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-RESEARCH ARTICLE-

FINTECH DEVELOPMENT AND ESG IN VIETNAM: CHALLENGES AND OPPORTUNITIES IN THE ERA OF DIGITAL TRANSFORMATION

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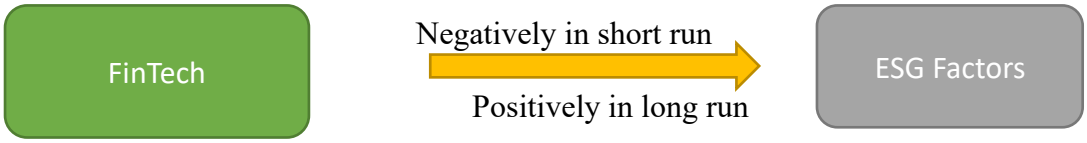
—Abstract—

FinTech (FT) has recently attracted substantial scholarly attention as a pivotal driver of sustainable development, with a distinctive influence on environmental, social, and governance (ESG) outcomes. This study seeks to advance the existing discourse by investigating the effect of FT on ESG factors within the context of Vietnam. Employing data spanning the period from 1996 to 2023, the research utilises the ARDL Bound testing approach to examine the relationship both in the short term and over the long term. The results indicate that FT negatively affects ESG in the short run, whereas it exhibits a significant positive impact on ESG in the long run. The reliability of these findings is further validated through Fully Modified OLS (FMOLS) and Canonical Cointegration Regression (CCR) methods. These findings underscore the necessity for tailored FT policies that consider the specific environmental and socio-economic contexts, thereby enhancing ESG performance and supporting sustainable development in Vietnam.

Keywords: FinTech; ESG; Vietnam; ARDL Bound Testing Method, FMOLS, Canonical Cointegration Regression.

Graphical Abstract



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INTRODUCTION

Environmental challenges, including ozone layer depletion, soil erosion, and pollution, have attracted global concern in recent years due to their detrimental effects on human health and ecosystems. For instance, air pollution in Asia has emerged as a critical issue, contributing to an estimated 1.5 million premature deaths annually. Similarly, climate change has raised significant apprehensions, as rising temperatures increase the likelihood of floods caused by heavy rainfall and typhoons, resulting in adverse consequences for economic stability and societal wellbeing, including substantial business losses and damage to infrastructure. Populations in Asian countries such as Vietnam are particularly vulnerable to climate-related disasters owing to inadequate infrastructure, limited resources, and institutional instability (Anh et al., 2023). According to the World Bank (WDI, 2024), Vietnam ranks among the top five countries most affected by climate change, having endured extreme weather events such as storms, floods, and droughts, which have severely impacted multiple sectors (Anh et al., 2023).

In response to these environmental risks, financiers and investors have increasingly focused on ESG considerations (Liu et al., 2025; Ng et al., 2020). ESG factors are gaining prominence because they not only drive long-term firm value, enhancing sustainable profitability, but also contribute to addressing global challenges such as climate change and environmental degradation (Edmans, 2023). Firms often generate negative externalities through the production of goods and services, adversely affecting public health and communities, which compels them to adopt sustainability-oriented ESG practices. Data from the Global Review of the Global Sustainable Investment Alliance (2017) indicate a 25% growth in total assets under management incorporating ESG standards since 2014, as cited in Ng et al. (2020). Nevertheless, progress in implementing ESG practices in Asian countries remains slow, largely due to high associated costs and firms' reluctance stemming from financial constraints.

Existing literature suggests that FT development can mitigate firms' financing constraints, often arising from information asymmetries. The proliferation of FT technologies, including artificial intelligence, smartphones, the Internet of Things (IoT), and blockchains, has transformed the operations of financial institutions, offering multiple benefits (Dwivedi et al., 2021). FT contributes to a financial system that is more secure, stable, transparent, cost-effective, and diversified. It also enhances ESG outcomes by facilitating funding for environmental and energy projects, supporting renewable energy, and promoting sustainability-oriented initiatives. From the principal–agent perspective, challenges such as information asymmetry, moral hazard, and inadequate oversight often divert firms' resources toward non-green projects, exacerbating agency problems.

The rapid development of FT alleviates these issues by reducing information

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asymmetry and mitigating principal–agent conflicts between firms and financial institutions, thereby improving ESG performance (Buchak et al., 2018). Likewise, from the stakeholder theory standpoint, FT technologies increase the accessibility of digital information, heightening stakeholders' focus on demand for green products and projects, which positively influences firms' ESG performance. Additionally, FT contributes indirectly by promoting sustainable innovation, resolving financial mismatches, and managing environmental uncertainty, further impacting ESG outcomes (Gao et al., 2024). In summary, FT represents a critical instrument for enhancing financial system efficiency and advancing the green transformation of enterprises (Girardone et al., 2024).

Despite its potential to support ESG improvements, empirical research examining the impact of FT on ESG practices remains scarce. Although discussions on this nexus are emerging, studies analysing the FT–ESG relationship, particularly at the macro level, are limited. Most existing research has concentrated on FT's benefits within corporate sectors, leaving macro-level insights underexplored. This study addresses this gap by analysing Vietnam's time series data from 1996 to 2023, offering new perspectives on FT's role in ESG. Vietnam is a pertinent case study as the country has intensified efforts to respond to climate change, particularly following its commitment to achieving net-zero emissions by 2050 at COP26. The issuance of Circular 96/2020/TT-BTC, mandating listed companies to disclose total direct and indirect greenhouse gas emissions alongside mitigation measures, further reflects this commitment (Hien & Ngoc, 2025). Specifically, this research contributes to the literature by investigating the FT–ESG relationship in Vietnam, where FT is rapidly developing and expected to achieve transformative breakthroughs (Lien et al., 2020). Although FT has garnered considerable attention from researchers, regulators, and policymakers, no empirical study has yet examined its impact on ESG performance in the Vietnamese context.

The structure of this study is as follows: Section 2 presents a review of relevant literature. Section 3 describes the variables and methodological approach. Section 4 presents the results and discussion, and Section 5 concludes with key findings and policy recommendations.

LITERATURE REVIEW

FT refers to the integration of technology with financial services, employing information technology to improve conventional financial products, making them more efficient, cost-effective, and accessible to both firms and consumers. The scope of FT encompasses a wide array of services and products, including digital payments, mobile banking, peer-to-peer lending, blockchain, crowdfunding, and big data analytics. FT also involves the application of the IoT and large-scale machine-to-machine communication within financial services, thereby exerting a notable influence on financial products and markets (Tran & Le, 2024).

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Existing research on FT has largely focused on its effects on corporate ESG performance. For example, Tran and Le (2024) investigated FT's influence on corporate ESG outcomes in Southeast Asia using a Fixed Effects model, reporting that firms in cities with superior FT infrastructure exhibited higher ESG performance. Similarly, Dicuonzo et al. (2024) examined Chinese firms and found that FT positively impacted ESG-related practices. Gao et al. (2024), analysing data from major Chinese firms over the 2011–2022 period, observed that corporate ESG performance improved in conjunction with FT adoption. In the banking sector, Dicuonzo et al. (2024) assessed 180 listed banks across the USA and Europe, finding that greater FT adoption substantially enhanced ESG scores.

In addition, Liu et al. (2025) explored both the mechanisms and effects of FT on corporate ESG performance in Chinese listed companies from 2011 to 2022, with instrumental variable analysis confirming significant improvements in ESG outcomes. Focusing on developed countries, Dicuonzo et al. (2024) evaluated FT's role in economic, environmental, and social sustainability between 2000 and 2021 using the Driscoll-Kraay Standard Error approach, concluding that FT strengthened environmental and social sustainability dimensions. Trotta et al. (2024) conducted a bibliometric analysis, revealing a limited number of studies examining the FT–ESG nexus, and performed an exploratory case study identifying that social factors within ESG encourage FT adoption in the banking sector.

Huang et al. (2025) examined FT's impact on ESG performance in China's new energy automobile sector over 2011–2022, with benchmark regressions and robustness checks confirming a positive influence. Likewise, Wang et al. (2025) demonstrated that AI, as part of FT, enhanced corporate ESG performance in China between 2010 and 2022. Sun and Wu (2025), analysing data from 30 Chinese provinces from 2011 to 2023, found that FT contributed positively to regional ESG performance using a two-way fixed effects model. Wanyan and Zhao (2025) investigated FT's role in ESG decoupling among Chinese listed companies, finding that FT strengthened corporate ESG performance, thereby improving social responsibility and profitability. Based on the foregoing evidence, the following hypothesis is proposed:

H1: *The development of FT has a significant impact on ESG factors in Vietnam.*

Research Gap

The review of current literature indicates a notable lack of empirical research addressing the influence of FT on ESG at the macro level. Given the limited studies exploring the FT–ESG relationship, this research seeks to contribute to the existing knowledge by examining the impact of FT on ESG using macro-level data. Specifically, the study investigates whether FT affects ESG factors in Vietnam, a context that, to the best of

our knowledge, has received minimal empirical attention. Consequently, this study addresses these gaps by analysing the FT–ESG nexus within the Vietnamese setting.

RESEARCH METHODOLOGY

Theoretical Underpinnings and Model Specification

As the primary objective of this study is to examine the influence of FT on ESG in Vietnam, the model is developed within the framework of the resource-based view (RBV). Numerous empirical studies indicate that digital transformation has the potential to enhance multiple dimensions of firm performance, including non-financial outcomes. Within the RBV framework, digital capabilities constitute valuable resources that enable firms to secure competitive advantages in dynamic environments. The adoption of digital technologies, such as FT, facilitates operational efficiency, optimised supply chains, and advanced data analytics through online platforms, thereby enabling firms to better meet customer needs. These improvements contribute to enhanced sustainability performance; for example, digitalisation supports better waste management and energy efficiency through intelligent production systems and smart logistics, ultimately benefiting environmental performance. FT also promotes social engagement by expanding stakeholder interaction and supporting local communities via e-commerce and social media. Moreover, digital technologies frequently strengthen risk management and internal governance mechanisms, including data privacy and cybersecurity frameworks, leading to more robust governance practices. Accordingly, it is reasonable to hypothesise that digital technologies such as FT exert a significant influence on ESG outcomes.

Building on this theoretical foundation and supported by prior empirical evidence (Barral, 2024; Hassani et al., 2024; Ng et al., 2020), the study proposes the following model:

$$ESG_t = \beta_0 + \beta_1 FT_t + \beta_2 EG_t + \beta_3 FD_t + \beta_4 URB_t + \beta_5 TO_t + \varepsilon_t \quad (1)$$

Where ESG represents environmental, social, and governance factors, EG denotes economic growth, FT refers to FinTech, FD signifies financial development, URB indicates urbanization, and TO stands for trade openness.

To achieve the objectives of this study, time series data for Vietnam covering the period from 1996 to 2023 were collected from secondary sources. FT and ESG are measured by aggregating relevant indicators using the widely recognised Principal Component Analysis (PCA) method. Table 1 presents a comprehensive overview of these indicators along with the study's control variables.

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Table 1: Measurement of Variables and Data Sources

Variables	Measurement	Data Source
FinTech	Index consisting of Fixed Broadband subscription, Mobile cellular subscriptions (both per 100 people) and percentage of individuals using internet in population	WDI
Urbanization	Urban population (percentage of total population)	WDI
Economic growth	GDP growth (annual percentage)	WDI
Trade openness	Imports plus exports (% of GDP)	WDI
Financial Development	Domestic credit given to private sector (as percentage of GDP).	WDI
ESG	Index consisting of rule of law, political stability and absence of violence, control of corruption, government effectiveness, regulatory quality and voice and accountability (each measured in estimate), participation rate in labour force (percentage of population between 15-64 ages), access to clean technologies and fuel for cooking as percentage of population), people having services of safely managed drinking water (as percentage of population), people having services of safely managed sanitation as percentage of population), access to electricity (as percentage of population), school enrolment, primary (% gross) and Unemployment, total (as percentage of total labour force), population at the age of 65 and above (as percentage of total population), prevalence of undernourishment (as percentage of population), prevalence of overweight (% of adults), total freshwater withdrawals annual (percentage of internal resources), fossil fuel energy consumption (percentage of total), Agriculture, fishing and forestry value added (percentage of GDP), electricity generation from coal sources (% of total), agricultural land (as percentage of total land) net energy imports (% of energy use), renewable energy consumption (percentage of total final energy consumption), renewable electricity production (percentage of total electricity production) and forest area (percentage of land area).	WDI and World Governance Indicators

Research Methodology

Prior to estimating the relationship between the dependent and independent variables, it is essential to determine whether the data series are stationary or exhibit a unit root. For this purpose, the Phillips-Perron (PP) test developed by Phillips and Perron (1988) and the Augmented Dickey-Fuller (ADF) test proposed by Dickey and Fuller (1979) were employed. Subsequently, the ARDL approach is applied to examine the relationship between FT and ESG in both the short and long run. Within time series analysis, the ARDL method is an efficient econometric tool for investigating dynamic relationships within a single-equation framework. In this approach, the current value of the dependent variable is modelled as a function of its own lagged values, referred to as autoregressive terms, as well as the current and lagged values of the explanatory variables, known as the distributed lag component. This method is particularly suitable

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when variables are integrated of mixed orders, that is, I(0) and I(1), or a combination of both, and it remains robust in small sample settings when a single long-run relationship exists among the variables (El Asli et al., 2024). The F-statistic, or Wald test, is used to assess the presence of a long-term relationship between the variables. The long-run dynamic relationship is estimated using the following ARDL equation:

$$\Delta ESG_t = \alpha_0 + \sum_{i=1}^{r} \alpha_{1k}\Delta ESG_{t-j} + \sum_{i=0}^{r} \alpha_{2k}\Delta FT_{t-j} + \sum_{i=0}^{r} \alpha_{3k}\Delta EG_{t-j} + \sum_{i=0}^{r} \alpha_{4k}\Delta TO_{t-j} + \sum_{i=0}^{r} \alpha_{5k}\Delta URB_{t-j} + \sum_{i=0}^{r} \alpha_{6k}\Delta FD_{t-j} + \beta_1 ESG_{t-1} + \beta_2 FT_{t-1} + \beta_3 EG_{t-1} + \beta_4 TO_{t-1} + \beta_5 URB_{t-1} + \varepsilon_t \quad (2)$$

In equation (2), Δ denotes the first difference operator, ε represents the error term, and α_0 corresponds to the intercept. The subsequent equation (3) presents the short-run ARDL specification:

$$\Delta ESG_t = \alpha_0 + \sum_{i=1}^{r} \alpha_{1k}\Delta ESG_{t-j} + \sum_{i=0}^{r} \alpha_{2k}\Delta FT_{t-j} + \sum_{i=0}^{r} \alpha_{3k}\Delta EG_{t-j} + \sum_{i=0}^{r} \alpha_{4k}\Delta TO_{t-j} + \sum_{i=0}^{r} \alpha_{4k}\Delta FD_{t-j} + \sum_{i=0}^{r} \alpha_{4k}\Delta URB_{t-j} + \alpha ECM_{t-1} + \varepsilon_t \quad (3)$$

Subsequently, the robustness of the ARDL results is verified using FMOLS and CCR approaches. FMOLS effectively addresses issues of autocorrelation, endogeneity, and small sample bias (Olorogun, 2024). In addition, CCR is applied as an alternative technique to validate the ARDL findings. This method was developed to correct the limitations of OLS by transforming the data within the covariance matrix, thereby eliminating asymptotic bias caused by long-term correlations (Zimon et al., 2023). The overall research methodology is illustrated in Figure 1.

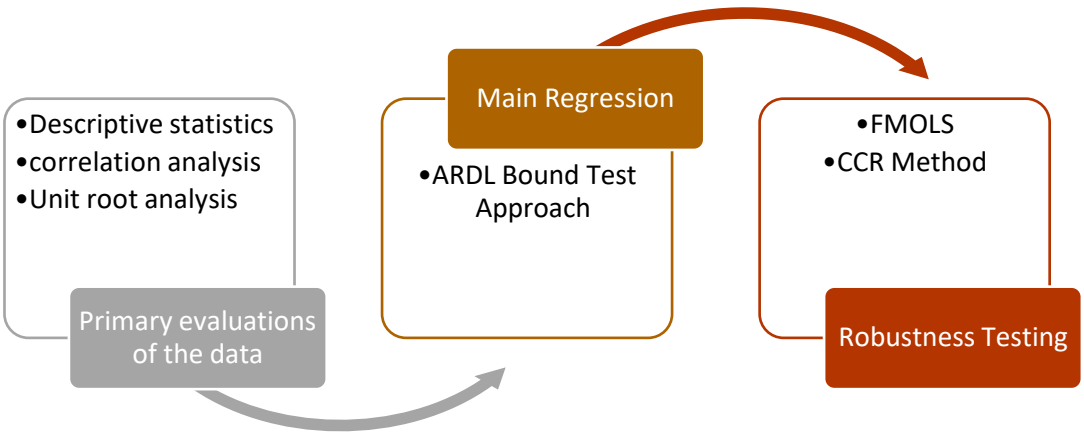

Figure 1: Methods of Empirical Research

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RESULTS AND DISCUSSION

Table 2 presents the descriptive statistics of all variables. The summary indicates that ESG exhibits a mean of 7.17e-09 and a standard deviation of 1.000, with observed values ranging from a minimum of -1.490 to a maximum of 1.423. For FT, the mean and standard deviation are 2.86e-08 and 1.000, respectively, with a minimum of -1.236 and a maximum of 1.072. Additionally, TO records the highest average value at 135.86, with its data spanning from 92.705 to 186.67, whereas FD displays the largest variability, with a standard deviation of 131.02 and values ranging from 18.670 to 131.02. Vietnam's EG has an average of 6.402, a standard deviation of 1.467, and values between 2.553 and 9.340. URB ranges from 22.072 to 38.129, with a mean of 29.764 and a standard deviation of 4.639. The Jarque-Bera (J-B) test indicates that none of the series exhibit significant departures from normality, as all statistics are statistically insignificant.

Table 2: Descriptive or Summary Statistics

Variables	Mean	Standard Deviation	Minimum Value	Maximum Value	J-B Stat
ESG	7.17e-09	1.000	-1.490	1.4236	2.4544
FT	2.86e-08	1.000	-1.2360	1.0728	4.106
EG	6.4021	1.467	2.553	9.340	4.2495
TO	135.86	25.993	92.705	186.67	0.855
FD	75.535	33.986	18.670	131.02	1.4693
URB	29.764	4.639	22.072	38.129	1.1748

Subsequently, a correlation analysis was performed to assess the strength and direction of linear relationships among the variables. The results, presented in Table 3, indicate that FT, URB, FD, and TO exhibit positive correlations with ESG, whereas EG shows a negative association with ESG in the context of Vietnam.

Table 3: Correlation among Variables

Variables	ESG	FT	EG	URB	FD	TO
ESG	1.000					
FT	0.904	1.000				
EG	-0.304	-0.3077	1.000			
URB	0.0982	0.0886	-0.336	1.000		
FD	0.936	0.8611	-0.330	-0.968	1.000	
TO	0.0863	0.6721	-0.263	-0.089	0.9082	1.000

Where, * shows significance at 10%.

Following the descriptive and correlation analyses, the integration order of the time series variables was examined using the PP and ADF tests. The results, presented in Table 4, reveal that all series are integrated of order zero according to the ADF test, except for EG, which is found to be integrated of order one based on the PP test.

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Table 4: Stationarity or Unit Root Tests

Variables	ADF		PP	
	I(0)	I(1)	I(0)	I(1)
ESG	1.5198	-3.757**	-0.460	-2.793**
EG	-1.1882	7.764***	-4.763***	---------
URB	-0.996	-2.645*	0.8473	-3.201**
FT	-1.7098	-2.896**	-1.0301	-2.9555**
TO	-1.425	-3.977***	-1.4333	-3.7411**
FD	-0.622	-5.238***	-0.606	-5.236***

Where *** and ** shows significance at 1% and 5%, respectively.

After confirming that EG is integrated of order I(1), the long-run cointegration among the variables was examined using the ARDL Bound test, with results reported in Table 5. The F-statistics exceed both the lower and upper critical bounds across all levels of significance, indicating the presence of a long-run cointegrating relationship among the study variables.

Table 5: ARDL Bound Test Results

Statistics	Value	K
F-Stat	5.810	5
Significance Level	I(0)	I(1)
10%	2.08	3.0
5%	2.39	3.38
2.5%	2.7	3.73
1%	3.06	4.15

Tables 6 and 7 present the short-run and long-run coefficient estimates, respectively. The error correction term, which is statistically significant and negative with a magnitude less than one, indicates that the model adjusts towards long-run equilibrium at a speed of 12.5 per cent. The results reveal that FT exerts a significant negative effect on ESG in the short run, whereas its long-run impact is significantly positive, thereby supporting the study's hypothesis. This outcome is consistent with prior empirical research and aligns with the RBV, which suggests that FT enhances financial accessibility, enabling firms to allocate more resources to ESG-related initiatives.

Table 6: ARDL Short Run Results

Variables	Coefficient	T-Stat	P- Value
Error Correction Model (ECM)	-0.125***	-7.9288	0.000
D(FT)	-0.019**	-2.238	0.046
D(FD)	-0.0007**	-3.690	0.0036
D(TO) D(EG)	0.0013***	6.642	0.000
D(URB)	-0.0008	-5.086	0.0004
	-0.0368**	-2.303	0.0418

Where, *** and ** show significance at 1, 5 and 10 %.

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Table 7: ARDL Long Run Results

Variables	Coefficient	T-Stat	Prob-Value
FT	0.508**	4.200	0.0015
EG	0.0096	0.648	0.529
FD	-0.002	-0.4161	0.685
TO	0.0204**	3.192	0.008
URB	0.0249	0.462	0.653

Where, **=p>0.05

Furthermore, improved FT reduces transaction costs, facilitating investments in socially responsible and green technology projects (Sun & Wu, 2025). From the perspective of financial intermediation theory, innovations in financial technology improve the efficiency of resource allocation and mitigate information asymmetries (Chatterjee et al., 2024).

The findings of Wanyan and Zhao (2025), Liu et al. (2025), and Chen and Xie (2025) corroborate these results, providing similar evidence of a positive relationship between FT and ESG.

Secondly, TO is found to have a significant positive effect on ESG performance in both the short and long run. This highlights that greater interaction with global markets enables an economy to adopt ESG practices more efficiently in line with international environmental and governance standards. Higher levels of TO allow countries to reduce pollution and enhance environmental outcomes by facilitating the import of cleaner, advanced technologies and adopting sustainable practices from trading partners (Bannour & Abdelkawy, 2024). These results are supported by Gao et al. (2026), Chen and Xie (2025), and Bannour and Abdelkawy (2024), who demonstrate that trade openness and digital trade positively influence ESG performance.

Fourth, URB exhibits a significant negative impact on ESG in the short run but an insignificant effect in the long run. This suggests that policymakers need to prioritise technological development, industrial modernisation, and structural reforms to mitigate the short-term adverse effects of urbanization. Over time, the long-run insignificance reflects the adaptation of systems and implementation of structural or technological changes that reduce the lasting influence of URB (Sklavos et al., 2025). This observation aligns with Sheng and Guo (2016), who report that URB affects environmental quality differently over time, and is further supported by Kwilinski et al. (2023), who argue that urbanisation negatively impacts green growth, a key component of the ESG environmental pillar.

Similarly, FD demonstrates a short-run negative effect on ESG while showing an insignificant impact in the long run. This indicates that initial expansions in FD may prioritise profit over ESG considerations, leading to potentially unsustainable practices. However, in the long term, enhanced regulatory frameworks and sustainable investment

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practices mitigate these negative effects. While these results contrast with Hassani et al. (2024) and Ng et al. (2020), who report a positive influence of FD on ESG, they are consistent with Sehrawat et al. (2015), who find that FD can degrade environmental quality by encouraging industrial activity in India. Zhang (2011) similarly notes that rising FD is associated with increased CO2 emissions in China. Lastly, EG is observed to have a significant negative effect on ESG in the short run and an insignificant impact in the long run. Although this contradicts theoretical expectations, it is consistent with the findings of Hassani et al. (2024), who also report an insignificant relationship between EG and ESG, and aligns with Abid (2017), who found that FD negatively affects environmental quality.

The robustness of these estimations is confirmed through various diagnostic tests, including checks for heteroscedasticity, serial correlation, model specification, and residual normality in the time-series data. Table 8 presents the results of these tests, revealing no evidence of residual non-normality, heteroscedasticity, correlation issues, or specification errors. Furthermore, coefficient stability is verified using CUSUM and CUSUM of squares tests, as shown in Figure 2, which indicate that the model is highly stable.

Table 8: Model Stability Checked through Different Diagnostic Tests

Tests	Statistics	P-Value	Decision
Normality	0.069	0.965	Residuals are Normally Distributed
Ramsey RESET	0.880	0.3701	Correct Functional Form
Serial Correlation	1.3165	0.3151	No Serial Correlation
Heteroskedasticity	0.895	0.584	No Heteroskedasticty

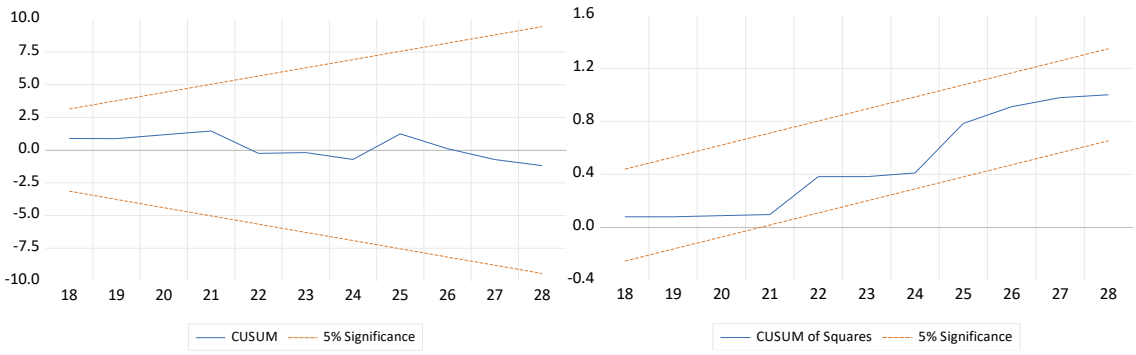

Figure 2: Parameter Stability through CUSUM and CUSUM of Square

Collectively, these diagnostic checks confirm that the model possesses appropriate econometric properties, validating the reliability of its findings for informing FT and ESG policy in Vietnam.

The results obtained from the ARDL approach are further validated using FMOLS and CCR techniques. As shown in Table 9, the coefficients from both FMOLS and CCR

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confirm the ARDL findings. Consistent with the long-run ARDL estimates, FT is observed to have a significant positive impact on ESG. Similarly, TO also demonstrates a positive effect on ESG, while EG does not exhibit a significant influence in either the CCR or FMOLS results. In line with the short-run ARDL outcomes, FD continues to show a negative effect on ESG in Vietnam.

Table 9: Robustness Output using FMOLS and CCR Methods

Variables	FMOLS			CCR		
	Coefficient	T-Stat	P-Value	Coefficient	T-Stat	P-Value
FT	0.347**	3.309	0.003	0.438**	2.987	0.007
EG	0.026	0.896	0.3799	0.0326	0.942	0.356
URB	0.1944***	4.8919	0.000	0.1576**	2.702	0.0133
TO	0.0087*	1.927	0.0676	0.0130*	1.897	0.0715
FD	-0.0124**	-2.432	0.0240	-0.0131**	-2.088	0.0491

Where, *** and ** show significance at 1, 5 and 10 %.

CONCLUSION, RECOMMENDATIONS AND LIMITATIONS OF THE STUDY

The primary objective of this study was to investigate the influence of FT on ESG factors in Vietnam. To address this aim, time series data spanning the period 1996–2023 were analysed using the ARDL approach. The results indicate that, consistent with the RBV and financial intermediation theory, FT exerts a positive effect on ESG in the long run, whereas its impact in the short run is negative. This suggests that in the early stages, FT expansion may increase energy consumption due to digital infrastructure demands, create regulatory disruptions, and prioritise financial inclusion over sustainable development. Over the long term, however, FT contributes positively to ESG through improved financial transparency, green financing, efficient resource allocation, and facilitation of investments in sustainable initiatives. The long-run positive effects highlight the importance of regulatory adaptation, technological maturity, and the integration of ESG considerations within digital financial systems. The findings also show that TO positively affects ESG in both the short and long run. Conversely, URB and FD have a significant negative effect in the short run but are insignificant over the long term. Additionally, EG exhibits a statistically significant negative relationship with ESG in the short run, which becomes insignificant in the long run. The robustness of these results is further confirmed through FMOLS and CCR estimations.

Based on these findings, several policy recommendations can be proposed for government authorities and policymakers in Vietnam. Firstly, regulatory frameworks should be designed to incorporate ESG standards in FT operations from the early stages to mitigate short-run negative impacts. Secondly, the government should promote the adoption of FT solutions that support sustainable finance, including digital infrastructure for carbon trading, environmental impact assessment, and green

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investment initiatives. Given FT's reliance on digital infrastructure, investment in renewable energy and energy-efficient data centres is crucial to reduce environmental impacts in the short term. FT firms and financial institutions should align their lending and investment activities with ESG principles to avoid financing environmentally harmful projects. Awareness campaigns and training programmes should be introduced to enhance understanding of ESG factors among FT firms, investors, and consumers. Furthermore, public–private partnerships should be encouraged to foster collaboration between FT companies, governmental agencies, and international organisations, thereby supporting the development of sustainable FT ecosystems.

This study has several limitations. First, the use of an aggregated ESG index may obscure the heterogeneous effects of FT on the individual social, governance, and environmental components. Second, limitations in data availability may restrict the measurement of FT development, as the selected proxy variables may not capture the full multidimensional nature of FT innovations. Third, the study focuses exclusively on Vietnam, which limits the generalisability of the results. Finally, the short- and long-run dynamics may be sensitive to the choice of lag structure, model specification, and estimation method. Future research could address these limitations by examining the separate indices for environmental, social, and governance factors to capture the disaggregated effects of FT. More comprehensive measures of FT, including digital payments, blockchain adoption, and crowdfunding platforms, should be considered. Expanding the analysis to include multiple countries, both developing and developed, would enhance the robustness and generalisability of findings. Additionally, alternative econometric techniques, such as quantile regression, nonlinear models, and GMM estimations, could be employed to account for heterogeneity and potential endogeneity. Future studies may also explore the moderating roles of governance, regulatory quality, and institutional frameworks in shaping the FT–ESG nexus. Finally, emerging areas such as digital finance, green FT, and the use of artificial intelligence in ESG initiatives warrant investigation to provide deeper insights into the relationship between FT and sustainability.

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