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Analyzing The Nexus Between Digital Financial Inclusion, Economic Growth, and Environmental Sustainability Impact in ASEAN Region

Nukman Taufik,[1*] Dwi Nastiti Danarsari [2]

[1]Faculty of Economics and Business, Universitas Indonesia; [2] Faculty of Economics and Business, Universitas Indonesia

Abstract

Purpose: This study aims to examine the impact of digital financial inclusion—proxied by debit card usage and ATM availability—on both economic growth and environmental sustainability across 11 ASEAN member countries during the period from 2010 to 2023.
Method: Using panel data regression analysis, the study employs the Feasible Generalized Least Squares (FGLS) estimation method to analyze the relationship between financial inclusion, economic growth, and carbon emissions.
Results: The analysis reveals a positive and significant relationship between debit card penetration and economic growth, suggesting that greater digital financial access contributes to economic performance. Conversely, the relationship between ATM availability and economic growth appears inconsistent.
Implication: These findings underscore the need for policymakers, financial regulators, and development agencies to design financial systems that not only promote growth but also incorporate environmental safeguards.
Originality: This research contributes to the literature by integrating digital financial inclusion metrics within an EKC framework to simultaneously evaluate economic and environmental outcomes in developing economies.

Keywords: Digital Financial Inclusion, Economic Growth, Environmental Sustainability, Carbon Emissions.

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*Corresponding Author. Email: nukman.taufik@office.ui.ac.id

Introduction

As the world grapples with the urgent need to balance economic growth with the safeguarding of the environment, some developed countries have increasingly recognized the vital necessity of pursuing sustainable development strategies that simultaneously drive prosperity and preserve ecosystems (Ritchie 2021). This global shift towards sustainability is reflected in the International Agreements such as the Paris Conference on Parties (COP) 2021. In here, financial industries as the key drivers of economic growth were called to play a significant role in fostering environmental sustainability (Azoulay et al. 2022). Historically, the financial sector has long been essential in developing economic growth by facilitating financing, investment, and economic stability (Regan and Paxton (2003), Kodan (Kablana) and Chhikara (2013)). Similarly, the positive impact of financial inclusion to the MSME's financing through Indonesian Islamic banking is demonstrated by Wibowo and Sriyana (2024).

As the world's fifth largest economic bloc with aggregated GDP of US$3.6 trillion in 2022, ASEAN has consistently outpaced other global regions in economic growth, exceeding both the United States (which had a growth rate of 1.1%) and the European Union (with a rate of 0.5%) over the past ten years (Rasjid 2023). On the other side, from the financial sector point of view, the Global Findex 2021 data revealed that ASEAN also has experienced a rise in financial inclusivity, with figures jumping from 51% in 2011 to 76% in 2021. Malarvizhi et al. (2019) explains that financial development in ASEAN-5 is proven to have a positive effect on economic levels. Yet, those economic and financial data progress, ASEAN continues to encounter considerable hurdles in its efforts to mitigate carbon emissions, as evidenced by data from OurWorldInData.org.

Furthermore, the influence of digital technology has become a pivotal force in financial services. It streamlines procedures such as withdrawing money, payments, and loan requests using digital platforms, and it can also reduce the energy needed for transportation. This transformation has led to the emergence of the notion of "Digital Financial Inclusion". Given this context, this study is motivated by two key research objectives. First, this study intends to examine how digital financial inclusion influences economic growth. With the increasing digitalization of financial services, there is improved access to funding, investment opportunities, and financial services, especially for groups that have been previously underserved (Liu et al., 2021; Ozili, 2018). Another objective is investigating the role of digital financial advancement in fostering environmental sustainability, particularly through the decrease of carbon emissions as the proxy of environmental sustainability. There has been a growing recognition in recent years of the potential for financial systems to aid in achieving environmental objectives. Previous studies written by J. Wang et al. (2022) and Tay, Tai, and Tan (2022) have indicated that the financial industry can promote sustainability by supporting green initiatives and encouraging eco-friendly practices.

Even though, there is increasing number research which are studying the relationship between financial development, economic progression, and environmental sustainability (Tay, Tai, and Tan 2022; X. Wang et al. 2022), yet most of this research has concentrated on areas like East Asia and Africa, with Southeast Asia receiving relatively little focus. The ASEAN region, characterized by its diverse economies and differing environmental

regulations, presents a distinctive setting to examine how financial inclusion interacts with economic growth and ecological consequences. This study aims to fill this gap by investigating how digital financial inclusion can help decouple economic growth from environmental harm. ASEAN presents an ideal context for this research due to its strong economic performance over the past decade and its demonstrated resilience during global crises. Nowadays, the industry provides a wide range of digital financial services such as e-wallets, mobile banking, until cryptocurrencies. Even though, not all products are not uniformly available or mature across all ASEAN countries. Majority members are transitioning from cash-based to digital as the medium of exchange. As used by Ozturk and Ullah (2022), ATMs and debit cards could offer a standardized representation of digital financial inclusion regardless levels of technological development. In this study, ATMs and debit cards employed as indicators because its serve as reliable proxies for technological progress in countries with very levels of technology advancement.

To analyze the relationship between digital financial inclusion, economic growth, and environmental sustainability, this study employs Feasible Generalized Least Square (FGLS) estimation techniques. This method will be used in situation whereas violations in autocorrelation and heteroscedasticity (Le, Chuc, and Taghizadeh-Hesary 2019). The analysis is based on data from 10 ASEAN member countries spanning the period from 2013 to 2023, so then the total observation from this sample is 154 observations.

Initial observations assumes that the growth of digital financial services is associated with a decrease in carbon emissions, reinforcing the theory that digital innovations can promote sustainability both economically and environmentally. First finding in the impact of digital financial inclusion is inconsistent with earlier work by Zhang, Cheung, and Qu (2024) and Khan et al. (2022), while the second finding seems also to be not in accordance with the research conduct by Zhang, Mohsin, and Taghizadeh-Hesary (2022) and J. Wang et al. (2022) because there is positive relation between digital financial inclusion and carbon productions. This research enriches the academic literature regarding sustainable development and digital finance. Furthermore, the results provide crucial policy recommendations that could assist ASEAN nations in harmonizing their financial objectives with environmental aspirations, in accordance with international agreements such as the COP Paris Agreement.

This paper is organized as follows: Section 1 introduces the research background, motivation, and objectives. Section 2 provides a comprehensive review of the literature on digital financial inclusion, economic growth, and environmental sustainability, along with relevant theoretical frameworks. Section 3 outlines the empirical model, variables, and dataset used in the analysis. Section 4 presents the findings of the study, including results from the endogeneity tests and the linear regression analysis conducted using FGLS methods. Finally, Section 5 concludes the paper with a discussion of the policy implications, limitations of the study, and suggestions for future research.

Literature Review

1. *The Determinants of Economic Growth*

Economic growth has been a key issue in economics until this digital era because of its strong link to human well-being and social advancement. The Classical Theory, the

Neoclassical Theory, the Endogenous Growth Theory, and the Modern Economic Growth Theory are few of the economic growth theories. The Environmental Kuznets Curve (EKC) is foundation framework of this research, this theory suggested that initially environmental damage increases along with economic growth, but with time, it declines as income per capita increases, suggesting increased environmental consciousness and technical progress. The decoupling of economic progress from environmental damage has been widely studied using this framework. In accordance with (Kien et al. 2023; Maria, Urata, and Intal Jr 2017) previous research, the discussion about the significance of financial access in promoting economic sustainability is relevant with the issue of economic decoupling. Through the adoption of technology in banking industry, it will accelerate the economic progress while reduce environment damage. However, there is limited exploration of how digital financial inclusion interacts with the EKC model to influence carbon emissions, especially in developing economies like those in the ASEAN region.

The Association of Southeast Asian Nations (ASEAN), established in 1967, includes several countries: Indonesia, Malaysia, Singapore, Thailand, the Philippines, Brunei, Vietnam, Laos, Myanmar, Cambodia, and Timor-Leste. This organization aims to encourage collaboration in economic, political, social, and cultural aspects to build a stable and thriving Southeast Asian community. Over the past decade, ASEAN has attracted significant global attention due to its remarkable economic growth. Factors such as market opportunities, increased interconnection within the ASEAN Economic Community (AEC), urban growth, rising populations, and foreign direct investment (FDI) have been instrumental in driving this success (Kien et al. 2023; Maria et al. 2017). According to the (ASEAN 2024), countries like Indonesia, Vietnam, and Philippines recorded robust average annual growth rates of over 5% pre-pandemic. Thailand and Malaysia, on the other hand, experienced more modest growth figures.

Even though ASEAN consists of many developing nations, financial inclusion has played a crucial role in boosting economic growth by allowing more individuals to participate in the economy and gain from technological progress. The advancements in the financial sector and fluctuations in oil prices have favourably influenced the long-term economy of ASEAN, as noted by Hidthiir et al. (2024). As per S&P Global, ASEAN is anticipated to remain among the fastest-growing areas globally for the following decade. The GDP is expected to rise from 1.3 trillion USD in 2022 to 4.1 trillion USD by 2035.

2. *Environmental Sustainability in ASEAN*

The levels of environmental sustainability differ greatly among countries, shaped by factors like economic progress, governance, and environmental regulations (Sarkar et al. 2024). Nevertheless, carbon emissions are a common and pressing issue, being the main contributor to climate change. This situation adversely affects air quality, the wellbeing of ecosystems, and the ability of a country to reach sustainable environmental goals (Morelli, 2011).

In accordance with COP 2021 Paris Agreement, which underscores the necessity for the financial services sector to play an active role in promoting sustainable economic development with a target to reach net-zero emissions by 2060, ASEAN has also initiated its

Green Economy project as part of the ASEAN Economic Community (AEC) Blueprint 2025. This initiative aims to cultivate a thriving ASEAN community that emphasizes environmental sustainability.

Mazzai (2022) notes that researchers are now making distinctions between economic growth and the carbon emissions associated with it. This research aims to identify regions or countries that have successfully separated economic development from fossil fuel consumption and carbon (CO2) emissions. OurWorldinData.org shows that developed nations, such as the United Kingdom and the United States, have been successful in decoupling their economic growth from carbon emissions.

Decoupling is an idea derived from an inverted U-shaped of Kuznets Curve which tells that as income rises, pollution initially increases, but will ultimately decline over time, even as income continues to grow. Zhu et al. (2016) discovered that, in line with the Kuznets Curve theory, some ASEAN countries demonstrate a noticeable positive correlation between energy consumption and carbon emissions. Furthermore, Tay et al. (2022b) mentioned that digitalization in financial services will be able to support the sustainable development.

3. Financial Inclusion in ASEAN

Originally, the concept of Financial Inclusion (FI) first emerged in the early 1990s. After the 2008 global financial crisis, this term became widely recognized as it was seen to help during economic difficulties. Financial inclusion is in line with the G20's agreement in 2009, which acknowledged that access to banking services can encourage economic growth and stability. As reported by Khan et al. (2022), it is anticipated that financial service accessibility will boost economic conditions in developing nations, especially in Asia. This improvement is evident in the decline of poverty, economic growth, fair income distribution, and stable financial systems. Key aspects of financial inclusion involve payment services, savings, loans, and insurance (Demirguc-Kunt et al., 2017).

The progress of financial inclusion, both traditional and digital, varies greatly among ASEAN nations, affected by their access to and utilization of formal financial services, which are shaped by socio-economic factors and financial regulations. Among the ASEAN countries, Malaysia, Singapore, Thailand, and Vietnam excel in their financial inclusion measures, as demonstrated by their high credit-to-GDP ratios (ASEAN, 2023). The World Bank's Global Findex 2021 report indicates that the overall financial inclusion rate in ASEAN is at 41%, with significant differences between countries—some having rates as low as 20% while others near 90%.

The 4th Industrial Revolution has urged the financial services sector to improve the use of digital technologies. Liu et al. (2021) point out the growth of Digital Financial Inclusion (DFI), a concept also acknowledged by Bank Indonesia (2014). Many ASEAN countries have created fairly advanced policy and regulatory frameworks for Digital Financial Services (DFS). For example, Indonesia and the Philippines have comprehensive policies and regulations, but the variety of digital products available is still limited (ASEAN 2023). Kouladoum, Wirajing, and Nchofoung (2022) argue that digital financial services greatly enhance the financial sector, spurred by the increasing use of mobile phones, internet, and broadband. Adel (2024) also highlights that in Asia, Africa, and Latin America, digital literacy,

technology acceptance, and internet access have positively influenced financial inclusion. It gives an alert that policy maker is urged to prepare digital financial plans and policies to develop financial inclusion. Subsequently, referring to Eco-Innovation Theory (Hojnik and Ruzzier 2016) suggested that innovations in technology can lead to sustainable economic growth by lowering environmental impact. This theory can complement the idea of Kuznets Theory, which lead to the idea of digital financial services can have a dual role in this process. First, it would help to increase economic growth by widen the access to financial products, even though it may initially demand for higher energy consumption and carbon printing. Second part, as economy goes by, digitalization access can promote sustainable practices through green technologies while reducing fossil fuels.

4. *Financial Inclusion to Economic Growth and Environmental Sustainability*

The role of financial inclusion is crucial for both boosting economic growth and ensuring environmental sustainability. One of them is explored by Chibba (2009), he pointed out that those lacking access to financial services encounter more significant financial obstacles. Later investigations, conducted by Khan et al. (2022) found a favourable link between financial inclusion and economic advancement, especially in developing nations where gaining access to financial services enhances economic activity and encourages involvement in the economy. On the flip side, some research conducted by Menyelim et al. (2021) and Nwisienyi and Obi (2020), discovered an adverse relationship, particularly in African countries, attributed to differences in the data and models utilized.

The advancement of digital financial services, including e-money, fintech solutions, and mobile banking, has greatly enhanced financial inclusion by allowing a wider range of people to access financial services. A study by Pramaswara (2023) revealed that digital financial inclusion has a positive impact on economic growth in Indonesia, and government programs such as cashless transactions have additionally promoted economic engagement. The adoption of mobile money and tools like ATMs and debit cards is associated with boosted economic growth by speeding up the flow of money and enhancing access to formal financial frameworks (Hasan, Abu Sayem, and Hossain 2024; Ozturk and Ullah 2022). Specifically in Southeast Asia, the technological adoption hasn't distributed evenly. Previous studies in regions are still relied on old indicators, such as: ATMs and debit cards, to measurement digital financial services (Amaliah et al. 2024). Compared to modern services, example: mobile money, e-wallet, etc, which may not be applicable in the landscape of ASEAN, ATMs and debit cards could perform a standardized proxies across all countries.

In this paper, authors measure digital financial inclusion using two indicators: ATMs to represent the supply side and debit cards to represent the demand side. Even though, this technology is conventional, but it can standardize the technology advancement between countries with vary economic scale. Similarly, debit cards as the proxy of the demand side by offering a convenient and secure alternative to cash for everyday transactions (Scholnick et al. 2008).

Regarding environmental sustainability, the improvement in financial inclusion also raises worries about higher energy use, leading to potential increases in carbon emissions and harm to the environment. Nonetheless, the Environmental Kuznets Curve (EKC) theory

implies that with rising income, awareness for the environment and investments in ecosystem conservation tend to grow. This impact is further intensified when digital financial inclusion is linked with green economic initiatives, as similarly explained by Jahanger and Usman (2023) that investment allocated in green technologies promotes the Sustainable Development Goals as the representation of the matured economic in EKC. On the other hand, Fareed et al. (2022) and Shahbaz et al. (2022) found the financial industry's growth along with manufacturing and industrialization tends to increase carbon emissions and energy use through expanded company operations and it is depicted the first phase in EKC.

Zhang et al. (2024) and X. Wang et al. (2022) suggested that nations exhibiting superior digital financial inclusion and adopting green technologies generally produce lower carbon emissions. Moreover, the efficiencies achieved from digital advancements in financial institutions can help lessen carbon footprints by encouraging the use of renewable energy and decreasing CO2 output (Hafeez et al. 2022). However, as variable measured in this research, few of previous research accounted for higher technology of digital financial inclusion, in this study eliminates the consideration technological maturity and consumer preferences.

Referring to EKC and Eco-Innovation Theory, digital financial inclusion can play dual role in economic development agent while maintaining the environmental sustainability by minimizing carbon emissions. The previous study (Tay, Tai, and Tan 2022; X. Wang et al. 2022) mostly disclosed the impact of financial access from East Asia, Middle East Asia, and Africa countries, while this research will elaborate on its applicability in the ASEAN region. For this reason, this research formulates the following hypothesis:

H_1: There is a positive influence between digital financial inclusion on economic growth; and

H_2: There is a negative influence between digital financial inclusion and carbon emissions.

Research exploring how financial development, economic growth, and environmental sustainability are related (Ozturk & Ullah, 2022; X. Wang et al., 2022), have less concentrated in Southeast Asia. That's way, this study focuses on how relevant these issues to ASEAN region. This region characterized by diverse economic scale and technology development, presents an interesting situation to examine the effects of financial inclusion on economic progress and environmental impacts.

Methods

In this research, we evaluate the impact of digital financial inclusion (DFI) on economic growth and carbon emissions within 11 ASEAN countries from 2010 to 2023. Currently, digital financial inclusion serves as an essential driver of economic advancement (Van et al., 2021). Numerous empirical research findings have indicated that digital financial inclusion negatively affects carbon emissions, considering both direct and indirect pathways impacting environmental quality (Zaidi, Hussain, and Uz Zaman 2021).

Based on these observations, we create two main econometric models as mentioned by Ozturk and Ullah (2022) to investigate these relationships. These models will be specified as follows:

1. Model for Economic Growth (GDP)

$$GDP_{it} = \beta_0 + \beta_1 DFI_{it} + \beta_2 INET_{it} + \beta_3 INDS_{it} + \beta_4 ENER_{it} + \beta_5 FDI_{it} + \beta_6 INFL_{it} + a_i + \varepsilon_{it} \quad \text{..... (1)}$$

2. Model for Environment Sustainability (GHG)

$$GHG_{it} = \beta_0 + \beta_1 DFI_{it} + \beta_2 INET_{it} + \beta_3 INDS_{it} + \beta_4 ENER_{it} + \beta_5 FDI_{it} + \beta_6 INFL_{it} + a_i + \varepsilon_{it} \quad \text{..... (2)}$$

Where in these two models (1 & 2), GDP denotes the economic growth rate, while GHG denotes greenhouse gasses emission. DFI or digital financial inclusion, the primary independent variable, is quantified using both supply-side indicators (ATMs) and demand-side measures (Debit cards). The remaining ones are control variables which are Internet penetration (INET), industrialization rate (INDS), energy consumption (ENER), net foreign direct investment (FDI), and inflation (INFL), all of which have been extensively established to impact economic growth dynamics. The error term (ε_{it}) accounts for unobserved variability and unpredictable shocks.

In here, we utilize panel data models that account for both time and cross-sectional aspects of the data. Thus, this dataset is regarded as more comprehensive in comparison to separate time-series or cross-sectional data. Assessing the specified models, the application of Feasible Generalized Least Squares (FGLS) is used because it gives several benefits. This method is effectively utilized to tackle potential endogeneity concerns in both models. Endogeneity occurs when the independent variable has a correlation with the error term, which results in biased estimations. FGLS is more advisable if there are endogeneity or autocorrelation problems in the panel data, as described by Arellano & Bond (1991).

The methods for collecting data are a crucial aspect of research, involving systematic and standardized approaches to gather the necessary sources of information for the study. Data can be gathered retrieved from secondary sources provided by credible global data provided, including official sites, recognized institutions, or databases dedicated to delivering business-related information. Table 1 shows the data description and sources.

Table 1

Description and data sources

Variables	Descriptions	Source
GDP growth	GDP growth (annually)	World bank
Greenhouse Gas emissions	Greenhouse Gas emissions (kt)	World bank
ATMs	ATMs per 100,000 adults	IMF
Debit card	Debit card (% age 15+)	IMF
Internet user	Individuals using the internet (% total population	World bank
Industrialization	Industry value added (% of GDP)	World bank
Energy Consumption	Total Energy consumption (btu)	EIA
Foreign Direct Investment	FDI inflows (% of GDP)	World bank
Inflation rate	Consumer prices (annualize)	World bank

Following established procedures, we recognize possible drawbacks, such as missing data for some years or nations, that were handled via interpolation or exclusion. To guarantee dependability, data was subjected to quality checks and validation procedures.

Results and Discussion

The descriptive statistical analysis provides an overview of the variables studied, such as the number of ATM, debit cards (DEBIT), economic growth (GDP), and carbon emissions (GHG). As shown in Table 2, we can infer that GDP has a wide range of values, including a negative mean, showing that certain countries had economic contractions. ATM and DEBIT distributions are more constant, with ATM values suggesting a minor drop in infrastructure, which could correspond to the global trend of migrating to digital payments. GHG (emissions) has a slightly negative skew, indicating that emissions decreases are more prevalent. The FDI (foreign direct investment) and INET (internet) variables have substantial kurtosis, showing big peaks in investment and internet usage across the sample, potentially due to outlier countries in these areas.

Table 2
Statistic Descriptive of The Research Model

Statistic	GDP	GHG	ATM	DEBIT	ENER	INFL	INET	INDS	FDI
Mean	4.311914	4.447635	40.64442	82.16933	9.34816	3.875282	48.93078	35.91488	5.051984
Median	5.073352	4.777214	28.93721	66.76618	9.024746	3.023052	47.6	35.0342	3.486946
Maximum	31.72574	7.090243	114.2714	239.0911	12.0125	31.23013	99	73.67241	34.94852
Minimum	-20.58424	0.648464	0.066486	0.068878	6.849498	-1.469843	0.25	9.137311	-32.95523
Std. Dev.	5.392044	1.749795	30.32167	73.93026	1.468214	4.585235	28.62519	11.7316	7.637163
Skewness	-0.433831	-0.638405	0.73447	0.585948	0.376492	3.182452	0.062289	1.158462	0.734351
Kurtosis	12.15479	2.560816	2.723536	2.106555	2.077346	16.43799	1.893226	5.014216	10.11078
Jarque-Bera	542.6123	11.6984	13.96387	11.94372	9.100597	1418.672	7.959666	60.47837	338.2884

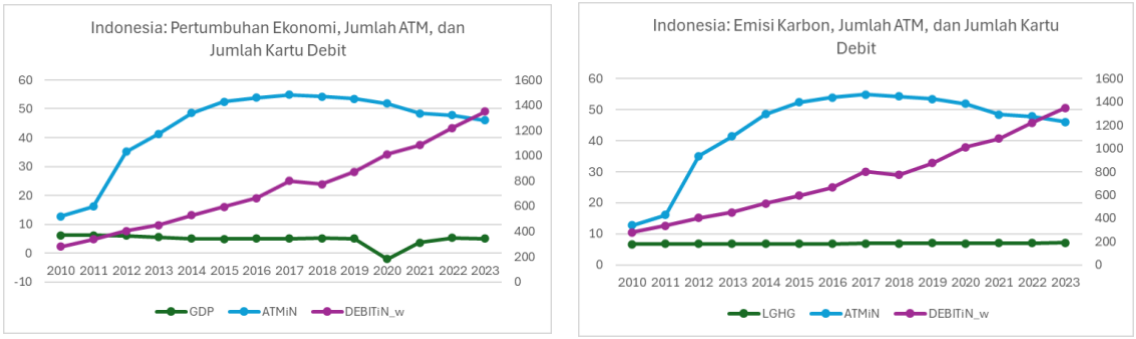
The results of the multicollinearity test, as shown in Table 3, depicts that there are some significant relationships between the independent variables. For example, DEBIT and INET show a high correlation of 0.864 and similarly with INET and DEBIT correlation coefficient (0.821), which could indicate potential multicollinearity that could affect the understanding of the model. However, none of these correlations reach numbers close to 1, so there are no signs of very serious multicollinearity. Nonetheless, attention should be paid to variables that have high correlations to avoid possible distortions in the regression results.

Table 3
Multicollinearity Test of all Variables

	GDP	GHG	ATM	DEBIT	ENER	INFL	INET	INDS	FDI
GDP	1	0.033325	-0.222357	-0.102109	-0.119729	-0.01234	-0.254002	-0.056772	-0.124976
GHG	0.033325	1	0.430677	0.368369	0.271795	-0.080473	0.221213	0.29944	0.043946
ATM	-0.222357	0.430677	1	0.567291	0.654	-0.319302	0.543352	0.263188	0.092283
DEBIT	-0.102109	0.368369	0.567291	1	0.864484	-0.303886	0.821465	0.069909	0.462253
ENER	-0.119729	0.271795	0.654	0.864484	1	-0.228606	0.785275	0.131263	0.526941
INFL	-0.01234	-0.080473	-0.319302	-0.303886	-0.228606	1	-0.204053	-0.081744	-0.0000896
INET	-0.254002	0.221213	0.543352	0.821465	0.785275	-0.204053	1	0.203891	0.320387
INDS	-0.056772	0.29944	0.263188	0.069909	0.131263	-0.081744	0.203891	1	-0.405015
FDI	-0.124976	0.043946	0.092283	0.462253	0.526941	-0.0000896	0.320387	-0.405015	1

The Figure 2 visualizes the plotting of the data, which shows the trend of ATM and debit card within period across countries. GDP has grown modestly and steadily over the years, ATMs peaked rapidly around 2016 before stabilizing, signalling a shift away from traditional infrastructure as digital payment methods gained hold. In contrast, the number of debit cards has constantly climbed, indicating a larger tendency toward digital financial inclusion. This increase in digital payments correlates with a considerable spike in GHG (carbon emissions) beginning around 2016, which parallels the increase in debit card usage, implying that the spread of digital financial services may be associated with increased energy consumption and environmental impact. Despite moderate GDP growth, the rapid rise in GHG emissions underlines the possible environmental difficulties.

Figure 2
Indonesian's Economic Growth and Emission Against ATM and Debit Card



Prior to regression analysis, diagnostic tests for autocorrelation and heteroscedasticity were performed to evaluate the robustness of the econometric models. The Breusch-Pagan test indicated that the GHG model had significant evidence of heteroscedasticity (p-value = 0.0014), suggesting that the error variance was non-constant, whereas the GDP model did not show heteroscedasticity (p-value = 0.0524). Similarly, taken from the Wooldridge test to assess whether any autocorrelation revealed in each model. The result shows no signs of autocorrelation in the GDP model (p-value = 0.1867), while the GHG model exhibited strong evidence of autocorrelation (p-value = 0.0002). These findings highlight the need to address the concerns, particularly in the GHG model, which exhibits both heteroscedasticity and autocorrelation. Statistically, estimation method using Feasible Generalized Least Squares (FGLS) is able to ensure both regression results unbiased and efficient.

Table 4
Breusch-Pagan Test Result for Each Model

Dependent Variable Model	Probability Value (Prob.)	Decision	Result
GDP	0.0524	Reject H_0	No Heteroscedasticity Detected
GHG	0.0014	Accept H_0	Heteroscedasticity Detected

Table 5
Wooldrige Test Result for Each Model

Dependent Variable Model	Probability Value (Prob.)	Decision	Result
GDP	0.0524	Reject H_0	No Heteroscedasticity Detected
GHG	0.0014	Accept H_0	Heteroscedasticity Detected

Based on Table 6, GDP model results indicate that digital financial inclusion variables, ATM and debit card usage, have significant effects on economic growth (GDP). Specifically, the number of debit card has a positive with coefficient 0.025% and significant impact on GDP at the 5% level, while ATM use has a negative impact with coefficient 0.068% that is statistically significant at the 1% level. This indicates that the use of ATMs may impede economic development, whereas the use of debit cards, which is a component of digital financial inclusion, fosters it. However, when authors re-run the data up to 2019, it was found that ATM still made a positive contribution despite the insignificant results obtained. Further control variables demonstrate that energy consumption has a positive but moderate impact on GDP, while internet use has a negative impact on economic development at the 1% significance level. Additionally, Foreign Direct Investment (FDI) has a negative correlation with GDP, which is statistically significant at the 1% level. Nevertheless, variables like inflation (INFL) and industrialization (INDS) have no statistically significant impact on economic growth.

The result implies that economic growth is significantly and favourably impacted by digital financial inclusion, particularly through the usage of debit cards. Using FGLS methods for regression analysis, it discovered that increases in debit card penetration are positively correlated with GDP growth. This confirms the findings of Ozturk and Ullah (2022) and Zhang et al. (2024), which highlight the fact that increased access to digital banking in developing nations improves transaction efficiency, accelerates the flow of money, and increases credit availability. In contrast, the study deviates from the initial assumption and earlier studies that highlighted the essential role of ATMs in financial inclusion, particularly in emerging areas, by finding an unanticipated negative link between ATM density and economic growth (Nwisienyi and Obi, 2020). Research findings conducted by Fernandes, Borges, and Caiado (2021) and Ahyar and Hakim (2022) claimed that digital financial inclusion along with conventional methods (like ATMs and debit cards) tends to experience stagnation when the new technology is offering more efficient user experience. Going to deeper about the debit card use has a more favourable effect than ATM use, it might suggest that debit cards are a more adaptable and popular form of digital financial inclusion, users are still able to have flexible transaction and sequentially this process will contribute to economic growth. On the other hand, ATM usage may point to a reliance on obsolete financial infrastructure in certain areas, which may not offer the same degree of economic interaction as more modern digital payment methods.

Previous research (Kulindwa 2023) showed that energy consumption has a mild but positive effect on GDP, particularly in developing countries linked to industrialization and

technology growth. Unexpectedly, increased internet use can negatively impact economic development, suggesting issues like digital inequality or poor infrastructure as also mentioned by Maurseth (2018). This study also finds a negative link between Foreign Direct Investment (FDI) and GDP in the ASEAN region, hinting at inefficiencies in how FDI is utilized. Lastly, the minor effects of inflation and industrialization on growth underscore the complexity of these factors in developing economies.

Table 6
Regression Result of GDP Model

	GDP	**GHG**
ATM	-0.068***	0.028***
	(0.020)	(0.006)
DEBIT	0.025*	0.020***
	(0.013)	(0.004)
ENER	1.500**	-0.736***
	(0.744)	(0.222)
INET	-0.112***	-0.023***
	(0.029)	(0.008)
INDS	0.109	0.071***
	(0.082)	(0.017)
FDI	-0.261***	0.038*
	(0.101)	(0.022)
INFL	-0.043	0.062**
	(0.109)	(0.031)
r^2	0.373	0.465

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Refer to the result from GHG or carbon emissions model, it shows that debit cards (coefficient = 0.02% significant at 1%) and ATMs (coefficient = 0.028% significant at 1%) are both positively correlated with carbon emissions, suggesting that increased digital financial inclusion is associated with greater environmental impact. This result indicates that although digital financial services increase access to formal financial systems, they may also result in greater carbon emissions. Other variables in the models, energy consumption (ENER) and internet penetration (INET) negatively correlated with emissions, while industrialization (INDS) and foreign investment (FDI) showed positive associations.

Hypothetically, digital financial inclusion should improve environmental sustainability by lowering carbon emissions through increasing of efficiency in financial transactions (Renzhi and Baek 2020). However, as measured by the number of ATMs and debit cards, the regression findings indicate that digital financial inclusion has a substantial positive influence on carbon emissions in ASEAN zone. One of the reasons is the increasing in access to digital financial services leads to greater economic activity and energy usage, which in turn raises emissions. These findings are written by Fareed et al. (2022) and Shahbaz et al. (2022), who point out that growth in the financial sector tends to exacerbate manufacturing and industrialization, which are major contributors to carbon emissions. Previous research (Bajwa et al. 2025) also found that even though debit cards and ATMs

could support economic growth in ASEAN, but its increase carbon emissions due to energy use. Furthermore, cards cause more emissions than ATMs because they have more transactions and higher energy-use devices as written in Smartgreenpost. Debit cards contribute to emissions from standby energy and manufacturing, while ATMs require more energy for cooling and cash transport. Although both promote financial inclusion, debit cards have a larger impact on carbon emissions.

Regarding the control variables, this study also suggests that more energy and internet access may lead to lower carbon emissions, it means that ASEAN is already started to have better technology and cleaner energy (IRENA and ACE 2022). In contrast, industrialization and foreign direct investment are associated with higher emissions and it becomes main challenge happened across developing countries. This is due to increased production demands and the need for stronger environmental regulations to mitigate environmental harm from industrial growth.

Overall, the results show that while digital financial inclusion can support economic growth (accept H_1). However, in Southeast Asia, it still poses an environmental problem through increased carbon emissions (reject H_2). Referring to the Kuznets Curve, it might conclude that ASEAN is still in developing phase meaning with the current economic level has not been able to raise awareness of environmental sustainability.

Conclusion

Using FGLS method, this study emphasizes the vital importance of including digital finance in supporting economic development and tackling environmental sustainability issues in ASEAN nations. It demonstrated how developments in financial technology, like debit cards and ATMs, have enhanced access to financial services. The findings show that while digital financial inclusion can support economic growth. Through debit card usage, it performs a positive effect on economic growth, indicating that increased access to digital banking can drive economic activities and open doors for individuals and small businesses. Conversely, the correlation between ATMs and GDP was surprisingly negative, suggesting a transition away from conventional ATM systems towards more advanced digital payment solutions.

Regarding environmental sustainability, the results differed from the initial expectation. The study finds that in Southeast Asia are still poses an environmental problem through increased carbon emissions. Both debit cards and ATMs showed a positive correlation with carbon emissions, suggesting that the growth of digital financial services could lead to higher energy consumption and increased demand for energy-heavy products. Referring to the Kuznets Curve, the economic decoupling will be formed where the country's awareness of environmental sustainability will begin to increase as the country progresses, however ASEAN has not yet progressed to that stage. The government and ASEAN organization need to prepare this according to the agreement of the world countries in the COP.

The results of this study lead to suggestions for future research to improve the discourse and increase the academic and practical value. Based on the findings, authors are recommended that ASEAN integrate green financial into the design of criteria and

implementation of digital financial services. It can be achieved by incentivizing the adoption of eco-friendly technologies within financial transactions and encouraging the development of sustainable fintech innovations. For further support, the establishment of a regional framework for green fintech development within ASEAN will be favourable. Such a framework could foster collaboration among member to harmonize regulations and promote investments in sustainable financial technologies. By prioritizing support for startups and financial institutions that align their digital offerings with sustainability objectives, this initiative is able not only drive economic growth but also contribute to environmental protection. Ultimately, this approach has the potential to position ASEAN as a leader in sustainable fintech innovation while addressing the dual challenges of fostering economic development and mitigating environmental damage.

Reference

Ahyar, Muhammad Khozin, and Abdul Hakim. 2022. "Affecting Financial Inclusion Toward Third Deposit Funds of Islamic Banking Indonesia." *Journal of Finance and Islamic Banking* 4(2):1–21. doi:10.22515/jfib.v4i2.2658.

Amaliah, Ima, Qaisar Ali, Oktofa Yudah Sudrajad, Sulistya Rusgianto, Harist Nu'man, and Tasya Aspiranti. 2024. "Does Digital Financial Inclusion Forecast Sustainable Economic Growth? Evidence from an Emerging Economy." *Journal of Open Innovation: Technology, Market, and Complexity* 10(2):100262. doi:https://doi.org/10.1016/j.joitmc.2024.100262.

ASEAN. 2023. *Advancing Digital Financial Inclusion in ASEAN Policy and Regulatory Enablers*.

ASEAN. 2024. "Implications of Energy Transition to ASEAN Trade in Critical Minerals." *ASEAN Statistical Brief – Vol 10 (July 2024)* 10(July):2024.

Azoulay, Mark, Alessandro Casoli, Thomas Kansy, Daniel Mikkelsen, Munya Muvezwa, Daniel Stephens, Sophie Underwood, Shally Venugopal, and Dee Yang. 2022. *Managing Financed Emissions: How Banks Can Support the Net-Zero Transition*.

Bajwa, Farooq Ahmad, Jingtao Fu, Ishtiaq Ahmad Bajwa, Manzar Rehman, and Karim Abbas. 2025. "Digital Financial Inclusion and Its Dual Impact on Economic and Environmental Outcomes in ASEAN Countries." 5(October 2024):53–75. doi:10.3934/DSFE.2025004.

Bank Indonesia. 2014. *Digital Financial Inclusion In Indonesia*.

Beck, Thorsten, Asl1 Demirgüç-Kunt, and Ross Levine. 2004. "Finance , Inequality and Poverty: Cross-Country Evidence." *World Bank Policy Research Working Paper 3338,*.

Chibba, Michael. 2009. "Financial Inclusion, Poverty Reduction and the Millennium Development Goals." *The European Journal of Development Research* 21:213–30. doi:10.1057/ejdr.2008.17.

Demirguc-Kunt, Asli, Leora Klapper, and Dorothe Singer. 2017. "Financial Inclusion and Inclusive Growth: A Review of Recent Empirical Evidence." *Financial Inclusion and Inclusive Growth: A Review of Recent Empirical Evidence* (April). doi:10.1596/1813-9450-8040.

Fareed, Zeeshan, Mubeen Abdur Rehman, Tomiwa Sunday Adebayo, Yihan Wang, Munir Ahmad, and Farrukh Shahzad. 2022. "Financial Inclusion and the Environmental Deterioration in Eurozone: The Moderating Role of Innovation Activity." *Technology in Society* 69. doi:10.1016/j.techsoc.2022.101961.

Fernandes, Carla, Maria Rosa Borges, and Jorge Caiado. 2021. "The Contribution of Digital Financial Services to Financial Inclusion in Mozambique: An ARDL Model Approach." *Applied Economics* 53(3):400 – 409. doi:10.1080/00036846.2020.1808177.

Hafeez, Muhammad, Saif Ur Rehman, C. M. Nadeem Faisal, Juan Yang, Sana Ullah, Md Abdul Kaium, and Muhammad Yousaf Malik. 2022. "Financial Efficiency and Its Impact on Renewable Energy Demand and CO2 Emissions: Do Eco-Innovations Matter for Highly Polluted Asian Economies?" *Sustainability (Switzerland)* 14(17). doi:10.3390/su141710950.

Hasan, Mostofa Mahmud, Md Abu Sayem, and BM Sajjad Hossain. 2024. "Resolving the Paradox: How Mobile Money Drives Economic Growth through Financial Inclusion." *Heliyon* 10(19). doi:10.1016/j.heliyon.2024.e38755.

Hidthiir, Mohammad Helmi bin, Zaki Ahmad, Mohd Zukime Mat Junoh, and Mohd Faizal Bin Yusof. 2024. "Dynamics of Economic Growth in ASEAN-5 Countries: A Panel ARDL Approach." *Discover Sustainability* 5(1). doi:10.1007/s43621-024-00351-x.

Hojnik, Jana, and Mitja Ruzzier. 2016. "The Driving Forces of Process Eco-Innovation and Its Impact on Performance: Insights from Slovenia." *Journal of Cleaner Production* 133. doi:10.1016/j.jclepro.2016.06.002.

IRENA, and ACE. 2022. *Renewable Energy Outlook for ASEAN towards a Regional Energy Transition*.

Jahanger, Atif, and Muhammad Usman. 2023. "Investigating the Role of Information and Communication Technologies, Economic Growth, and Foreign Direct Investment in the Mitigation of Ecological Damages for Achieving Sustainable Development Goals." *Evaluation Review* 47(4):653–79. doi:10.1177/0193841X221135673.

Khan, Nasir, Mahwish Zafar, Abiodun Funso Okunlola, Zeman Zoltan, and Magda Robert. 2022. "Effects of Financial Inclusion on Economic Growth, Poverty, Sustainability, and Financial Efficiency: Evidence from the G20 Countries." *Sustainability* 14(19):12688.

Kien, Pham Van, Jenho Peter Ou, Dr Muhammad Sadiq, Tran Thai Ha Nguyen, Pham Quang Huy, and Trung Kien Tran. 2023. "What Role Financial Inclusion, Green Trade and Natural Resources Utilization Play in ASEAN Economic Growth: Evidence from Post COVID Era." *Resources Policy* 85:103884. doi:https://doi.org/10.1016/j.resourpol.2023.103884.

Kim, Jong-Hee. 2016. "A Study on the Effect of Financial Inclusion on the Relationship Between Income Inequality and Economic Growth." *Emerging Markets Finance and Trade* 52(2):498–512. doi:10.2307/26752364.

Kodan (Kablana), Anand S., and Kuldip S. Chhikara. 2013. "A Theoretical and Quantitative Analysis of Financial Inclusion and Economic Growth." *Management and Labour Studies* 38(1–2):103–33. doi:10.1177/0258042X13498009.

Kouladoum, Jean-Claude, Muhamadu Awal Kindzeka Wirajing, and Tii N. Nchofoung. 2022. "Digital Technologies and Financial Inclusion in Sub-Saharan Africa." *Telecommunications Policy* 46(9):102387. doi:https://doi.org/10.1016/j.telpol.2022.102387.

Kulindwa, Yusuph John. 2023. "Energy Consumption and Economic Growth: A Panel Causal Analysis for East African Sub-Region." *SSRN*.

Le, Thai-Ha, Anh Tu Chuc, and Farhad Taghizadeh-Hesary. 2019. "Financial Inclusion and Its Impact on Financial Efficiency and Sustainability: Empirical Evidence from Asia." *Borsa Istanbul Review* 19(4):310 – 322. doi:10.1016/j.bir.2019.07.002.

Liu, Yang, Lin Luan, Weilong Wu, Zhiqiang Zhang, and Yen Hsu. 2021a. "Can Digital Financial Inclusion Promote China's Economic Growth?" *International Review of Financial Analysis* 78. doi:10.1016/j.irfa.2021.101889.

Liu, Yang, Lin Luan, Weilong Wu, Zhiqiang Zhang, and Yen Hsu. 2021b. "Can Digital Financial Inclusion Promote China's Economic Growth?" *International Review of Financial Analysis* 78. doi:10.1016/j.irfa.2021.101889.

Malarvizhi, Chinnasamy Agamudai Nambhi, Yashar Zeynali, Abdullah Al Mamun, and Ghazali Bin Ahmad. 2019. "Financial Development and Economic Growth in ASEAN-5 Countries." *Global Business Review* 20(1):57–71. doi:10.1177/0972150918802684.

Maria, Rebecca Sta, Shujiro Urata, and Ponciano S. Intal Jr. 2017. *The ASEAN Economic Community Into 2025 and Beyond*. Vol. 5.

Maurseth, Per Botolf. 2018. "The Effect of the Internet on Economic Growth: Counter-Evidence from Cross-Country Panel Data." *Economics Letters* (172):74–77.

Mazzai, Alessandra. 2022."Decoupling (Emissions from Economic Growth)." https://www.climateforesight.eu/seeds/decoupling-emissions-from-economic-growth/.

Menyelim, Chima M., Abiola A. Babajide, Alexander E. Omankhanlen, and Benjamin I. Ehikioya. 2021. "Financial Inclusion, Income Inequality and Sustainable Economic Growth in Sub-Saharan African Countries." *Sustainability* 13(4). doi:10.3390/su13041780.

Nwisienyi, Kenechukwu J., and Onyeka A. Obi. 2020. "An Analysis of Financial Inclusion and Economic Growth in Nigeria; An ARDL Approach." *International Journal of Research and Innovation in Social Science* 4(10):126–34.

Ozili, Peterson K. 2018. "Impact of Digital Finance on Financial Inclusion and Stability." *Borsa Istanbul Review* 18(4):329 – 340. doi:10.1016/j.bir.2017.12.003.

Ozturk, Ilhan, and Sana Ullah. 2022. "Does Digital Financial Inclusion Matter for Economic Growth and Environmental Sustainability in OBRI Economies? An Empirical Analysis." *Resources, Conservation and Recycling* 185. doi:10.1016/j.resconrec.2022.106489.

Pramaswara, Muhammad Alifanda. 2023. "Pengaruh Inklusi Keuangan Di Era Ekonomi Digital Dalam Meningkatkan Pertumbuhan Ekonomi." *Journal of Development Economic and Social Studies* 2 No.1. doi:https://doi.org/10.21776/jdess.2023.02.1.19.

Rasjid, Arsjad. 2023."The ASEAN Region Is the World's Economic Dark Horse. Here's Why." https://www.weforum.org/stories/2023/08/asean-economic-growth/.

Regan, Sue., and Will. Paxton. 2003. *Beyond Bank Accounts : Full Financial Inclusion*. Institute for Public Policy Research : National Association of Citizens Advice Bureaux.

Renzhi, Nuobu, and Yong Jun Baek. 2020. "Can Financial Inclusion Be an Effective Mitigation Measure? Evidence from Panel Data Analysis of the Environmental Kuznets Curve." *Finance Research Letters* 37:101725. doi:10.1016/j.frl.2020.101725.

Ritchie, Hannah. 2021."Many Countries Have Decoupled Economic Growth from CO2 Emissions, Even If We Take Offshored Production into Account." https://ourworldindata.org/co2-gdp-decoupling.

Sarkar, Md Sujahangir Kabir, Md Nazirul Islam Sarker, Sumaiya Sadeka, Isahaque Ali, and Abul Quasem Al-Amin. 2024. "Comparative Analysis of Environmental Sustainability Indicators: Insights from Japan, Bangladesh, and Thailand." *Heliyon* 10(13):e33362. doi:10.1016/j.heliyon.2024.e33362.

Scholnick, Barry, Nadia Massoud, Anthony Saunders, Santiago Carbo-Valverde, and Francisco Rodríguez-Fernández. 2008. "The Economics of Credit Cards, Debit Cards and ATMs: A Survey and Some New Evidence." *Journal of Banking and Finance* 32(8):1468–83. doi:10.1016/j.jbankfin.2007.05.001.

Shahbaz, Muhammad, Jiaman Li, Xiucheng Dong, and Kangyin Dong. 2022. "How Financial Inclusion Affects the Collaborative Reduction of Pollutant and Carbon Emissions: The Case of China." *Energy Economics* 107. doi:10.1016/j.eneco.2022.105847.

Tay, Lee-Ying, Hen-Toong Tai, and Gek-Siang Tan. 2022a. "Digital Financial Inclusion: A Gateway to Sustainable Development." *Heliyon* 8(6). doi:10.1016/j.heliyon.2022.e09766.

Tay, Lee-Ying, Hen-Toong Tai, and Gek-Siang Tan. 2022b. "Digital Financial Inclusion: A Gateway to Sustainable Development." *Heliyon* 8(6). doi:10.1016/j.heliyon.2022.e09766.

Van, Loan Thi-Hong, Anh The Vo, Nhan Thien Nguyen, and Duc Hong Vo. 2021a. "Financial Inclusion and Economic GROWTH: An International Evidence." *Emerging Markets Finance and Trade* 57(1):239–63. doi:10.1080/1540496X.2019.1697672.

Van, Loan Thi-Hong, Anh The Vo, Nhan Thien Nguyen, and Duc Hong Vo. 2021b. "Financial Inclusion and Economic GROWTH: An International Evidence." *Emerging Markets Finance and Trade* 57(1):239–63. doi:10.1080/1540496X.2019.1697672.

Wang, Jianda, Kangyin Dong, Xiucheng Dong, and Farhad Taghizadeh-Hesary. 2022. "Assessing the Digital Economy and Its Carbon-Mitigation Effects: The Case of China." *Energy Economics* 113. doi:10.1016/j.eneco.2022.106198.

Wang, Xiong, Xiao Wang, Xiaohang Ren, and Fenghua Wen. 2022. "Can Digital Financial Inclusion Affect CO2 Emissions of China at the Prefecture Level? Evidence from a Spatial Econometric Approach." *Energy Economics* 109. doi:10.1016/j.eneco.2022.105966.

Wibowo, Muhammad Yusuf Perkasa, and Jaka Sriyana. 2024. "Does Financial Inclusion Increase MSME Financing at Islamic Banks During Covid 19?" *Journal of Finance and Islamic Banking* 7(1):1–14.

Zaidi, Syed Anees Haider, Muzzammil Hussain, and Qamar Uz Zaman. 2021. "Dynamic Linkages between Financial Inclusion and Carbon Emissions: Evidence from Selected OECD Countries." *Resources, Environment and Sustainability* 4:100022. doi:https://doi.org/10.1016/j.resenv.2021.100022.

Zhang, Dongyang, Muhammad Mohsin, and Farhad Taghizadeh-Hesary. 2022. "Does Green Finance Counteract the Climate Change Mitigation: Asymmetric Effect of Renewable Energy Investment and R&D." *Energy Economics* 113. doi:10.1016/j.eneco.2022.106183.

Zhang, Yuxi, Adrian (Wai Kong) Cheung, and Xiaodong Qu. 2024. "Can Digital Financial Inclusion Promote the Coupling Coordination between Pollution Reduction and Low-Carbon Development? Evidence from China." *Economic Analysis and Policy* 82:1113–30. doi:10.1016/j.eap.2024.05.007.

Zhu, Huiming, Lijun Duan, Yawei Guo, and Keming Yu. 2016. "The Effects of FDI, Economic Growth and Energy Consumption on Carbon Emissions in ASEAN-5: Evidence from Panel Quantile Regression." *Economic Modelling* 58:237–48. doi:https://doi.org/10.1016/j.econmod.2016.05.003.