



How do digital transformation and green policies affect FDI flows in the ASEAN region?

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ABSTRACT

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In the era of digital transformation and sustainable development, both digitalization and environmental policies are increasingly central to national development strategies, especially in ASEAN. These transitions are reshaping investment environments and influencing the flow of Foreign Direct Investment (FDI). This study investigates the impact of digital transformation, green policies, and selected macroeconomic factors on FDI inflows in ASEAN countries. Using a balanced panel dataset covering six ASEAN economies from 2008 to 2022, the research applies the Fixed Effects Model (FEM) with robust standard errors to address heteroskedasticity and autocorrelation. Data were collected from six ASEAN countries from 2008 to 2022. Empirical findings show that higher Internet penetration significantly increases FDI inflows, while greater CO₂ emission intensity tends to reduce investment attraction. Financial development also promotes FDI, confirming the role of an efficient financial system. Inflation exhibits mixed effects, reflecting diverse macroeconomic conditions among countries. Overall, the findings emphasize that both digital readiness and environmental commitment play vital roles in attracting sustainable and high-quality FDI, providing useful implications for ASEAN governments in fostering digital and green transformation to strengthen long-term investment competitiveness.

Contribution/Originality: This study is one of the few that integrates digital transformation and environmental policy indicators into a unified econometric framework to analyze FDI determinants in ASEAN. The findings offer novel evidence on the dual role of technological advancement and green governance in attracting sustainable foreign investment.

1. INTRODUCTION

In the context of globalization and the ongoing Fourth Industrial Revolution, the ASEAN region faces both significant opportunities and challenges in attracting foreign direct investment (FDI). Two prominent factors digital transformation and green development policies are increasingly playing a pivotal role in the FDI attraction strategies of member states. Digital transformation not only enhances productivity, strengthens governance efficiency, and improves business transparency but also boosts the overall competitiveness of the investment environment. Meanwhile, green policies including regulations on environmental protection, clean energy, and sustainable development are becoming critical criteria for investors in selecting host countries.

Our study seeks to address the following research questions (RQs).

RQ1. How do digital transformation, green policies, and other macroeconomic factors affect foreign direct investment (FDI) inflows in the ASEAN region?

RQ2. Are there significant differences in the impact of these factors on FDI inflows in Vietnam compared to other ASEAN countries?

The remainder of this paper is structured as follows: Section 2 reviews the relevant literature and provides an in-depth analysis of key thematic areas. We then introduce a conceptual model, which is synthesized from supporting literature and systematically developed with corresponding hypotheses. Section 3 details the methodologies used for sampling and measurement. Section 4 presents a summary of the research findings. Section 5 initiates a comprehensive discussion of these results, while Section 6 expands on the theoretical and practical implications, addresses current limitations, and proposes potential avenues for future research.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Literature Review

This section provides a comprehensive review of the existing literature relevant to Foreign Direct Investment (FDI) and its key determinants, with a particular focus on the roles of digital transformation and green policies. It first establishes the theoretical foundation by discussing Dunning's OLI Paradigm, which serves as the overarching framework for understanding FDI motivations. Subsequently, the section delves into empirical studies exploring the impact of digital advancements and environmental considerations on FDI inflows. Finally, it examines other significant macroeconomic and financial factors that influence foreign investment decisions, ultimately identifying the research gaps that this study aims to address.

2.1.1. Theoretical Framework: Dunning's OLI Paradigm and FDI

The OLI (Ownership, Location, Internalization) paradigm is a widely utilized theoretical framework for analyzing and explaining Foreign Direct Investment (FDI) decisions. This model was first proposed by John Dunning in the 1970s and has since become a widely accepted tool for analyzing the complex motivations behind foreign direct investment activities. The OLI model was developed by synthesizing key elements from numerous preceding research works, providing a relatively comprehensive explanation of FDI. According to Dunning (1977) and Dunning (1980), firms invest abroad to leverage three interrelated factors: Ownership Advantages (O), Location Advantages (L), and Internalization Incentives (I). Overall, this model offers a comprehensive approach to analyzing the intricate drivers behind foreign investment activities and elucidating the interplay among these factors in shaping a firm's investment decisions.

2.1.1.1. O (Ownership Advantages)

This advantage refers to the exclusive competitive advantages a firm possesses, enabling it to generate higher income or offset additional costs incurred when operating in a foreign country. Ownership advantages typically include patents, proprietary technology, strong brands, unique managerial know-how, or access to distinctive resources. These advantages provide firms with a strong market position and the potential to achieve higher profits or lower costs when investing in foreign markets, without being shared with competitors.

2.1.1.2. L (Location Advantages)

Location advantages represent one of the critical factors considered in FDI decisions. These advantages are typically based on the geographical, economic, and institutional characteristics of the host country. They encompass access to transportation infrastructure (sea, road), the availability of low-cost raw materials, an abundant workforce with competitive wages, skilled labor, preferential tax policies, or a stable legal environment. Furthermore, firms also assess the availability of resources and infrastructure to maximize their potential utilization.

2.1.1.3. I (Internalization Advantages)

Internalization advantages pertain to a firm's decision on whether to produce a specific product or service internally or to contract with a third party (e.g., through licensing or outsourcing). The benefits of outsourcing may include lower costs, specialized skills, and better local market understanding. However, this often comes with limitations in control over quality or technology, or potential risks of high transaction costs associated with traditional export activities. In such cases, firms may opt to directly control their operations by engaging in FDI. This can be achieved by forming joint ventures with local partners or acquiring existing local companies. Internalized transactions are often less costly, safer, and more viable, allowing for synchronized production processes and seamless movement of goods and services among subsidiaries. Figure 1 presents the conceptual framework, which depicts how digital transformation and green policies, together with selected macroeconomic variables such as financial development and inflation, influence FDI inflows in ASEAN economies.

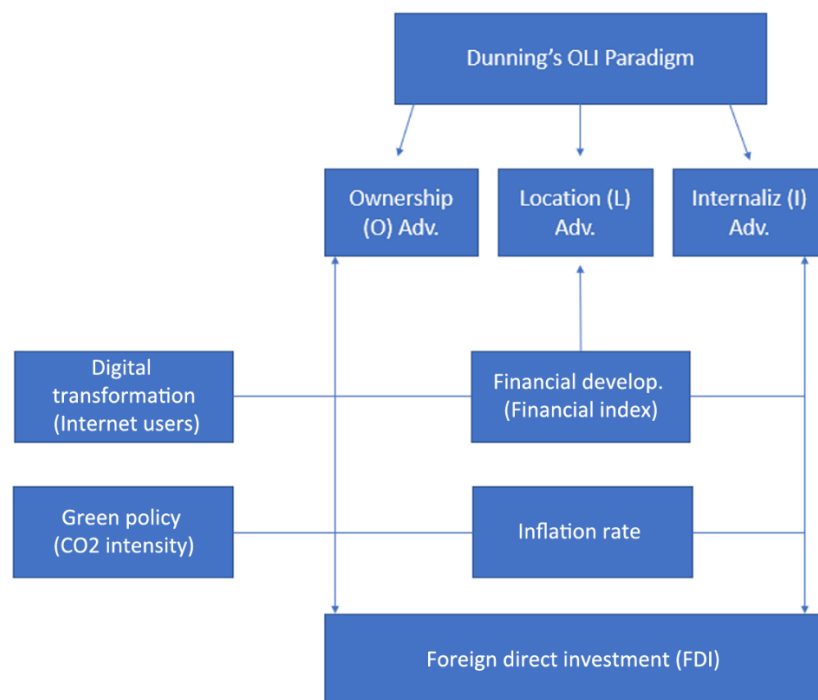


Figure 1. Conceptual framework based on dunning's OLI paradigm and research variables.

2.1.1.4. Limitations of the OLI Model

Despite its wide adoption and comprehensive analytical framework, Dunning's OLI model still possesses certain limitations that warrant consideration. Firstly, the model's scope is sometimes considered constrained, as it primarily focuses on explaining the motivations behind FDI but may not be sufficiently comprehensive to address other macroeconomic or specific factors that could influence investment decisions. Secondly, some researchers point out a lack of robust empirical evidence to substantiate the model's validity across diverse contexts, leading to criticisms regarding its empirical rigor. Furthermore, the model is occasionally criticized for oversimplifying the complex dynamics behind FDI, potentially failing to accurately reflect the multifaceted reality of investment decisions in the global economy.

Additionally, the applicability of the OLI model to emerging economies remains a subject of debate, given its original development with a focus on developed economies. Critics also raise concerns about the underlying theories upon which the OLI model is based, including transaction cost theory and internalization theory, arguing that these theories have their own limitations and may not provide a complete explanation of FDI. Finally, the highly dynamic and rapidly changing nature of FDI in the modern global business environment poses a challenge, as the OLI model may not fully capture the intricacies of investment decisions in an ever-evolving world.

2.1.2. Digital Transformation and FDI: Empirical Evidence and Mechanisms

In recent decades, digital transformation has emerged as a pivotal force reshaping the global economic landscape. Digital transformation refers to the strategic integration and application of digital technologies such as big data analytics, artificial intelligence, the Internet of Things (IoT), and cloud computing to enable significant business improvements, enhance customer experience, and foster innovation (Verhoef et al., 2021; Vial, 2019). The rapid evolution of information and communication technologies (ICTs) has ushered in an era in which both nations and enterprises continuously pursue digitalization to strengthen productivity and competitiveness (Brennen & Kreiss, 2016; Kraus et al., 2022). In this context, digital transformation is not merely a technological trend but a strategic imperative that profoundly influences a country's ability to attract and utilize Foreign Direct Investment (FDI) (Kshetri, 2014; United Nations Conference on Trade and Development (UNCTAD), 2020). Consequently, it plays a crucial role in promoting innovation-driven economic growth and supporting the broader agenda of sustainable development across emerging economies (Yoon, Kim, & Jeong, 2023; Zhao, Li, & Zhang, 2022).

Continuing its strategic role, digital transformation is increasingly recognized as a crucial factor in attracting Foreign Direct Investment (FDI), especially in developing economies. Numerous empirical studies have indicated a positive impact of digital transformation on FDI through aspects such as digital infrastructure development, internet usage rates, and the digitalization of public administration. For instance, in Vietnam, a study by H. H. Nguyen and Vu (2024) using provincial-level data from 2010–2020 revealed that enhancing Information and Communication Technology (ICT) infrastructure and applying digital transformation in government and society had a clear effect on FDI attraction. However, the same study noted that digital transformation in economic sectors like e-commerce or digitalized manufacturing had not yet yielded equivalent effectiveness. In China, Zhang, Masron, and Lu (2024), in their study across 270 cities, also showed that public investment in digital infrastructure such as broadband and data centers significantly increased FDI inflows, particularly in lower-income areas. Dean, Lovely, and Wang (2009) examined the pollution haven hypothesis in China and found that only pollution-intensive joint ventures from Hong Kong, Macao, and Taiwan were attracted by low environmental standards, while OECD investors were not (Dean et al., 2009). A similar study in Saudi Arabia by Bardesi (2024) also confirmed that factors like expanded internet access, increased smartphone usage, and government digitization policies played a significant role in attracting long-term FDI. A study on the Yellow River Basin shows that moderate FDI promotes industrial upgrading, while excessive inflows and overly strict environmental regulation can hinder it (Yu, 2024).

The mechanisms through which digital transformation influences Foreign Direct Investment (FDI) can be understood through several complementary channels. Firstly, digital transformation significantly reduces transaction and information search costs for foreign investors by enabling digitized administrative procedures, electronic information portals, and online payment systems, thereby improving transparency and efficiency in investment processes (Alfaro, Chanda, Kalemli-Ozcan, & Sayek, 2004; United Nations Conference on Trade and Development (UNCTAD), 2020). This digitalization of governance enhances institutional quality, reduces bureaucratic barriers, and fosters an enabling business environment conducive to FDI inflows (Kshetri, 2014).

Secondly, the adoption of advanced digital technologies such as artificial intelligence (AI), big data analytics, and cloud computing enhances labor productivity and operational efficiency, creating favorable conditions for FDI to be directed toward modern, technology-intensive industries (Kraus et al., 2022; Vial, 2019). Thirdly, the rapid expansion of the digital economy has opened new investment frontiers, including fintech, e-commerce, digital logistics, and high-tech manufacturing sectors that are increasingly attractive to international investors seeking digital-driven growth opportunities (OECD, 2020). A prominent example can be observed in Vietnam, where partnerships with global technology firms such as NVIDIA to establish data centers and AI infrastructure illustrate how digital transformation acts as a “magnet” for high-quality and innovation-oriented FDI (World Bank, 2023).

Finally, digital transformation enhances human capital through digital skills training and education, fostering a workforce capable of adapting to technological change and the needs of multinational enterprises (Verhoef et al.,

2021). In sum, digital transformation not only provides favorable conditions in terms of infrastructure and governance but also reshapes the economic structure and labor market toward greater dynamism, transparency, and innovation factors that are essential in attracting sustainable FDI in today's highly competitive global economy.

2.1.3. Green Policies and Sustainable Development Factors Affecting FDI

In the context of increasing global concern about environmental degradation and climate change, green policies and sustainability considerations have become pivotal determinants of Foreign Direct Investment (FDI) flows (Chen, Hu, He, & Zhang, 2024; Famanta, Randhawa, & Yajing, 2024; Phung, Rasoulinezhad, & Luong, 2023). Green policies are governmental or organizational strategies designed to lessen environmental impact and promote ecological stewardship. These policies often involve regulations, incentives, and initiatives that encourage sustainable practices across various sectors. Concurrently, the concept of sustainable development emphasizes a balance between economic growth, social equity, and environmental protection for future generations, ensuring resource availability for the long term. The rising awareness of climate change and pressure from stakeholders have prompted multinational enterprises (MNEs) to consider environmental and sustainability factors as an integral part of their investment decisions. This makes nations with clear commitments to green policies and sustainable development more appealing to foreign investors seeking long-term competitive advantages and corporate social responsibility.

Green policies and sustainable development factors are increasingly demonstrating a positive role in attracting foreign direct investment (FDI). Contrary to traditional concerns that stringent environmental regulations might increase costs and deter investment, recent empirical evidence suggests the opposite: well-designed environmental policies can foster innovation, enhance competitiveness, and attract higher-quality and more sustainable FDI (Dean et al., 2009; Poelhekke & Van Der Ploeg, 2015). In the case of China, Dean et al. (2009) found that strengthened environmental controls did not discourage foreign investors; instead, they incentivized technological innovation within domestic industries, partly driven by knowledge spillovers from multinational enterprises. Similarly, evidence from the Yellow River Basin shows that stricter environmental regulations encourage industrial upgrading and green technology adoption, with FDI acting as a critical intermediary in this transformation process. On a broader scale, countries that adopt transparent and credible green governance frameworks tend to attract more environmentally responsible investors, reinforcing the shift from "pollution haven" to "green competitiveness" (Eskeland & Harrison, 2003; United Nations Conference on Trade and Development (UNCTAD), 2020).

The positive mechanisms through which green policies and sustainable development influence foreign direct investment (FDI) can be explained from multiple perspectives. Firstly, these policies help attract "green FDI" flows investments originating from multinational corporations pursuing sustainable development strategies. These firms tend to seek out countries with clear, stable legal environments that support the transition to green technologies or renewable energy, thereby optimizing their long-term sustainable growth objectives (Famanta et al., 2024; Li & Zheng, 2025). Additionally, choosing to invest in countries with strong environmental commitments also helps corporations enhance their reputation, protect their brand image, and mitigate reputational risks especially as consumers and investors increasingly prioritize social and environmental responsibility (Chen et al., 2024; Johnson, 2017).

Furthermore, sound sustainable development policies and environmental management also serve to reduce long-term legal risks and compliance costs for foreign investors. A stable legal environment that promotes transparency and sustainability allows FDI enterprises to invest with greater confidence in the long run, as they are less likely to face sudden policy changes or significant adjustment costs due to non-compliance with future standards (Phung et al., 2023). Moreover, green policies have the potential to create new markets for environmentally friendly products and services. When governments issue regulations prioritizing green consumption, supporting clean technologies, or implementing emissions standards, this simultaneously stimulates domestic market demand in these areas, thereby

opening attractive investment opportunities for foreign enterprises specializing in clean technology, renewable energy, or waste treatment (Ofori & Asongu, 2023; Pan, 2025).

Finally, environmental policies are often accompanied by administrative reforms, improved public governance, and increased transparency in law enforcement. These factors positively influence the investment decisions of multinational corporations, which highly value the level of institutional risk and the effectiveness of policy implementation in host countries (Doytch & Ashraf, 2022; Radi & Westerhoff, 2024). Therefore, it can be affirmed that green policies and sustainable development factors not only help improve environmental quality but also contribute to enhancing national competitiveness in attracting strategic, high-quality, and innovation-linked FDI.

2.1.4. Other Macroeconomic and Financial Determinants of FDI

In addition to key factors such as digital transformation and environmental policies, the research model also incorporates other macroeconomic variables capable of influencing Foreign Direct Investment (FDI) flows, notably the Financial Development Index and the Inflation Rate. These macro variables are widely regarded in previous studies as important for shaping a country's investment environment. For example, the financial development index has been shown to exert a significant influence on FDI inflows when the domestic financial system is sufficiently developed (An, Chen, & Yeh, 2025; Chee & Nair, 2010; Nguyen, Dieu Thi, & Bui, 2023). Meanwhile, the inflation rate is found to have a complex relationship with FDI: some studies report that moderate inflation supports investment flows by signaling growth potential, while high and volatile inflation tend to deter foreign investment due to increased uncertainty and risk (Iqbal, Budiman Hakim, & Anggraeni, 2025). Firstly, the Financial Development Index reflects the level of development of a nation's financial system, encompassing the growth of financial institutions (banks, insurance companies, investment funds, etc.) and financial markets (capital markets, bonds, stocks, etc.). A developed financial system helps reduce transaction costs, increase access to credit, and provide efficient financial services for both domestic businesses and foreign investors. Alfaro et al. (2004) is one prominent study demonstrating that financial development plays a crucial intermediary role in facilitating the conversion of FDI into economic growth. Banga (2003) also indicated that countries with developed banking systems and financial markets tend to attract higher FDI due to providing a stable and favorable financial environment for production and business activities. The primary mechanism of impact lies in the fact that foreign investors can more easily borrow domestic capital, enjoy better liquidity, and mitigate financial risks during their operations in the host country. Secondly, the inflation rate is a crucial macroeconomic indicator reflecting the stability of an economy. Theoretically, high inflation typically signals an unfavorable environment for FDI as it increases input costs, complicates financial planning, and indicates macroeconomic instability. However, some studies also suggest that under conditions where inflation is moderately controlled and accompanied by economic growth, its negative impact on FDI can be mitigated. Research by Schneider and Frey (1985) asserted that high inflation is a factor reducing FDI, while low and stable inflation contributes to maintaining investor confidence. Recent studies in developing Asian countries also indicate that inflation below a threshold of 6–7% generally does not deter FDI, especially when accompanied by high GDP growth rates. The primary mechanism of impact operates through the expectation channel: if investors perceive inflation as reflecting an overheated economy not coupled with policy reforms, they will withdraw to avoid risks related to exchange rates, interest rates, and rising production costs. Conversely, if inflation occurs within a context of expanding production and consumption, market confidence may still be sustained.

2.2. Hypothesis Development

Based on the theoretical foundation of the OLI model and the empirical evidence reviewed in Section 2.1, this study proposes the following hypotheses regarding factors influencing foreign direct investment (FDI) flows in ASEAN countries.

H₁: Internet user penetration has a positive effect on FDI inflows in ASEAN countries.

Drawing from the literature review in Section 2.1.2, digital transformation, as measured by internet user penetration, plays a crucial role in attracting FDI. Developed digital infrastructure and widespread internet adoption significantly reduce transaction costs, increase information transparency, and expand market opportunities for foreign investors. Empirical studies have demonstrated that enhanced internet access and usage improve operational efficiency and create a favorable business environment, thereby increasing a country's attractiveness to multinational corporations. Therefore, we expect that higher internet penetration will stimulate FDI inflows into ASEAN countries.

H₂: CO₂ emissions intensity has a negative effect on FDI attractiveness in ASEAN countries.

As discussed in Section 2.1.3, green policies and commitments to sustainable development are increasingly becoming decisive factors for FDI. High CO₂ emissions intensity often reflects less stringent environmental policies or a high reliance on fossil fuel consumption, which can reduce a country's attractiveness to foreign investors, particularly those companies with sustainable strategies and a commitment to corporate social responsibility. Countries with weak environmental commitments may face reputational risks and potential future adjustment costs, making them less appealing to "green FDI" flows.

H₃: The inflation rate has a negative effect on FDI inflows in ASEAN countries.

Analysis in Section 2.1.4 indicates that macroeconomic stability is a key factor in foreign investment decisions. While acknowledging certain nuances, high inflation is generally perceived as a sign of economic instability, increasing production costs, complicating financial planning, and creating exchange rate risks. This erodes real profits and increases uncertainty for foreign investors. Therefore, a high and unstable inflation rate is predicted to reduce the attractiveness of ASEAN countries for FDI.

H₄: The Financial Development Index has a positive effect on FDI inflows in ASEAN countries.

As reviewed in Section 2.1.4, a developed financial system plays an essential role in facilitating FDI. The Financial Development Index reflects access to credit, the efficiency of financial services, and the stability of financial markets. A robust financial system helps reduce transaction costs for foreign investors, provides diverse financing options, and supports business operations. This creates a more favorable environment for multinational corporations as they seek locations to expand their activities.

3. METHODS

3.1. Data Collection and Sampling

This study employs a balanced panel dataset encompassing six key member states of the Association of Southeast Asian Nations (ASEAN): Vietnam, Singapore, Malaysia, Indonesia, Thailand, and the Philippines. The dataset covers a 15-year period from 2008 to 2022, resulting in a total of 90 observations (6 countries \times 15 years). The selection of these specific countries was guided by practical considerations and their strategic importance within the ASEAN region. These six nations collectively represent the largest share of Foreign Direct Investment (FDI) inflows into ASEAN, accounting for approximately 80% of the bloc's total FDI during the period 2008–2023, according to data from UNCTAD and the World Bank. Furthermore, they are characterized by significant market sizes, varying levels of digital transformation readiness, and evolving policy environments, which align well with the analytical focus on digital transformation, green policies, and their impact on FDI. Conversely, data for the remaining ASEAN countries (Laos, Cambodia, Myanmar, and Brunei) were found to be severely limited, particularly for indicators related to digital infrastructure and green policies. Including these countries would have compromised the reliability of the quantitative model and potentially introduced statistical bias due to substantial data gaps or significant disparities in development trajectories. Thus, the selected sample ensures both the robustness of the analysis and the generalizability of the findings to the more economically dynamic segment of the ASEAN region. The data for this study were systematically collected from multiple reputable international databases to ensure consistency, accuracy, and reliability. The dependent variable, FDI inflows (measured as a percentage of GDP), was primarily sourced from the World Bank's

World Development Indicators (WDI) database. Key independent variables and control variables were gathered accordingly.

For Digital Transformation Indicators, Internet Users (percentage of total population) were collected from the World Bank's WDI database and United Nations reports, serving as primary indicators of digital infrastructure development. Additionally, Mobile Phone Subscriptions (per 100 people) were sourced from the World Bank's WDI database, reflecting the penetration of mobile communication technology, and the E-Government Development Index (EGDI) was obtained from United Nations E-Government Surveys, indicating the level of digital service provision by governments. Regarding Green Policy Indicators, CO₂ Emission Intensity (measured as CO₂ emissions per unit of GDP) was obtained from the International Energy Agency (IEA) and other reliable environmental databases, reflecting a country's environmental performance and policy stringency. Renewable Energy Consumption (percentage of total final energy consumption) was also sourced from the IEA and World Bank's Sustainable Energy for All database, indicating efforts towards sustainable energy transition.

Finally, for macroeconomic and control variables, the inflation rate (annual percentage change in the consumer price index) was collected from the WDI database, accounting for macroeconomic stability. The Financial Development Index (FDI), used as a proxy for the depth and efficiency of the financial system, was primarily derived from the International Monetary Fund (IMF) financial development indicators (referred to as 'fin' in our model outputs to avoid confusion with Foreign Direct Investment). Other variables such as GDP per capita (constant 2015 US\$), trade openness (sum of exports and imports as a percentage of GDP), and institutional quality (represented by composite scores from World Governance Indicators - WGI, such as government effectiveness or control of corruption) were also included, sourced from the WDI database and World Bank's WGI database respectively, to account for potential confounding factors. The collected data were organized into a two-dimensional panel format, with cross-sectional units being the selected countries and time-series observations spanning the 15-year period. To address any isolated data gaps, missing values for certain indicators were handled using linear interpolation, provided that the proportion of missing data was minimal (e.g., less than 5% for any given variable) and did not violate relevant statistical assumptions, thereby maintaining the integrity and representativeness of the dataset for subsequent econometric analysis.

3.2. Model Specification and Variables

This section outlines the econometric model employed to investigate the impact of digital transformation and green policies on FDI inflows in ASEAN countries. Building upon the theoretical framework established in Section 2, we hypothesize that digital transformation (Internet Users) and financial development positively influence FDI, while CO₂ emission intensity and inflation rate have significant impacts on FDI.

The dependent variable in this study is FDI inflows (FDI_{it}), measured as the net foreign direct investment as a percentage of GDP, primarily sourced from the World Bank's World Development Indicators (WDI) database. The key independent variables of interest are: Internet Users ($InternetUsers_{it}$): representing digital transformation, this variable is defined as the percentage of the total population with internet access, obtained from the World Bank's WDI database and United Nations reports. CO₂ Emission Intensity ($CO2Intensity_{it}$): serving as an indicator for green policies and environmental performance, it is measured as CO₂ emissions per unit of GDP, sourced from the International Energy Agency (IEA) and other reliable environmental databases.

In addition to these, a set of control variables are included to account for other factors that might influence FDI inflows: Inflation Rate ($InflationRate_{it}$) - measured as the annual percentage change in the consumer price index, collected from the WDI database, to account for macroeconomic stability, and Financial Development Index ($FinDevIndex_{it}$) - used as a proxy for the depth and efficiency of the financial system. This index was primarily derived from the International Monetary Fund (IMF) financial development indicators (referred to as 'fin' in our model outputs to avoid confusion with Foreign Direct Investment). It is important to note that while a broader set of

variables, including Mobile Phone Subscriptions, E-Government Development Index (EGDI), Renewable Energy Consumption, GDP per capita, Trade Openness, and Institutional Quality (from WGI), were initially collected and considered as potential drivers or control variables, some were subsequently excluded from the final econometric model. This exclusion was primarily due to issues of multicollinearity, as identified by Variance Inflation Factor (VIF) tests, which could compromise the reliability and interpretability of the estimated coefficients. The selected variables for the final model ensure a robust and parsimonious representation of the hypothesized relationships.

3.3. Econometric Model and Estimation Strategy

To test the research hypotheses and analyze the impact of digital transformation, green policies, and control variables on FDI inflows, this study employs a panel data regression model. The general form of the econometric model is specified as follows.

$$FDI_{it} = \beta_0 + \beta_1 InternetUsers_{it} + \beta_2 CO2Intensity_{it} + \beta_3 InflationRate_{it} + \beta_4 FinDevIndex_{it} + \mu_i + \lambda_t + \epsilon_{it} \quad (1)$$

Where: FDI_{it} is the dependent variable, representing Foreign Direct Investment inflows for country i in year t . $InternetUsers_{it}$ is a key independent variable, indicating the level of digital transformation in country i in year t . $CO2Intensity_{it}$ is a key independent variable, reflecting the CO₂ emission intensity of country i in year t , representing the green policy aspect. $InflationRate_{it}$ is a control variable, denoting the inflation rate of country i in year t . $FinDevIndex_{it}$ is a control variable, representing the financial development index of country i in year t . β_0 is the intercept. $\beta_1, \beta_2, \beta_3, \beta_4$ are the corresponding regression coefficients of the independent variables, representing their impact on FDI. μ_i captures the unobserved country-specific effects, accounting for time-invariant but cross-country varying factors (e.g., geographical, cultural, historical characteristics). λ_t represents the time-specific effects, accounting for unobserved factors that are constant across countries but vary over time (e.g., global economic shocks, general technological trends). ϵ_{it} is the idiosyncratic error term. To select the most appropriate estimation method for the panel data, a Hausman test was conducted to compare between the Fixed Effects Model (FEM) and the Random Effects Model (REM). The results of the Hausman test ($\chi^2(4) = 22.13$, Prob > $\chi^2 = 0.0002$) indicated that the Fixed Effects Model (FEM) was more appropriate. FEM was chosen as it allows for the control of unobserved country-specific characteristics that may be correlated with the independent variables, thereby helping to mitigate omitted variable bias and providing more consistent estimates. Furthermore, to ensure the robustness of the estimated results, robust standard errors (specifically, cluster-robust standard errors at the country level) were utilized. This approach aims to address potential issues of heteroskedasticity and autocorrelation often present in panel data. By adjusting the standard errors, the statistical significance tests (t-statistics and p-values) become more reliable, enabling accurate conclusions regarding the relationships among the variables.

4. RESULTS

This section presents the quantitative analysis results obtained from the panel data regression model specified in Section 3.3. The findings are presented in a logical order, starting with descriptive statistics, followed by the estimation results from the Fixed Effects (FEM) model with robust standard errors.

4.1. Descriptive Statistics

Prior to delving into the regression results, it is essential to present the descriptive statistics of the variables to provide an overview of the data characteristics. Table 1 presents the descriptive statistics for all variables included in the econometric model. This provides an overview of the data characteristics across the ASEAN countries from 2008 to 2022.

Table 1. Descriptive statistics.

Variable	Obs.	Mean	Std.dev.	Min.	Max.
Fdi	90	6.035	7.818	-0.858	33.304
Net	90	52.871	25.783	6.220	97.400
Mob	90	3.818	0.483	3.066	4.947
Egi	90	0.613	0.146	0.403	0.915
CO ₂	90	0.192	0.068	0.075	0.342
Ren	84	19.606	13.266	0.500	41.100
Gdp	90	3.818	0.483	3.066	4.947
inf	90	3.495	3.566	-1.138	23.115
fin	84	0.525	0.176	-0.290	0.832
trd	90	3.818	0.483	3.066	4.947
wgi	90	0.082	0.719	-0.571	1.623

Before proceeding to regression estimation, descriptive statistics are provided to summarize the key characteristics of the dataset. Table 2 presents the descriptive statistics of the main variables, including the number of observations, mean, standard deviation, minimum, and maximum values. These statistics show the variation across FDI inflows, digital transformation, green policy indicators, inflation rate, and financial development in the selected ASEAN countries during the study period.

Table 2. Descriptive statistics.

Variable	N	Mean	Std. Dev.	Min	Max
FDI	90	6.035	7.818	-0.858	33.305
Internet users (net)	90	52.871	25.783	6.220	97.4
CO2 intensity (CO2)	90	0.192	0.068	0.075	0.342
Inflation rate (inf)	90	3.495	3.566	-1.139	23.115
Financial development index(fin)	84	0.526	0.175	0.290	0.831

Note: N refers to the number of observations. Data for Financial Development Index (fin) is available for 84 observations, while other variables in the model (FDI, Internet Users, CO2 Intensity, and Inflation Rate) have 90 observations, reflecting differences in data availability for specific years or countries within the sample period.

4.2. Correlation Analysis

This section presents the correlation matrix among the variables included in the econometric model. This analysis provides initial insights into the linear relationships between the variables and serves as a preliminary assessment of potential multicollinearity issues.

Table 3. Correlation Matrix.

	fdi	net	CO ₂	inf	fin
Fdi	1.000 90				
Net	0.525 0.000 90	1.000 90			
Co2	-0.571 0.000 90	-0.094 0.380 90	1.000 90		
Inf	-0.098 0.357 90	-0.398 0.000 90	0.080 0.451 90	1.000 90	
fin	0.481 0.000 84	0.650 0.000 84	-0.085 0.442 84	-0.422 0.000 84	1.000 84

Note: Values represent Pearson correlation coefficients. The numbers below the coefficients are p-values, and the numbers below the p-values indicate the number of observations for each pair. N ranges from 84 to 90, depending on data availability for each pair of variables.

The correlation matrix in Table 3 reveals several important linear relationships among the variables. Regarding the relationship with FDI inflows, Internet Users (net) exhibits a moderately strong positive correlation ($r = 0.5247$, $p < 0.001$), suggesting that economies with higher internet penetration tend to attract more foreign investment. Conversely, CO2 Intensity (co2) shows a moderately strong negative correlation with FDI ($r = -0.5711$, $p < 0.001$),

indicating that countries with higher CO₂ emission intensity are associated with lower FDI inflows, aligning with the increasing global emphasis on environmental sustainability. Furthermore, the Financial Development Index (fin) is positively correlated with FDI ($r = 0.4812$, $p < 0.001$), implying that a more developed financial system is linked to greater FDI attraction. In contrast, the Inflation Rate (inf) demonstrates a weak negative and statistically insignificant correlation with FDI ($r = -0.0982$, $p = 0.3571$), suggesting its linear relationship with FDI in this sample may be minimal or more complex. An examination of the correlations among the independent variables is crucial for assessing potential multicollinearity. Most correlation coefficients among these variables are below commonly cited thresholds (e.g., 0.7 or 0.8), which suggests a low risk of severe multicollinearity at this preliminary stage. However, a notable positive correlation exists between Internet Users (net) and the Financial Development Index (fin) ($r = 0.6499$, $p < 0.001$). While this is a relatively strong correlation, its precise impact on multicollinearity will be formally assessed by the Variance Inflation Factor (VIF) tests during the regression analysis, as mentioned in Section 3.2.

4.3. Regression Results

This section reports the estimated results from the Fixed Effects (FEM) regression analysis, examining the impact of digital transformation and green policies on FDI inflows in ASEAN countries. The model was estimated using robust standard errors to account for potential heteroskedasticity and autocorrelation.

Table 4. Fixed effects (FEM) regression results on FDI inflows.

Fdi	Coefficient	Robust Std. err.	t	P> t	[95% conf. interval	
Net	0.144	0.027	5.40	0.000	0.091	0.197
CO ₂	-59.337	8.478	-7.00	0.000	-76.212	-42.463
Inf	0.526	0.129	4.08	0.000	0.269	0.782
Fin	10.233	3.724	2.75	0.007	2.820	17.645
_cons	2.934	2.014	1.46	0.149	-1.074	6.943
Number of obs	84					
F(4, 79)	17.20					
Prob > F	0.000					
R-squared	0.641					
Root MSE	4.691					

The results presented in Table 4 indicate that the overall model is statistically significant and explains a substantial portion of the variation in FDI inflows. Specifically, the model yields an R-squared value of 0.6409, meaning approximately 64.09% of the variance in FDI inflows can be explained by the independent variables included in the model. The F-statistic of 17.20 with a p-value of 0.0000 further confirms the overall statistical significance of the model, indicating that the independent variables collectively have a significant impact on FDI inflows. Now, we delve into the specific effects of each independent variable on FDI inflows: Internet Users (net) - The coefficient for Internet Users is 0.1439711, which is positive and statistically significant at the 1% level (p-value = 0.000). This finding suggests that an increase in internet users (representing digital transformation) in ASEAN countries is significantly associated with a rise in FDI inflows. This result supports the hypothesis that digital transformation enhances a country's attractiveness for foreign direct investment. CO₂ Intensity (co2) - The coefficient for CO₂ Intensity is -59.33742, and it is highly statistically significant at the 1% level (p-value = 0.000). The negative sign indicates that a higher intensity of CO₂ emissions is associated with lower FDI inflows. This suggests that countries with less stringent environmental policies or higher environmental impact may be less appealing to foreign investors, reflecting a growing global trend towards sustainable and green investments. Inflation Rate (inf) - The inflation rate shows a positive and statistically significant coefficient of 0.5257346 (p-value = 0.000). This result might initially appear counter-intuitive, as high inflation typically deters investment. However, in certain contexts, a moderate inflation rate might accompany robust economic growth or strong domestic demand, which could attract foreign

investors seeking market opportunities. Further qualitative analysis or specific country-level insights might be needed to fully interpret this relationship. Financial Development Index (fin) - The Financial Development Index has a positive and statistically significant coefficient of 10.2325 (p -value = 0.007). This indicates that a more developed financial system in a country significantly contributes to attracting greater FDI inflows. A sophisticated financial sector can reduce transaction costs, facilitate capital allocation, and provide better access to credit and other financial services for foreign firms, thereby enhancing investment opportunities.

5. DISCUSSIONS

5.1. Interpretation of Results

The regression results demonstrate that Internet usage has a positive and statistically significant effect on foreign direct investment (FDI) inflows. Specifically, in the robust model with heteroscedasticity-consistent standard errors (vce(robust)), the coefficient of the Internet users variable is 0.144 ($p < 0.01$), indicating that a one-percentage-point increase in Internet penetration corresponds to an average increase of approximately 0.144 units in FDI. This suggests that digital infrastructure plays a crucial role in attracting FDI, underscoring the growing importance of digital transformation in national economic development strategies.

Meanwhile, the CO₂ emissions variable has a negative and highly significant coefficient (-59.34, $p < 0.01$), suggesting that environmental pollution acts as a substantial barrier to foreign investment. This finding reinforces the argument that international investors are increasingly concerned with environmental sustainability when making investment decisions.

Inflation also exerts a positive and significant influence on FDI (0.53, $p < 0.01$) in the robust model, indicating that a moderate level of inflation can be interpreted as a signal of economic expansion in developing countries. Lastly, the financial development variable shows a positive and significant coefficient (10.23, $p < 0.01$), implying that a well-functioning financial system contributes positively to FDI inflows by enhancing capital accessibility and reducing financial risks.

However, when the fixed effects model is employed to control for unobserved heterogeneity across countries, the coefficient for Internet users declines to 0.052 ($p = 0.05$), though it remains statistically significant. This implies that even after accounting for country-specific characteristics, Internet access still plays a meaningful role in attracting FDI. Notably, in the fixed effects model, the coefficient of financial development becomes negative and statistically significant (-28.03, $p < 0.01$), suggesting that, in the absence of appropriate governance and regulatory mechanisms, rapid financial sector expansion may lead to instability and reduce investment attractiveness.

The Hausman test ($p = 0.0002$) confirms that the fixed effects model is more appropriate than the random effects model, highlighting the necessity of controlling for cross-country differences to avoid biased estimations.

5.2. New Findings and Contradictions

5.2.1. New Findings

5.2.1.1. Internet Users Have a Positive Impact on FDI

The regression results reveal that the proportion of Internet users has a positive and statistically significant impact on FDI inflows. This represents a novel contribution to the existing body of FDI literature, which has traditionally focused on macroeconomic and institutional determinants, with limited attention given to the influence of digital infrastructure.

5.2.1.2. CO₂ Emissions as a Barrier to International Investment

The study finds that CO₂ emissions have a clearly negative impact on FDI inflows. This provides a new perspective on international capital flows by highlighting the importance of environmental factors in global investment strategies. The result is particularly relevant in the context of the rising emphasis on ESG

(Environmental, Social, and Governance) principles, which are increasingly prioritized by countries especially within the ASEAN region.

5.2.1.3. Inflation May Signal Positive Economic Conditions in Certain Contexts

Traditionally, inflation is perceived as a negative factor for economic performance. However, this study presents findings that challenge this conventional view: the inflation variable exhibits a positive and statistically significant coefficient in the robust model. This suggests that in certain developing countries, a moderate rise in inflation may reflect market expansion and economic growth, thereby facilitating the attraction of investment particularly foreign direct investment (FDI).

5.2.2. Contradictions in the Study

5.2.2.1. Divergent Effects of Financial Development (FIN)

In the robust model, financial development (FIN) has a positive and statistically significant effect, aligning with the hypothesis that a developed financial system supports FDI inflows by improving access to credit and reducing transaction costs.

However, in the fixed effects (FE) model, FIN exhibits a negative and statistically significant coefficient. This result contradicts conventional theory and raises concerns about the stability and efficiency of domestic financial systems, as well as the potential for macro-financial risks in the absence of adequate institutional oversight.

This is a key contradictory finding, suggesting that the impact of financial development on FDI is neither linear nor uniformly positive. Instead, it is contingent on governance quality, institutional context, and the level of macroeconomic stability.

5.2.2.2. Reduced Impact of Internet Users Under Fixed Effects Model

The coefficient of the Internet users variable in the robust model is 0.144 ($p < 0.01$), but it decreases to 0.052 ($p = 0.05$) in the fixed effects (FE) model. This reduction suggests that much of the positive effect of Internet usage on FDI may be attributed to inherent cross-country differences such as economic size or the level of infrastructure development. Therefore, the technological effect is not entirely endogenous but is shaped by the structural conditions of each country.

5.2.2.3. CO₂ Variable Becomes Statistically Insignificant in the FE Model

While CO₂ emissions exhibit a strong negative impact on FDI in the robust model, the coefficient becomes statistically insignificant in the fixed effects (FE) model. This suggests that CO₂ emission levels may be closely tied to time-invariant country characteristics such as the presence of heavy industries rather than dynamic changes over time.

6. CONCLUSIONS

6.1. Theoretical Contributions

This study contributes to the expansion of the theoretical framework on foreign direct investment (FDI) by integrating two modern and increasingly important factors: digital transformation and sustainable development. Incorporating these elements into the analysis helps identify new drivers influencing international capital flows, beyond traditional determinants such as market size, labor costs, or macroeconomic stability. At the same time, it reflects a shift in the mindset toward attracting FDI, as many countries now focus not only on the quantity but also on the quality of investment inflows. The proportion of internet users is employed as a proxy variable for the level of digital transformation in the economy. This variable captures the accessibility of technology, the development of digital infrastructure, and the ease of doing business for foreign investors. Including this factor in the model not only

enables the assessment of a country's technological capacity but also reflects its readiness for digitalization. This offers a new perspective, aligning with the context in which FDI enterprises increasingly prioritize technological factors and operational efficiency in host locations.

In addition, the study employs the CO₂-to-GDP ratio to reflect the level of relative emissions an indirect yet effective approach to assessing a country's environmental commitment. This indicator does not depend on specific legal regulations but rather reflects actual performance in emission control. Incorporating environmental factors in this way enables the FDI analysis model to better align with current global trends, in which international capital flows especially high-quality FDI increasingly prioritize markets with a green development orientation and transparency in the investment environment.

On the other hand, the study utilizes a linear regression model with robust standard errors an appropriate choice when working with panel data in the ASEAN context, where significant disparities exist in terms of size, development level, and data quality across countries. This method helps ensure more reliable regression results while matching the characteristics of the dataset and the research objectives.

Based on these foundations, the study contributes to enriching the empirical evidence on the relationship between FDI and non-traditional factors such as digital transformation and environmental policies dimensions that are playing an increasingly important role in shaping development strategies and investment attraction in developing countries.

6.2. Practical Implications

The research findings indicate that both digital transformation and green policies have a significant impact on a country's ability to attract FDI within the ASEAN region. This suggests that, in addition to stabilizing traditional macroeconomic factors, governments should consider technology and sustainable development as integral components of their foreign investment strategies. The positive effect of the "Internet users" variable demonstrates that countries with more widespread digital infrastructure are better positioned to attract FDI. A well-developed digital infrastructure not only facilitates business operations but also enhances transparency and efficiency in administrative procedures, helping investors reduce costs and risks. Therefore, investing in digital connectivity, improving e-government systems, and supporting business digitalization should be regarded as medium-term priorities in investment policy.

Conversely, the CO₂-to-GDP ratio shows a negative correlation with FDI, indicating that countries with higher emission levels may be less attractive to international investors particularly green capital flows or high-tech FDI. This finding suggests that emission control, the promotion of clean energy policies, and greater environmental transparency not only contribute to sustainable development but also serve as competitive advantages in attracting FDI in the new era.

In addition, inflation and the financial development index also exhibit significant effects in the model. High inflation is often associated with macroeconomic instability, which undermines investor confidence, while a well-developed financial system facilitates efficient capital allocation and enhances access to finance for FDI enterprises. These results underscore the continuing importance of maintaining macroeconomic stability and advancing financial sector reforms as foundational conditions for retaining and effectively absorbing foreign investment.

Accordingly, ASEAN countries including Vietnam should adopt a more comprehensive strategy for FDI attraction: not only relying on cost advantages but also improving digital capacity, strengthening environmental standards, and ensuring long-term economic stability.

6.3. Limitations and Suggestions for Further Studies

The study still presents certain limitations in both data scope and model design. First, although the initial objective was to include all ASEAN countries, due to limitations in data availability and completeness particularly for variables representing digital transformation and environmental policies the study focused on only six countries with

relatively comprehensive data during the 2008–2023 period. While this narrowing of scope was necessary to ensure the model's stability and reliability, it also reduces the generalizability of the findings across the entire region.

Second, the proxy variables used in the model are somewhat one-dimensional and isolated in nature. Specifically, while the “Internet users” variable reflects the level of technology penetration, it does not fully capture the depth of digital transformation, including aspects such as public sector digitalization, digital service development, or digital readiness. Similarly, the CO₂ intensity index primarily reflects output in terms of emissions, but does not comprehensively account for policy dimensions such as regulatory frameworks, green investment incentives, or environmental information transparency.

Third, while the linear regression model employed in this study helps to identify the basic relationships between variables, it does not fully capture the complex interactions that may exist in reality. For instance, the impact of digital transformation on FDI may vary depending on the level of green policy implementation, and vice versa. Additionally, the relationships among variables may be nonlinear in nature, particularly in the context of developing economies.

Based on these limitations, future research could be extended in three directions. First, more comprehensive and in-depth indices should be employed to measure digital transformation and green policy, such as the E-Government Development Index (EGDI), the Global Innovation Index (GII), or the Environmental Stringency Index. Second, more advanced analytical models such as nonlinear regressions or interaction models could be applied to examine interdependencies and the combined effects of multiple factors influencing FDI flows. Third, the scope of the study could be expanded by categorizing countries into subgroups (e.g., by income level, degree of digitalization, or sustainability performance) to assess variations in FDI attraction mechanisms across different types of ASEAN economies.

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