2023). These findings indicate that financial expansion alone is insufficient and may not yield meaningful developmental outcomes without supportive institutional and policy frameworks.

In emerging economies, including ASEAN, financial inclusion has expanded significantly (Wahyudi et al., 2024, p. 123), yet its contribution to human development outcomes remains uneven. This inconsistency is often attributed to structural factors such as institutional quality, regulatory effectiveness, and disparities in access and usage (Abdelghaffar et al., 2022, p. 166). Collectively, these findings suggest that the relationship between financial development and human development is conditional rather than deterministic, emphasising the need to move beyond aggregate measures and examine the specific channels through which financial systems influence development.

In this regard, this study conceptualises financial development as a multidimensional construct comprising financial access, financial depth, and digital financial inclusion. Financial access reflects the availability and reaches of financial services to individuals and businesses; financial depth captures the size and liquidity of financial institutions and markets; and digital financial inclusion represents the extent to which digital technologies facilitate the delivery and use of financial services. By disaggregating financial development into these

dimensions, this study seeks to provide a more nuanced understanding of how different aspects of financial systems contribute to human development outcomes.

2.2 Theoretical Background

Financial Intermediation Theory and Sustainable Development Theory provide a complementary framework for understanding how financial development influences human development (Archer & Idun, 2023). Financial Intermediation Theory explains the role of financial institutions in mobilising savings, allocating capital, and reducing information asymmetry within the economy (Abdelghaffar et al., 2022; Séraphin & Carelle, 2025). Through these functions, financial systems determine how resources are accessed and distributed across sectors (Vojinović et al., 2024). In this study, financial access, financial depth, and digital financial inclusion represent key dimensions of financial intermediation. These dimensions shape not only the availability of financial services but also the efficiency and inclusiveness of capital allocation, thereby influencing broader economic and social outcomes (Vojinović et al., 2024).

However, financial intermediation alone does not guarantee improvements in human development (Afolabi et al., 2023). The effectiveness of financial systems depends on how financial resources are utilised and whether they are directed toward activities that generate sustainable and inclusive benefits (Mani et al., 2024). This highlights the relevance of Sustainable Development Theory, which emphasises integrating economic growth with social inclusion and environmental sustainability (Yuan, 2025). From this perspective, development outcomes should be assessed not only in terms of economic expansion but

also in terms of improvements in social welfare and environmental quality (Chaturvedi, 2024). Within this theoretical framework, sustainability performance (ESG) emerges as a critical mechanism linking financial development to human development in ASEAN countries. ESG reflects the extent to which economic and financial activities align with environmental, social, and governance objectives (Makhdalena et al., 2023).

2.3 Dimensions of Financial Development

To better understand the evolving role of financial systems, financial development can be disaggregated into three key dimensions: financial access, financial depth, and digital financial inclusion. Financial access refers to the availability of financial services to underserved populations, thereby expanding participation in the financial system, although not necessarily ensuring active use (Damane & Ho, 2024, p. 6). By improving access to credit, savings, and financial tools, financial access enables broader participation in economic activities and supports investments that enhance social and economic well-being (Farah et al., 2026).

Financial depth captures the size and liquidity of financial markets and institutions, reflecting the extent of financial intermediation (Mishra, 2022, p. 7). However, its contribution is conditional rather than linear (Bod'a, 2023). While greater financial depth can facilitate capital allocation and investment, its positive effects typically emerge only when supported by sufficient financial access and strong institutional frameworks (Shapoval, 2021, p. 211). In the absence of these conditions, financial depth may lead to inefficient resource allocation or the

concentration of financial benefits (Danquah & Adu, 2025, p. 12).

Digital financial inclusion refers to the adoption and effective use of digital financial technologies, which reduces barriers to access and enhances financial inclusion (Dey, 2025). Through mobile banking, digital payments, and online financial platforms, digital inclusion expands outreach and efficiency (Khera et al., 2022). Nevertheless, its effectiveness depends on digital literacy and institutional quality, which determine the extent to which individuals and firms can meaningfully utilise digital financial services (Sahay et al., 2021).

Empirical evidence shows that financial access and financial depth affect economic outcomes in different but complementary ways. Meanwhile, digital inclusion marries these concepts with technological innovation, offering transformative potential to bridge existing gaps. Financial access and depth generally promote economic growth and reduce poverty, but their effects are not always straightforward. In particular, financial depth can have negative effects when access is limited, highlighting the importance of inclusive financial systems that ensure broad and equitable reach (Shapoval, 2021, p. 207). High mobile penetration rates in developing countries have enabled significant progress, but rural-urban differences and digital literacy gaps remain critical challenges (Dudu et al., 2024, p. 2038). Understanding the interplay among these components is critical for designing resilient financial systems that can adapt to shocks, foster innovation, and promote equitable development (Ofosu-Mensah Ababio et al., 2023)

2.4 Sustainability Performance (ESG) as a Transmission Mechanism

Sustainability performance (ESG) is a key mechanism linking financial development to human development in ASEAN countries (Fu & Irfan, 2022). Stakeholder theory emphasises that governments and institutions create value by addressing the needs of citizens, communities, and regulators and by aligning financial policies with social and environmental priorities (Cakti & Aryani, 2023). Signaling theory suggests that strong national ESG performance reflects transparency, governance quality, and effective policymaking, which is particularly important in ASEAN economies characterised by varying levels of institutional strength (Vo et al., 2021). From the resource-based view, ESG represents national capabilities that enable countries to utilise financial development effectively for sustainable and inclusive growth (Makhdalena et al., 2023). Together, these perspectives position ESG not merely as an outcome, but as a national-level mechanism through which financial access, depth, and digital inclusion contribute to improved human development outcomes.

However, the relationship between financial development and ESG performance in ASEAN remains inconclusive. Prior studies report mixed findings, suggesting that the impact of financial development on sustainability outcomes varies across countries and contexts (Setyowati et al., 2025; Ng et al., 2020). While financial development is generally associated with higher ESG performance globally (Hassani et al., 2024), this relationship appears more complex within ASEAN due to differences in financial structures, institutional quality, and sustainability disclosure practices (Putri & Pratama, 2023). These variations indicate that the relationship may be non-linear and highly context-dependent (Huy et al., 2025).

This complexity is further compounded by the early stage of sustainable finance frameworks and inconsistent ESG reporting standards across ASEAN countries, which limit comparability and policy alignment (Loan et al., 2024; Naibaho et al., 2025). Additionally, herding behaviour among firms contributes to uneven adoption of sustainability practices, reinforcing heterogeneity across the region (Warokka et al., 2025). Collectively, these factors highlight the need for a more nuanced and systematic examination of how financial development influences ESG outcomes within ASEAN. In particular, understanding the mechanisms through which financial access, depth, and digital inclusion shape sustainability performance is essential for promoting more consistent and effective ESG integration across the region (Ahmad et al., 2025).

2.5 Finance, ESG, and Human Development in ASEAN

The ASEAN region provides a unique setting for examining the interplay between financial development, sustainability, and human development (Muhammed & Musa, 2025). The region has experienced rapid financial expansion, particularly in access to financial services and digital financial inclusion, alongside significant heterogeneity in institutional quality and digital capacity (Trabelsi & Fhima, 2024, p. 127). This diversity creates a complex environment in which the effects of financial development on environmental, social, and governance (ESG) outcomes, as well as broader human well-being, are likely to vary across countries (Elatrroush, 2023, p. 16).

Existing studies indicate that digital financial inclusion can enhance economic participation and resilience in ASEAN economies; however, its broader developmental impact depends critically on

the quality of governance and sustainability practices (Wahyudi et al., 2024, p. 108). At the same time, ESG adoption remains uneven across the region, reflecting differences in regulatory frameworks, institutional capacity, and policy implementation (Handoyo & Anas, 2024). These variations influence how financial resources are allocated and utilized, thereby shaping sustainability outcomes and development trajectories (Xiao et al., 2023, p. 49). This issue is particularly salient given ASEAN's exposure to environmental and social risks, and the growing emphasis on integrating ESG considerations into investment and policy frameworks to promote sustainable development (Sadiq et al., 2022).

Taken together, these dynamics suggest that sustainability performance may serve as a critical link between financial development and human development (Singhal et al., 2023). Specifically, ESG influences whether financial expansion translates into meaningful societal progress by shaping the direction, inclusiveness, and effectiveness of financial resource allocation (Xie et al., 2025). Against this backdrop, this study examines the relationships between financial development, ESG performance, and human development within the ASEAN context, with particular emphasis on the mediating role of sustainability performance.

2.6 Research Gap and Hypothesis Development

Despite a large body of research, important gaps remain in understanding how financial development influences human development. Most studies rely on aggregate measures, which mask the distinct roles of financial access, financial depth, and digital financial inclusion (Samputra, 2023; Tissaoui et al., 2024). Yet these dimensions

operate through different channels and produce distinct effects on development outcomes (Mburamatatare et al., 2025). As a result, existing evidence provides limited insight into the specific pathways through which financial systems shape human development.

Second, while sustainability performance (ESG) has gained increasing attention, its role as a transmission mechanism remains underexplored. Most studies examine ESG either as an outcome of financial development or as a determinant of firm performance, with limited focus on its role in shaping national-level development outcomes (Muchenje et al., 2025; Zhang et al., 2025; Zheng et al., 2025). This gap is particularly evident in ASEAN economies, where differences in institutional quality and sustainability practices may shape the relationship between financial development and human development (Asmarani & Ningsih, 2023, p. 96).

Third, empirical evidence on ASEAN remains limited and fragmented. Many studies focus on single-country analyses or global samples, thereby overlooking regional diversity in financial systems (Dash, 2025, p. 395), digital readiness (Hodijah & Hastuti, 2022, p. 32), and ESG adoption (Chen & Zhang, 2022, p. 2). As a result, existing findings provide limited insight into the region-specific dynamics of the finance–development relationship. Finally, the measurement of digital financial inclusion remains incomplete. Existing studies often rely on single indicators, which do not capture their multidimensional nature (Anton & Nucu, 2024, p. 581; Yang et al., 2025, p. 342). This limits the ability to assess the impact of digital financial services on sustainability and development outcomes.

To address these gaps, this study focuses on the mechanisms through which

financial development influences human development. It disaggregates financial development into financial access, financial depth, and digital financial inclusion, and introduces sustainability performance (ESG) as a mediating variable. By focusing on ASEAN economies and employing a multidimensional Digital Financial Services Index (DFSI), this study provides a more nuanced and context-specific understanding of the finance–development relationship.

2.7 Hypothesis Development

2.7.1 *Financial Development and ESG Performance*

Financial development influences sustainability performance through its role in resource allocation and investment decisions (Nasreen et al., 2023). Financial access expands participation in the financial system, enabling individuals and firms to engage in economic activities that support inclusive and socially responsible outcomes (Idris et al., 2023). Financial depth strengthens financial systems' ability to mobilise and allocate capital, facilitating long-term investments aligned with environmental and social objectives (Shapoval, 2021). However, its effects are contingent on the inclusiveness and efficiency of financial systems (Nabil, 2024).

Digital financial inclusion further strengthens these mechanisms by reducing transaction costs, improving access to financial services, and enhancing transparency (Mpofu, 2024). Through digital platforms, financial resources can be distributed more efficiently and inclusively, supporting sustainability-oriented investments (Jovović & Vuković, 2024). However, its effectiveness depends on digital literacy and institutional quality, which shape its ability to generate meaningful ESG outcomes (Lu et al., 2022).

Based on these arguments, the following hypotheses are proposed:

H1: Financial access has a positive effect on sustainability performance.

H2: Financial depth positively affects sustainability performance.

H3: Digital financial inclusion positively affects sustainability performance.

2.7.2 Sustainability Performance and Human Development

Sustainability performance reflects the extent to which economic activities align with environmental protection, social inclusion, and good governance (Drago et al., 2025). At the national level, stronger ESG performance indicates more effective policies, higher institutional quality, and more responsible resource allocation (Ma et al., 2024; Wang et al., 2023). These factors contribute to improvements in human development by enhancing access to education and healthcare, improving environmental quality, and raising overall living standards (Gidage & Bhide, 2024; Wang, 2024).

In ASEAN, where disparities in institutional capacity and governance persist (Omeje, 2024), ESG plays a critical role in determining whether financial development translates into tangible welfare gains (Makhdalena et al., 2023; Salem et al., 2025). Countries with stronger ESG performance are better able to convert financial resources into inclusive and sustainable development outcomes (Xie et al., 2025). Accordingly, the following hypothesis is proposed:

H4: Sustainability performance (ESG) has a positive effect on human development.

2.7.3 ESG as Mediating Role

Financial development provides the infrastructure for economic activity (Awdeh et al., 2023); its impact on human development depends on how financial resources are allocated and utilised (Afolabi et al., 2023). ESG serves as a key transmission mechanism by shaping the direction and quality of these allocations (Barykin et al., 2022). Financial systems that support sustainability-oriented investments are more likely to generate long-term social and environmental benefits, thereby improving human development outcomes (Akala et al., 2022).

In contrast, financial development that is misaligned with sustainability objectives may lead to inefficient or unequal resource distribution, thereby limiting its contribution to human development (Singhal et al., 2023). This suggests that ESG mediates the relationship between financial development and human development. Therefore, the following mediation hypotheses are proposed:

H5: Sustainability performance (ESG) mediates the relationship between financial access and human development.

H6: Sustainability performance (ESG) mediates the relationship between financial depth and human development.

H7: Sustainability performance (ESG) mediates the relationship between digital financial inclusion and human development.

2.8 Conceptual Framework

This study develops a conceptual framework, presented in Figure 1, grounded in Financial Intermediation Theory and Sustainable Development Theory, to examine how financial development influences human development through national sustainability performance (ESG).

Independent Variables

Mediating Variable

Dependent Variable

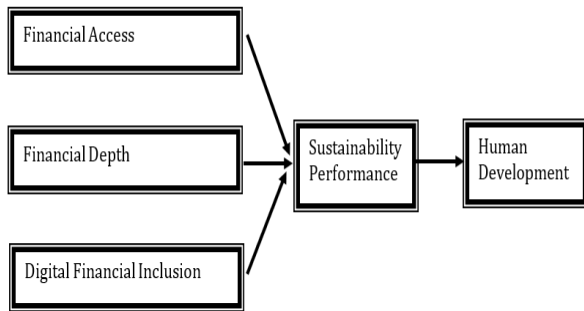


Figure 1: Conceptual framework

3.0 METHODS

3.1 Research Design

This study adopts a quantitative research design, using panel data analysis to examine the relationships among financial development, sustainability performance (ESG), and human development across ASEAN countries. A panel approach is appropriate because it captures both cross-country heterogeneity and temporal dynamics, enabling more robust and efficient estimation than cross-sectional or time-series models. It follows a mechanism-based framework in which financial development influences human development indirectly through sustainability performance (ESG). This

enables the identification of both direct and indirect (mediated) effects.

3.2 Data and Sample

This study uses a balanced panel of eight ASEAN countries covering the period 2015–2024, resulting in 80 country-year observations. The countries included are Malaysia, Indonesia, Thailand, Singapore, Vietnam, Brunei Darussalam, the Philippines, and Cambodia. Myanmar and Laos are excluded because complete data are not available for the study period. Human development is measured using the Human Development Index (HDI), while the ESG score represents sustainability performance. Financial development is examined through financial access, financial depth, and digital financial inclusion. Financial access is measured by bank branches and ATM density per 100,000 adults, financial depth by domestic credit to the private sector as a percentage of GDP, and digital financial inclusion by the constructed Digital Financial Services Index (DFSI). Final consumption expenditure growth is included as a control variable. The data are obtained from UNDP, Refinitiv, the World Bank, and the International Telecommunication Union. Table 1 summarises the variables, measurements, and data sources used in this study.

Table 1: Definition and Measurement of Variables

Variable	Measurement	Source
Dependent Variable, Human Development	Human Development Index (composite of education, health, income), HDI	UNDP
Mediating Variable, Sustainability Performance	Environmental, Social, Governance score, ESG	Refinitiv
Independent Variables, Financial Access	Bank branches per 100,000 adults. ATM per 100,000 adults.	World Bank
Independent Variables, Financial Depth	Domestic credit to private sector (% of GDP)	World Bank

Independent Variables, Digital Financial Inclusion	Composite index (Fishburn-weighted): account ownership, digital payments, mobile subscriptions, internet usage	Constructed (based on World Bank, ITU)
Control Variables, Economic Activity	Final consumption expenditure growth (%)	World Bank

3.3 Construction of Digital Financial Services Index (DFSI)

Digital financial inclusion is measured using a composite Digital Financial Services Index (DFSI). A composite measure is used because single indicator cannot adequately represent access to and use of digital financial services. The final index consists of four indicators: account ownership (A1), digital payment use (A2), mobile subscriptions (A3), and internet penetration (A4). An additional digital payment indicator was initially considered but removed due to conceptual overlap with A2. The final index, therefore, retains four indicators that represent both the use of digital financial services and the infrastructure that supports their use.

Before aggregation, each indicator is transformed using min-max normalisation to place variables measured in different units on a common scale:

$$X_{ijt}^* = \frac{X_{ijt} - X_j^{\min}}{X_j^{\max} - X_j^{\min}}$$

where X_{ijt} represents indicator j for country i in year t , while $X_j^{\min}$ and $X_j^{\max}$ represent the minimum and maximum values of the respective indicator in the sample.

The normalised indicators are then combined using rank-based Fishburn weights. The main specification adopts a

usage-first ranking because the index is intended to capture digital financial inclusion rather than digital infrastructure alone. Digital payment use (A2), therefore, receives the highest weight (0.5208), followed by internet penetration (A4 = 0.2708), mobile subscriptions (A3 = 0.1458), and account ownership (A1 = 0.0625). Greater weight is placed on actual digital financial activity, while internet and mobile connectivity are treated as enabling conditions. Account ownership receives the lowest weight because holding an account does not necessarily indicate active use of digital financial services.

Accordingly, the main DFSI is calculated as:

$$DSFI_{it} = 100[0.0625 A1_{it}^* + 0.5208 A2_{it}^* + 0.1458 A3_{it}^* + 0.2708 A4_{it}^*]$$

The resulting index ranges from 0 to 100, with higher values indicating greater digital financial inclusion. To examine whether the empirical findings depend on the chosen ranking, an alternative infrastructure-first specification is also constructed and summarised in Table 2. Under this specification, internet penetration receives the largest weight (0.5208), followed by mobile subscriptions (0.2708), account ownership (0.1458), and digital payment use (0.0625). The main models are re-estimated using this alternative DFSI. The results remain consistent with those obtained from the

usage-first index, indicating that the main findings are not driven by the specific weighting structure used to construct DFSI.

Table 2: DFSI Construction

Indicator	Measure	Main weight	Alternative weight
A1	Account ownership	0.0625	0.1458
A2	Digital payment use	0.5208	0.0625
A3	Mobile subscriptions	0.1458	0.2708
A4	Internet penetration	0.2708	0.5208
Orientation		Usage-first	Infrastructure-first

3.4 Panel Data and Model Selection

The study uses panel data covering eight ASEAN countries over the period 2015–2024. Panel data are appropriate for this study because they allow the analysis to account for cross-country differences while capturing changes within each country over time. This is particularly relevant in the ASEAN context, where countries differ considerably in their financial systems, level of digitalisation, institutional conditions, and development outcomes. Some of these differences are difficult to observe directly but may still influence sustainability performance and human development,

Both fixed-effects (FE) and random-effects (RE) models were considered. The FE model controls for unobserved country-specific characteristics that remain relatively stable over time by allowing each country to have its own intercept. The RE model, in contrast, assumes that these unobserved country-specific effects are not correlated with the explanatory variables. This distinction is important because factors such as institutional structure, regulatory

environment, and characteristics of the financial system may be related to the financial development indicators examined in this study. The Hausman specification test was therefore used to determine which estimator was more appropriate.

3.5 Model Specification

Three empirical models are estimated to examine the relationships proposed in the conceptual framework. The models are structured sequentially to determine whether financial development and digital financial inclusion are associated with sustainability performance and human development, and whether sustainability performance mediates these relationships.

Model 1: Sustainability Performance

The first model examines whether financial access, financial depth, and digital financial inclusion are associated with sustainability performance. Bank branches and ATM density represent financial access, financial depth is measured by domestic credit to the private sector (DCPS), and digital financial inclusion is captured by

financial depth is measured by domestic credit to the private sector (DCPS), and digital financial inclusion is captured by the Digital Financial Services Index (DFSI). Consumption growth is included as a control variable

$$ESG_{it} = \alpha_i + \beta_1 branches_{it} + \beta_2 atm_{it} + \beta_3 dcps_{it} + \beta_4 dfsi_{it} + \beta_5 consumption_{it} + \epsilon_{it} \quad (1)$$

where i represents the country and t represents the year. This model is used to test H1, H2, and H3 concerning the effects of financial access, financial depth, and digital financial inclusion on sustainability performance.

Model 2: Human Development

The second model examines the relationship between the financial development variables and human development with ESG introduced as a mediator. Human development, measured by the Human Development Index (HDI), is specified as the dependent variable.

$$HDI_{it} = \alpha_i + \beta_1 branches_{it} + \beta_2 atm_{it} + \beta_3 dcps_{it} + \beta_4 dfsi_{it} + \beta_5 consumption_{it} + \epsilon_{it} \quad (2)$$

This model establishes the relationship between the financial development variables and HDI before accounting for sustainability performance. In the mediation analysis, it therefore provides the total-effect relationship against which the direct effects in Model 3 are compared.

Model 3: Human Development with ESG as Mediator

The third model incorporates ESG into the HDI equation to examine whether

sustainability performance helps explain the associations between financial development and digital financial inclusion and human development.

$$HDI_{it} = \alpha_i + \beta_1 branches_{it} + \beta_2 atm_{it} + \beta_3 dcps_{it} + \beta_4 dfsi_{it} + \beta_5 esg_{it} + \beta_6 consumption_{it} + \epsilon_{it} \quad (3)$$

The coefficient of ESG in Model 3 provides the basis for testing H4, which proposes a positive relationship between sustainability performance and human development. Models 1–3 are then considered together when assessing the mediation hypotheses H5, H6, and H7. In particular, the analysis examines whether the financial development variables influence ESG in Model 1, whether they are associated with HDI in Model 2, and whether their relationships with HDI change after ESG is introduced in Model 3. The statistical significance of the indirect effects is assessed separately in the mediation analysis described in Section 3.6.

3.6 Mediation Analysis

The mediation analysis examines whether sustainability performance (ESG) serves as a channel through which financial development and digital financial inclusion influence human development. The analysis is conducted using three fixed-effects models. Model 1 examines the effects of financial access, financial depth, and digital financial inclusion on ESG. Model 2 estimates their direct effects on human development, while Model 3 introduces ESG to examine whether these relationships change once sustainability performance is accounted for.

For the mediation effect, particular attention is given to four paths. Path a represents the effect of the independent variable on ESG, while path b captures the

effect of ESG on human development after controlling for the independent variables. Path c represents the total effect on human development before ESG is included, whereas path c' represents the remaining direct effect after ESG is introduced. The indirect effect is calculated as the product of paths a and b (ab). Its statistical significance is assessed using the Sobel test. A statistically significant indirect effect provides evidence that ESG mediates the relationship between the respective financial development variable and human development.

3.7 Endogeneity and Robustness Check

Although the fixed-effects model controls for unobserved country characteristics that remain constant over time, it does not fully eliminate the possibility of reverse causality. For example, stronger sustainability performance may itself encourage the development of digital financial systems, while higher levels of human development may also support improvements in financial inclusion and ESG performance.

To examine whether the main findings are sensitive to this issue, the study conducts an additional robustness check using one-year-lagged explanatory variables. In this specification, financial development, digital financial inclusion, ESG, and the control variable are measured in the preceding year, while the dependent variable is measured in the current year. Introducing a temporal lag helps reduce the possibility that current ESG or human development outcomes are simultaneously determining the explanatory variables.

The lagged models are estimated using the same fixed-effects framework as the main analysis. Because the first observation

for each country has no preceding-year value, the lagged specification contains 72 country-year observations. The purpose of this test is not to claim that endogeneity has been completely eliminated, but to examine whether the main relationships remain when explanatory variables are temporally separated from the outcomes.

4.0 Findings

4.1 DFSI Analysis

Based on the constructed Digital Financial Services Index (DFSI), ASEAN countries show a clear and consistent upward trend in digital financial inclusion from 2015 to 2024. This indicates that the region has undergone a significant digital transformation of its financial systems over the past decade. Overall, all countries demonstrate improvement in DFSI, although the level and speed of development differ significantly. Singapore records the highest DFSI values throughout the period, increasing steadily from around 84 in 2015 to nearly 98 in 2024. This reflects its highly advanced, mature digital financial ecosystem, supported by robust infrastructure and high digital adoption.

Malaysia also shows strong performance, with DFSI rising from approximately 70 to almost 89, indicating continuous progress in expanding digital financial services and access. Similarly, countries such as Thailand, Brunei, and Vietnam show significant improvements, with Vietnam standing out as one of the fastest-growing economies in terms of DFSI, increasing from about 31 to 76 over the study period. Meanwhile, Indonesia and the Philippines exhibit moderate but steady growth in DFSI. Although their initial levels are relatively low, both countries have shown clear acceleration in recent years, particularly after 2019, reflecting the

increasing adoption of digital financial platforms. The results indicate a clear pattern of rising inclusion in the digital financial sector across ASEAN, with evidence of convergence as lower-performing

countries gradually narrow the gap with more advanced economies. This reflects a regional shift toward a more digitally inclusive financial system.

4.2 Descriptive Statistic

Table 3: Summary of Panel Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
HDI	80	0.77	0.10	0.56	0.95
ESG	80	61.87	18.81	28.80	95.60
DFSI	80	64.94	23.50	6.15	97.92
Branches	80	10.21	4.27	2.90	21.00
ATM	80	52.71	26.92	13	114.00
DCPS	80	91.19	43.53	34.56	164.10
Consumption	80	3.51	4.20	-13.35	20.25

Table 3 presents descriptive statistics based on the study's conceptual framework, beginning with the dependent variable, followed by the mediating variable, independent variables, and control variables. The dependent variable, human development (HDI), records an average value of 0.77, with values ranging from 0.56 to 0.95. This indicates that the countries in the sample fall between medium and high levels of human development, with noticeable variation across countries. The mediating variable, sustainability performance (ESG), has a mean score of 61.87, with a range of 28.8 to 95.6. This suggests that while some countries demonstrate strong ESG performance, others are still at a developing stage, supporting the role of ESG as a key channel through which financial factors may influence development outcomes.

The independent variables include DFSI, bank branches, ATMs, and domestic credit to the private sector (DCPS). The DFSI shows an average value of 64.94, with a wide range from 6.15 to 97.92, indicating large disparities in digital financial access. Similarly, bank branches and ATMs exhibit variation across countries, reflecting differences in traditional financial infrastructure. The DCPS variable, with a mean of 91.19 and a wide range from 34.56 to 164.10, indicates significant differences in financial depth among countries. Finally, the control variable, consumption, has an average value of 3.51, with values ranging from -13.35 to 20.25, suggesting fluctuations in economic conditions across countries and over time. Overall, the descriptive statistics show substantial variation across all variables, supporting the use of panel data analysis to examine the relationships proposed in the conceptual framework.

4.3 Hausman Test

The results indicate that the chi-square statistic is 25.72 with a p-value of 0.0001, which is statistically significant at the 1% level. This leads to the rejection of the null hypothesis that the Random Effects model is appropriate. Therefore, the Fixed Effects model is preferred, as it provides consistent and reliable estimates by controlling unobserved heterogeneity across cross-sectional units. Since the Fixed Effects (FE) model was selected based on the Hausman test, the analysis properly accounts for differences among the eight ASEAN countries included in this study over the period 2015–2024.

Using the FE model, the analysis focuses on changes within each country over time rather than differences between countries. This is especially important for supporting the study's main finding that digital financial inclusion does not directly improve human development but instead works indirectly through sustainability performance. The fixed-effects model, therefore, allows the analysis to focus on within-country changes over time while controlling for time-invariant country characteristics.

4.4 Determinants of Sustainability Performance

Model 1 examines the effects of financial access, financial depth, and digital financial inclusion on sustainability performance (ESG). Table 4 presents the Fixed Effects regression results. It indicates that the model is statistically significant and explains a substantial proportion of the variation in sustainability performance across ASEAN countries over time. Among the financial development variables, digital financial inclusion (DFSI) emerges as the only significant determinant of ESG performance. Specifically, the results show that an increase in DFSI significantly improves sustainability outcomes, suggesting that digital financial systems play an important role in promoting environmentally and socially responsible practices.

In contrast, traditional financial development indicators, such as financial access (measured by bank branches and ATM density) and financial depth, do not exhibit a statistically significant effect on ESG. This implies that simply expanding physical banking infrastructure or increasing credit availability may not be sufficient to enhance sustainability performance in the ASEAN context. Instead, the findings highlight the growing importance of digital financial inclusion as a more effective driver of sustainability. These results provide strong support for Hypothesis 3, while Hypotheses 1 and 2 are not supported.

Table 4: Fixed Effects Regression Results for Sustainability Performance (ESG)

Variable	FE
Branches	-0.2645 (.2230)
ATM	0.0623

	(.3150)
DCPS	0.0290
	(.2940)
DFSI	0.0874***
	(<.001)
Consumption	0.0028
	(.8870)
Constant	52.9555***
	(<.001)
R-squared	0.7627
Observations	80

Note: p-values are reported in parentheses. *** p < .01, ** p < .05, * p < .10.

4.5 Human Development Model without ESG as Mediator

Model 2 examines the relationship between the financial development variables and human development prior to the introduction of ESG. This provides the total-effect specification used in the subsequent mediation analysis. The results show that DFSI has a positive and statistically significant relationship with HDI ($\beta=0.000396$), while bank branches, ATM

density, DCPS, and consumption is statistically insignificant. The significant DFSI coefficient establishes an initial relationship with HDI before the mediating role of ESG is considered. This means that countries with higher digital financial access and usage tend to have better human development outcomes. On the other hand, bank branches, ATM availability, domestic credit, and consumption expenditure do not show a significant relationship with HDI in this model.

Table 5: Fixed Effects Regression Results for Human Development (HDI)

Variable	FE
Branches	-0.0016
	(.305)
ATM	0.0005
	(.232)
DCPS	0.0003

	(.123)
DFSI	.0003961***
	(.0008)
Consumption	-6.81e-06
	(.971)
Constant	0.7069***
	(<.001)
R-squared	0.6853
Observations	80

Note: p-values are reported in parentheses. *** p < .01, ** p < .05, * p < .10.

4.6 Mediating Role of Sustainability Performance

Table 6: Fixed Effects Regression Results for Human Development (HDI) with ESG as a Mediating Variable

Variable	FE
Branches	-0.000220
	(.859)
ATM	0.0001598
	(.491)
DCPS	0.000118
	(.307)
DFSI	-0.0000677
	(.496)
Consumption	-0.0000217
	(.880)
ESG	0.005306***
	(<.001)
Constant	0.4259633***
	(<.001)

R-squared	0.8754
Observations	80

Note: p-values are reported in parentheses. *** $p < .01$, ** $p < .05$, * $p < .10$.

The mediation analysis examines whether sustainability performance (ESG) mediates the associations of financial access, financial depth, and digital financial inclusion with human development. Before assessing the indirect effects, Model 3 shows that ESG has a positive and statistically significant relationship with HDI ($\beta =$

0.005306, $p < .001$). This finding supports H4, which proposes that stronger sustainability performance is associated with higher human development. The indirect effects were then assessed using the coefficients from the fixed-effects models and tested using the Sobel test.

Table 7: Mediation Effects of Financial Development on Human Development through ESG

Hypothesis	Relationship	Indirect Effect	Sobel Z	p-value	Decision
H5	Branches -> ESG -> HDI	-0.001409	-1.28	.199	Not supported
H5	ATM -> ESG -> HDI	0.000319	0.98	.325	Not supported
H6	DCPS -> ESG -> HDI	0.000162	1.19	.233	Not supported
H7	DFSI -> ESG -> HDI	0.000455	6.20	<.001	Supported

Note: Bank branches and ATM density represent financial access. Indirect effects are calculated as the product of the coefficient linking the respective financial-development variable to ESG (path a) and the coefficient linking ESG to HDI while controlling for the financial-development variables (path b). Statistical significance of the indirect effects is assessed using the Sobel test.

Table 7 above shows the results do not provide evidence that ESG mediates the relationship between financial access and human development. Bank branches and ATM density represent financial access. The indirect effect through ESG is -0.001409 for bank branches ($z = -1.28$, $p = .199$) and

0.000319 for ATM density ($z = 0.98$, $p = .325$). Neither indirect effect is statistically significant. This is consistent with Model 1, where neither bank branches nor ATM density has a significant relationship with ESG. H5 is therefore not supported.

A similar result is found for financial depth. The indirect effect of domestic credit to the private sector (DCPS) on human development through ESG is positive but statistically insignificant (indirect effect = 0.000162, $z = 1.19$, $p = .233$). This indicates that the relationship between financial depth and human development does not operate significantly through sustainability performance in the present sample. H6 is therefore not supported.

The result is different for digital financial inclusion. DFSI has a positive and statistically significant relationship with ESG in Model 1 ($\beta = 0.0874$, $p < .001$). Before ESG was introduced, DFSI alshad a positive and significant relationship with human development ($\beta = 0.0003961$, $p < .001$). Once ESG is included in Model 3, however, the direct effect of DFSI becomes statistically insignificant ($\beta = -0.0000677$, $p = .496$).

More importantly, the indirect effect of DFSI on HDI through ESG is positive and statistically significant (indirect effect = 0.000455, Sobel $z = 6.20$, $p < .001$). This provides evidence that the relationship between digital financial inclusion and human development operates through sustainability performance. In other words, the findings suggest that digital financial inclusion is associated with better human development outcomes, mainly when improvements in digital financial systems are accompanied by stronger sustainability performance. H7 is therefore supported.

The mediation results distinguish digital financial inclusion from the more traditional dimensions of financial development examined in this study. Financial access and financial depth do not show significant indirect effects through ESG, whereas the DFSI–ESG–HDI pathway is statistically significant. The findings therefore, identify sustainability performance as an important link between digital financial inclusion and human development in ASEAN.

4.7 Endogeneity and Robustness Check

To assess whether the main findings are sensitive to potential reverse causality, the models were re-estimated using one-year-lagged explanatory variables. The results remain broadly consistent with the main fixed-effects estimates.

Table 8: lagged-variable robustness test

Relationship	Coefficient	p-value	Decision
Lagged DFSI -> ESG	0.0665	< .001	Positive and significant
Lagged DFSI -> HDI	0.000438	< .001	Positive and significant
Lagged ESG -> HDI	0.003861	< .001	Positive and significant
Lagged DFSI -> HDI with ESG	0.000097	.489	Not significant

Note: This changes the effective sample from 80 to 72 observations.

Table 8 shows lagged DFSI continues to have a positive and statistically significant

relationship with sustainability performance ($\beta = 0.0665$, $p < .001$). It also

remains positively associated with human development prior to the introduction of ESG ($\beta = 0.000438$, $p < .001$). When lagged ESG is included in the HDI model, ESG remains positive and statistically significant ($\beta = 0.003861$, $p < .001$), while the direct effect of lagged DFSI becomes statistically insignificant ($\beta = 0.000097$, $p = .489$).

The indirect effect of lagged DFSI on human development through ESG is also statistically significant (indirect effect = 0.000257 , Sobel $z = 3.43$, $p < .001$). This result provides additional support for the mediating role of sustainability performance. It shows that the main DFSI–ESG–HDI relationship remains when the explanatory variables are measured one year before the outcome.

Some differences are observed for the traditional financial development indicators across the lagged specifications, suggesting that their relationships are less stable over time. Nevertheless, the principal finding concerning digital financial inclusion remains consistent with the main analysis. The lagged specification, therefore, provides additional evidence that contemporaneous relationships between the variables do not solely drive the results.

4.8 Discussion

The findings show a clear difference between traditional financial development and digital financial inclusion. Financial access and financial depth are not significantly associated with ESG, while digital financial inclusion shows a positive relationship. This suggests that simply expanding bank branches, ATMs, or private-sector credit may not be enough to improve sustainability performance. What seems to matter more is how financial services are delivered and used. This finding is consistent with Nasreen et al. (2023), who

found that the sustainability benefits of financial development in Asian economies become more evident when technological progress is taken into account. It is also consistent with Li and Pang (2023) and Lu et al. (2022), who reported positive links between digital financial inclusion and ESG performance.

The mediation results provide a clearer picture of this relationship. ESG is positively associated with human development, and the indirect effect of DFSI on HDI through ESG is significant. In contrast, ESG does not significantly mediate the effects of financial access or financial depth. This means that the role of ESG found in this study is specific to digital financial inclusion rather than financial development in general. Digital finance may widen access and make financial services easier to use, but these benefits do not necessarily translate directly into better human development. The findings suggest that stronger sustainability performance is an important part of that process.

This pattern also supports the use of Financial Intermediation Theory together with Sustainable Development Theory. Financial Intermediation Theory explains how the financial system improves access to and allocation of financial resources. However, the insignificant results for traditional financial access and depth show that greater financial intermediation alone may not be sufficient. Sustainable Development Theory helps explain the next part of the relationship: how financial development contributes to wider social and environmental outcomes. In this study, ESG connects these two perspectives by showing how digital financial development is associated with human development through sustainability performance.

The findings are particularly relevant to ASEAN, where digital financial services have expanded rapidly, but countries remain at different stages of digital and sustainable development. Khoi and Dinh (2025) similarly found that digital financial inclusion contributes to sustainable development in ASEAN, although its effects differ across countries. The present study adds to this evidence by showing that sustainability performance may be one of the channels linking digital financial

Table 9: Summary of Hypothesis Testing

Hypothesis	Proposed Relationship	Decision
H1	Financial access → ESG (+)	Not supported
H2	Financial depth → ESG (+)	Not supported
H3	Digital financial inclusion → ESG (+)	Supported
H4	ESG → Human development (+)	Supported
H5	Financial access → ESG → HDI	Not supported
H6	Financial depth → ESG → HDI	Not supported
H7	Digital financial inclusion → ESG → HDI	Supported

inclusion with human development. The implication is straightforward: expanding digital finance is important, but its wider developmental value may depend on whether stronger sustainability practices accompany that expansion.

Overall, the findings provide support for H3, H4, and H7, while H1, H2, H5, and H6 are not supported. Table 9 summarises the results of the hypothesis testing.

5.0 LIMITATION

This study has several limitations that should be considered when interpreting the findings. First, the analysis is limited to eight ASEAN countries due to data availability. Although the sample captures differences in financial development, digitalisation, sustainability performance, and human development across the region, the findings may not fully represent ASEAN economies, for which complete data were unavailable. Second, ESG is measured at the national level. This provides a broad measure of sustainability performance but may not capture differences across industries, institutions, or firms within each country.

The study also acknowledges the possibility of endogeneity and reverse causality. While country fixed effects control for unobserved characteristics that remain relatively stable over time, they do not eliminate all sources of endogeneity. The additional analysis using one-year lagged explanatory variables provides some reassurance, as the main DFSI–ESG–HDI relationship remains consistent when the explanatory variables are temporally separated from the outcomes. However, this robustness test should not be interpreted as establishing causality. Finally, the DFSI is constructed from available indicators of account ownership, digital payment use, mobile subscriptions, and internet

penetration. Although these indicators capture important dimensions of digital financial inclusion, they may not fully reflect newer forms of digital finance, such as mobile wallets, fintech-based services, and other emerging digital financial activities.

6.0 CONCLUSION

The findings show that the different dimensions of financial development do not contribute to sustainability performance in the same way. Financial access, measured by bank branches and ATM density, is not statistically related to ESG, and financial depth, measured by DCPS, is also insignificant. H1 and H2 are therefore not supported. In contrast, digital financial inclusion has a positive and significant relationship with ESG, supporting H3.

ESG, in turn, is positively and significantly associated with human development, supporting H4. The mediation analysis provides a more specific result. ESG does not significantly mediate the relationship between financial access and human development or between financial depth and human development. H5 and H6 are therefore not supported. However, the indirect effect of DFSI on HDI through ESG is positive and statistically significant, while the direct relationship becomes insignificant after ESG is introduced. This provides support for H7. These results are consistent with the mediation evidence reported in Section 4.6.

These findings suggest that the developmental contribution of digital financial inclusion in ASEAN is not simply a matter of expanding digital access. What appears to matter is whether digital financial development is accompanied by stronger sustainability performance. At the same time, the absence of significant mediation for traditional financial access and financial

depth shows that this mechanism should not be generalised to all forms of financial development.

The study contributes to the literature in two ways. First, it distinguishes financial access, financial depth, and digital financial inclusion rather than treating financial development as a single broad construct. This allows their different relationships with sustainability performance to be observed more clearly. Second, by positioning ESG between financial development and human development, the study provides evidence of a specific pathway through which digital financial inclusion is associated with broader development outcomes. The multidimensional DFSI also provides a broader representation of digital financial inclusion than relying on a single measure of digital access or usage.

From a policy perspective, the findings suggest that expanding digital financial services alone may not be enough to generate broader development benefits. Greater attention should be given to how digital finance is connected with sustainability objectives. For ASEAN policymakers, this includes encouraging digital financial services that support responsible lending, inclusive finance, and sustainability-oriented investment, while improving the consistency of ESG reporting across countries. Addressing differences in digital literacy, infrastructure, and affordability also remains important so that improvements in digital financial systems are accessible to a wider share of the population.

Future research could extend the analysis to other countries or regions and examine whether the same transmission mechanism holds in different institutional settings. Further work could also incorporate newer measures of digital

finance, including fintech usage and mobile wallet adoption, as comparable data become available. Firm- or household-level studies may provide additional insight into how digital financial services translate into sustainability practices and improvements in individual well-being.

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