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Delving into the green growth dilemma and ESG investing in Southeast Asia

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This academic study examines the connection between ESG (Environmental, Social, and Governance) investing and green growth advancement in Southeast Asia, highlighting the region's susceptibility to environmental pollution. ESG investing proves to be an effective policy tool for sustainability, with a 1% increase in environmental investment linked to a 0.56% rise in the Green Growth Index. However, GDP growth negatively affects the index, indicating a need to harmonize economic and sustainable development goals. Additionally, larger populations and more registered vehicles hinder green growth, requiring detailed policy measures. Internet connection speed has minimal impact. To promote green growth, Southeast Asian nations should prioritize ESG investing, create transparent policies, offer tax incentives, and partner with financial institutions. Policies must aim to separate GDP growth from environmental harm, support sustainable development, and address population and vehicle-related issues through strategic urban planning. While internet speed's effect is negligible, advancing digitalization is crucial for sustainability via improved technology infrastructure and digital literacy programs.

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Introduction

The green growth dilemma refers to the global commitment to tackling environmental pollution and climate change challenges (Ye and Rasoulinezhad 2023; Yu et al. 2023). Although nations worldwide have pledged to adopt sustainable practices and promote green growth, progress toward these environmental goals has been slow (Capasso et al. 2019; Jiang et al. 2023). Despite recognizing the urgent need for transformative actions, many countries struggle to balance economic development with environmental sustainability. As argued by Straka et al. (2020), Phung et al., (2023), Li et al. (2023), Rasoulinezhad and Eksi (2024), Yu et al. (2024), and Ashfaq et al. (2024), the main challenge is implementing effective policies and initiatives that support economic growth while considering ecological impacts.

Environmental, Social, and Governance (ESG) investing is crucial for driving the transition towards green growth. According to Wang et al. (2024) and Feng and Yuan (2024), this investment approach integrates sustainability factors into decision-making, motivating businesses to adopt environmentally responsible practices, maintain social standards, and demonstrate strong governance. By including ESG criteria in investment strategies, capital flows to companies that prioritize environmental stewardship, social responsibility, and ethical governance. This not only aligns investment portfolios with sustainable values but also influences corporate behavior, positively impacting the broader economy (Wang et al. 2024). Qian and Yu (2024) and Tan et al. (2024) argue that ESG investing accelerates green growth by channeling financial resources to enterprises committed to sustainable practices, promoting a quicker transition to a more environmentally conscious and socially responsible global economy.

In pursuit of the transition to a sustainable, net-zero emissions, and resilient world within this decade, a significant increase in climate investment is imperative. Notably, global investment in the low-carbon energy transition reached a substantial $755 billion in 2021, reflecting a considerable commitment to cleaner and more sustainable energy sources. Furthermore, the energy sector is poised for a substantial boost, with annual global energy investment projected to rise to USD 1.9 trillion in 2021, marking a nearly 10% rebound from the previous year. The urgency of addressing environmental challenges is underscored by the need for a substantial investment of USD 8.1 trillion in nature by 2050 to combat the environmental pollution crisis (UN 2021). In the shorter term, countries are called upon to mobilize an annual green investment of $5 trillion by 2025 to expedite progress towards sustainable development goals (OECD 2021). Notably, Environmental, Social, and Governance (ESG) funds have gained prominence, now constituting 10% of worldwide fund assets. These statistics illuminate the increasing momentum and financial commitment toward building a more environmentally conscious and sustainable global future (Egorova et al. 2022; Chen et al. 2023; Andrey 2023).

Southeast Asia holds significant importance in the pursuit of green growth goals and Environmental, Social, and Governance (ESG) investing for several compelling reasons. Firstly, the region is home to diverse ecosystems, including vital rainforests and marine environments, making it crucial for global biodiversity conservation efforts. Addressing environmental challenges in Southeast Asia is pivotal for mitigating the impacts of climate change and preserving unique ecosystems. Secondly, rapid urbanization and industrialization in the region present both challenges and opportunities (Liu et al. 2023). By incorporating sustainable practices and ESG principles into these developmental processes, Southeast Asian nations can contribute substantially to global efforts in reducing carbon emissions and fostering environmentally responsible economic growth (Zhang and Lau 2022). Additionally, the region's burgeoning population and rising middle class create a substantial market for sustainable technologies and products. Investors focusing on ESG criteria recognize the potential for positive impact and financial returns in supporting green initiatives in Southeast Asia.

This paper aims to thoroughly examine the effects of Environmental, Social, and Governance (ESG) investing on the green growth trajectory of Southeast Asia. The central research question is: How does ESG investing influence and contribute to the advancement of sustainable and environmentally responsible economic development in Southeast Asian nations? By analyzing ESG investment trends, policy frameworks, and corporate practices in the region, the paper seeks to illuminate how ESG principles are shaping and influencing green growth in Southeast Asia. The primary contributions of this research are in offering a comprehensive understanding of the relationship between ESG investing and the sustainable development goals of Southeast Asian countries.

The primary method employed in this research to investigate the impacts of Environmental, Social, and Governance (ESG) investing on the green growth of Southeast Asia is the utilization of panel data analysis. By utilizing panel data, this study aims to provide a comprehensive and dynamic perspective, considering both cross-sectional and time-series variations in the data. The application of panel data methodology allows for a more nuanced examination of the relationship between ESG investing and green growth indicators across different countries in Southeast Asia over a specified period. However, it is crucial to acknowledge a key limitation inherent in this research. The primary constraint lies in the unavailability of certain data points, which may pose challenges in achieving a fully exhaustive analysis. Despite efforts to gather comprehensive datasets, the study recognizes the potential gaps in information that may influence the depth and precision of the findings.

This paper is structured to provide a comprehensive exploration of the impacts of Environmental, Social, and Governance (ESG) investing on the green growth of Southeast Asia. Section 2 delves into a thorough literature review, offering insights into the existing body of knowledge on ESG investing, green growth, and their interplay, with a particular focus on relevant studies within the Southeast Asian context. In Section 3, the theoretical background is outlined, presenting the conceptual framework that underpins the research and providing a theoretical lens through which the subsequent empirical analysis will be conducted. Section 4 details the research methodology, elucidating the use of panel data analysis to examine the relationship between ESG investing and green growth in Southeast Asia. Section 5 presents the findings derived from the empirical analysis, offering a nuanced understanding of the observed patterns and relationships. Finally, in Section 6, the paper concludes by synthesizing the key findings, discussing their implications, and providing recommendations for future research.

Literature review

In this section, a review of pertinent literature is presented, organized into specific categories as outlined below:

Greening economic growth. Several previous studies, such as those by Rasoulinezhad (2020), Yoshino et al., (2021), Rasoulinezhad and Taghizadeh-Hesary (2022), Fang et al. (2022), Taghizadeh-Hesary et al., (2022), Liu et al. (2023), and Feng and Liu (2023), have extensively explored the connection between green economic growth and sustainable development, revealing

the complex relationships between environmentally responsible practices and economic prosperity. Xu et al. (2022), and Zhao and Rasoulinezhad (2023) conducted pioneering research that emphasized the economic rationale for tackling climate change, highlighting the potential co-benefits of ecological preservation and economic progress. Additionally, Houssam et al. (2023) examined the crucial role of ecosystem services in supporting economic activities. Furthermore, Ashfaq et al. (2024) investigated the long-term impacts of environmental policies on economic productivity.

ESG investing and sustainability. Numerous scholarly inquiries have explored the domain of ESG (Environmental, Social, and Governance) investing, examining its complex relationship with sustainability. Noteworthy studies have assessed the effectiveness of ESG criteria in promoting sustainable business practices and their impact on long-term financial performance. For instance, Jong and Rocco (2022), Chen et al., (2023) and Parikh et al. (2023) analyzed the connection between corporate sustainability performance and financial valuation. Additionally, Jong and Rocco (2022), and Ahmad et al. (2024) provided a comprehensive review of the evolving landscape of ESG investing and its influence on corporate decision-making. Allred (2020), Jonsdottir et al., (2022), and Huang (2024) also investigated the financial implications of integrating ESG factors into investment portfolios.

Southeast Asian countries and green context. Numerous studies have focused on Southeast Asian countries within the context of environmental sustainability and green initiatives, examining the unique challenges and opportunities presented by this region. Scholars have explored the environmental policies, conservation efforts, and sustainable development strategies undertaken by Southeast Asian nations. For instance, Bai et al., (2023)analyzed the environmental Kuznets curve for selected Southeast Asian countries, investigating the relationship between economic growth and environmental degradation. Furthermore, Lei et al., (2023) studied mitigation relationship with governance, energy innovation and environmental innovations across Southeast Asia. Additionally, Lai et al., (2023) examined the role of government policies in promoting sustainable development through green building technologies in the region.

Research hypothesis and novelties. The research hypothesis underlying this paper posits that there exists a significant relationship between Environmental, Social, and Governance (ESG) investing and the green growth trajectory of Southeast Asian countries. The investigation centers on discerning the specific mechanisms through which ESG principles influence and contribute to sustainable economic development within the Southeast Asian context. The novelty of this research lies in its endeavor to bridge the gap in understanding the intricate dynamics between ESG investing and green growth in a region marked by diverse economies, cultures, and environmental challenges. By scrutinizing the empirical evidence derived from panel data analysis, the paper aims to unveil the nuanced ways in which ESG practices intersect with and potentially shape the environmental sustainability initiatives of Southeast Asian nations.

Theoretical discussion

Southeast Asia is a significant contributor to global environmental pollution, with carbon dioxide emissions rising rapidly between 1990 and 2010, outpacing any other region. In 2021, Indonesia alone produced the highest CO2 emissions in Southeast Asia, at approximately 619 million metric tons (Liu et al., 2023). The region's share of global energy-related CO2 emissions increased from 2.8% in 1990 to 6.5% in 2020 (Nikkei Asia, 2023). Despite the potential for green growth, Southeast Asia faces considerable challenges in transitioning to a sustainable energy landscape. Renewable sources like wind and solar are expected to meet at least 31% of national energy needs by 2030, and the region's renewable energy potential is estimated to be 40 to 50 times the current electricity generation. However, several impediments exist. Weak medium-term decarbonization policies undermine emission reduction efforts, coal power dependency complicates the transition, and incomplete electricity system reforms create bottlenecks, hindering the smooth integration of renewable energy into the power grid.

ESG (Environmental, Social, and Governance) investing holds substantial potential to drive green growth in Southeast Asia by addressing several pressing regional challenges. Firstly, by directing capital toward companies dedicated to sustainable practices, ESG investing fosters environmentally friendly methodologies. This financial backing incentivizes businesses to implement advanced, eco-friendly technologies and sustainable operational models, aiding the transition away from carbon-intensive practices and bridging the gaps in medium-term decarbonization strategies. Moreover, ESG principles encompass not only environmental aspects but also social and governance factors, ensuring that investments yield benefits for local communities. This multifaceted approach helps reduce dependency on coal power by promoting the development of cleaner, more equitable energy solutions that address both ecological and social needs.

Additionally, ESG investing enhances transparency and accountability within corporate governance, catalyzing comprehensive reforms in electricity systems that prioritize sustainability. This improved oversight can lead to more responsible energy production and consumption practices, ultimately supporting broader environmental goals. Lastly, by fostering international cooperation, ESG investments can facilitate the expansion of global electrical grids, enabling the efficient cross-border transfer of renewable energy.

Research material and model

This academic research endeavors to delve into the intricate relationship between ESG (Environmental, Social, and Governance) investing and green growth in Southeast Asian countries. The imperative for undertaking this study lies in the region's susceptibility to environmental pollution, emphasizing the critical need for sustainable practices. ESG investing emerges as a potentially efficient policy instrument for Southeast Asian nations to progress toward sustainability targets. The empirical analysis focuses on a sample of seven Southeast Asian countries—Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam—spanning from 2005 to 2020. Notably, data limitations restrict the inclusion of other regional countries. The dependent variable, the green growth index, amalgamates OECD Green Growth Indicators encompassing environmental and resource productivity, natural asset base, environmental dimensions of quality of life, and technology and innovation patents. The explanatory variable is environmental investment, acting as a proxy for ESG investing, drawn from OECD, ADB Data Library, and ESCAP online database. Controlling for the relationship between dependent and explanatory variables, GDP growth, population size, the number of registered vehicles, and internet connection speed are selected. Table 1 provides detailed information about these variables. This research aspires to contribute valuable insights into the nexus between ESG investing and green growth, offering a foundation for informed policy decisions in the context of Southeast Asia's sustainable development.

Table 1 Outline of variables in the research model.

Variable	Definition	Abbreviation	Role in model	Sources of data
Green growth index	A composite measure incorporating OECD Green Growth Indicators, including environmental and resource productivity, natural asset base, environmental dimensions of quality of life, and technology and innovation patents.	GGINDEX	Dependent variable	Geometric average of data from OECD (https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH)
Environmental Investment	Proxy for ESG investing, reflecting financial commitments to environmental initiatives	EIN	Explanatory variable	OECD, ADB Data Library, ESCAP online database
GDP growth	Annual growth rate of the Gross Domestic Product (GDP) as a measure of economic performance.	GDPG	Controlling variable	World Bank Open Database
Population size	Total population of the respective Southeast Asian country	POPS		World Bank
Number of registered vehicles	Total count of registered vehicles, indicating transportation-related environmental impact.	REGV		World Bank, National Transport Authorities
Internet Connection Speed	The speed of internet connections, reflecting technological infrastructure.	INSP		ITU, National Telecom Authorities

Source: Researcher.

Table 2 Descriptive statistics of the variables.

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
Green growth index	112	26.43	14.65	12.35	47.44
Environmental Investment	112	132455.6	124.366	9323.566	298775.46
GDP growth	112	4.35	9.744	1.176	12.657
Population size	112	54665432.34	1324.67	3445634.67	122396007.50
Number of registered vehicles	112	1342254.54	546.533	7657444.34	1767844.560
Internet Connection Speed	112	36.53	13.253	27.68	284.13

Source: Researcher.

Table 2 presents the descriptive statistics for the variables. The data shows that the green growth index has an average value of 26.4 from 2005 to 2020, with Singapore having the highest value of 47.44 and Cambodia the lowest at 12.35. Among the variables, GDP growth exhibits the smallest standard deviation, indicating a notable consistency in GDP growth rates across the Southeast Asian countries in the sample.

The projected impact of key variables on the Green Growth Index within this research model can be clarified by detailing their specific roles and expected contributions. Each variable's influence is based on its function in the model and its potential to affect the green growth trajectory in Southeast Asian countries. By examining the roles of Environmental Investment, GDP Growth, Population Size, Number of Registered Vehicles, and Internet Connection Speed, this research seeks to unravel the complex relationships that shape the region's sustainable development landscape. Careful consideration of these variables and their interactions is essential for building a comprehensive understanding of the factors influencing green growth in Southeast Asia.

Environmental Investment, serving as a surrogate for ESG (Environmental, Social, and Governance) investing, is anticipated to exhibit a positive correlation with the Green Growth Index in this research model. The expectation is rooted in the premise that a heightened commitment to environmental initiatives, as reflected through substantial environmental investments, will yield positive outcomes for the overall green growth agenda. Countries demonstrating a stronger dedication to environmentally conscious practices and sustainable development through strategic financial commitments are likely to experience favorable impacts on their Green Growth Index. This positive association signifies that as investments in environmental initiatives increase, the potential for achieving sustainable growth outcomes, encompassing aspects such as resource efficiency, conservation, and innovation, is expected to amplify.

Similarly, the expected positive impact of GDP growth on the Green Growth Index is rooted in the premise that a burgeoning economy is likely to foster increased investments in sustainable practices and technologies. Economic growth provides nations with the financial resources and capabilities to allocate funds towards environmental conservation, renewable energy projects, and the implementation of eco-friendly technologies. The positive correlation anticipates that as the economy expands, there will be a parallel commitment to adopting and innovating sustainable solutions, contributing positively to the overall green growth agenda. This expectation aligns with the idea that economic prosperity and environmental sustainability can coexist synergistically, with robust GDP growth serving as a facilitator for the integration of eco-friendly initiatives and practices in the developmental agenda of Southeast Asian countries.

Population size might exhibit a mixed impact, where larger populations could lead to higher resource consumption but might also drive innovation and sustainable development efforts. Conversely, the anticipated negative influence of the Number of Registered Vehicles on the Green Growth Index stems from the inherent environmental ramifications associated with heightened vehicular activity. As the number of registered vehicles increases, so does the potential for elevated levels of air pollution, carbon emissions, and other adverse environmental effects. The negative correlation underscores the environmental challenges posed by a surge in vehicular density, which may counteract the positive strides towards sustainability. It suggests that despite economic

Table 3 Estimation process.

Estimation step	Methodology	Description
1. Slope Homogeneity	Pesaran and Yamagata (2008)	Examination of panel's slope homogeneity status.
2. Cross-Sectional Dependency	Pesaran (2021) Statistic	Evaluation of interconnectedness among Southeast Asian countries.
3. Series Stationarity	CADF (Pesaran 2007)	Assessment of the stationarity status of the series.
4. Long-Term Nexus	Westerlund (2007) Method	Investigation into the long-term relationships between variables.
5. Cointegration Estimation	CUP-FM Approach	Utilization of the Continuously Updated Fully Modified approach for cross-sectional panel cointegration estimation.
6. Robustness Analysis	Alternative Estimators	Post-estimation assessment through Fully Modified OLS and CUP-BC (Continuously Updated Bias-Corrected) to ensure reliability and generalizability of findings.

Source: Researcher.

growth and technological advancements, the environmental toll of a burgeoning fleet of registered vehicles could pose a significant obstacle to achieving a green and sustainable trajectory in the Southeast Asian context

Finally, the expected positive relationship between Internet Connection Speed and the Green Growth Index is underpinned by the notion that advanced technological infrastructure fosters enhanced efficiency and innovation in environmental initiatives. A faster and more reliable internet connection is indicative of a technologically progressive environment, which can facilitate the rapid dissemination of information, collaboration, and the adoption of sustainable practices. Increased connectivity often correlates with the efficient implementation of environmentally conscious policies, improved resource management, and the adoption of innovative solutions to address ecological challenges. The anticipation is that countries with robust and high-speed internet connectivity are better positioned to leverage technology for environmental monitoring, sustainable development planning, and the deployment of cutting-edge solutions.

The panel data model is expressed as follows for the paper:

$$GGI_{it} = \beta_0 + \beta_1 EI_{it} + \beta_2 GDPG_{it} + \beta_3 POP_{it} + \beta_4 NVEH_{it} + \beta_5 INTS_{it} + \varepsilon_{it} \quad (1)$$

Where GGI is green growth index for country i at time t, while EI, GDPG, POP, NVEH, and INTS are environmental investment, GDP growth, population size, number of registered vehicles, and internet connection speed. ε_{it} is error term of the empirical model.

To gauge the impact of independent variables, a comprehensive panel data econometric analysis is conducted, involving several methodological steps. Initially, the homogeneity status of the panel's slope is examined using Pesaran and Yamagata's (2008) approach. Given the interconnection among Southeast Asian countries, evaluating cross-sectional dependency is crucial, achieved through the application of Pesaran's (2021) statistic. Subsequently, the series' stationarity status is assessed using the CADF and CIPS approaches proposed by Pesaran (2007). The inquiry then investigates the long-term relationships among the variables using Westerlund's (2007) method. Additionally, the CUP-FM (Continuously Updated Fully Modified) approach, acknowledged for its efficacy in cross-sectional panel cointegration estimation, is employed. Following estimation, the reliability of the findings undergoes a rigorous assessment through a robustness analysis. Table 3 illustrates the estimation steps:

Results & estimations

In this section, the empirical results are clarified by systematically presenting sequential tests and their corresponding outcomes.

Table 4 Slope homogeneity analysis.

Statistics	Value	*P*-value
Delta Δ	14.392	0.000
Adjusted Delta Δ	10.922	0.000

Source: Researcher.

Table 5 Discussion on cross-sectional dependency existence in the model.

Variable	Stat.	*P*-value
Green growth index	14.305	0.000
Environmental Investment	27.502	0.000
GDP growth	23.647	0.000
Population size	32.106	0.000
Number of registered vehicles	18.602	0.000
Internet Connection Speed	13.205	0.010

Source: Researcher.

The initial analysis focuses on slope homogeneity, with detailed findings shown in Table 4. The significance of all p-values at the 5% level indicates that the panel exhibits homogeneity in slopes.

The second evaluation focuses on cross-sectional dependency through the utilization of Pesaran's (2021) measure, which measures the correlation between the cross-sectional units of the panel. The outcomes of this test are elucidated in Table 5, solidifying the rejection of the null hypothesis due to the significance of p-values at the 5% level.

Following this, the Cross-sectional Augmented Dickey-Fuller (CADF) and CIPS approaches are employed to determine the level of integration within the series. The results, presented in Table 6, indicate that the series are stationary at the first level of difference.

Table 7 exhibits the outcomes of the ensuing test, utilizing the Westerlund (2007) technique to explore the status of the long-term association among the variables. Drawing insights from the p-values of the four statistics, it can be deduced that within our panel data, the variables demonstrate cointegration in the long term.

Table 8 provides a comprehensive presentation and discussion of the results pertaining to the coefficient estimation derived from the panel cointegration estimator.

The analysis reveals a strong and positive correlation between environmental investment and the Green Growth Index in Southeast Asia. Specifically, the findings indicate that a

Table 6 Panel test for unit root status.

Variable	CIPS test		CADF test	
	Level	1st level	Level	1st level
Green growth index	−1.264	−4.307	−0.446	−3.796
Environmental Investment	−1.563	−5.480	−2.351	−10.304
GDP growth	−1.675	−6.125	−0.669	−3.889
Population size	−2.546	−8.697	1.694	5.410
Number of registered vehicles	−1.045	−5.406	−1.989	−7.239
Internet Connection Speed	−1.785	−6.507	−0.794	−4.005

Source: Researcher.

Table 7 Results of Westerlund (2007) test.

Statistic	Outcome of test	
	Value of t-stat.	Prob.
G_t	−3.569	0.049
G_a	−13.110	0.004
P_t	−4.760	0.036
P_a	−6.102	0.003

Source: Researcher.

Table 8 Results of coefficient evaluation.

Variable	Coefficient	Prob.
Environmental Investment	0.569	0.029
GDP growth	−0.392	0.001
Population size	−0.210	0.057
Number of registered vehicles	−0.352	0.013
Internet Connection Speed	0.103	0.296

Source: Researcher.

1% increase in environmental investment results in a 0.56% increase in the Green Growth Index. This interpretation emphasizes that greater commitment to environmental initiatives, as evidenced by increased investments, significantly enhances green growth outcomes in the region. The positive correlation can be attributed to several factors: increased environmental investment often drives the adoption of sustainable practices, fosters innovation in green technologies, and promotes the conservation of natural resources. As countries in Southeast Asia channel resources into eco-friendly projects, the subsequent improvement in the Green Growth Index reflects a collective effort towards sustainable and environmentally responsible economic development.

Additionally, the analysis reveals a negative relationship between GDP growth and the Green Growth Index in Southeast Asia. This finding indicates that economic expansion in the region is not aligned with sustainable development goals, suggesting that current economic activities may not fully embrace environmentally responsible practices. The negative correlation implies that as GDP increases, the Green Growth Index tends to decline, highlighting a significant challenge: the pursuit of economic growth does not automatically equate to sustainable development. This result calls for a critical reassessment of existing economic practices to ensure that growth is integrated with ecological considerations and the overarching objectives of green growth. It emphasizes the need for strategies that harmonize economic development with environmental sustainability to foster a truly sustainable future for the region.

Moreover, the research findings reveal that population size adversely affects green growth in Southeast Asia. The analysis indicates that an increase in population numbers hampers progress toward green growth objectives. This interpretation raises critical concerns about the challenges that population growth poses to the region's sustainability initiatives. The negative correlation suggests that as the population rises, the Green Growth Index tends to decline, highlighting the need for an in-depth examination of the intricate relationship between population dynamics and sustainable development. Policymakers must address the implications of population growth on resource consumption, environmental impact, and the region's capacity to harmonize economic expansion with ecological preservation. Such considerations are essential for developing effective strategies that ensure sustainable development amid increasing population pressures.

The estimation further confirms that a 1% increase in the number of registered vehicles in Southeast Asia correlates with a 0.35% decrease in the Green Growth Index. This finding indicates that the expansion of vehicular activity in the region adversely affects overall green growth. The negative correlation highlights the environmental challenges associated with increased motorization, such as heightened levels of air pollution and carbon emissions. This interpretation suggests that as the number of registered vehicles increases, the region encounters difficulties in maintaining or enhancing its green growth initiatives. Contributing factors to this negative impact may include a dependence on conventional fossil fuel-powered vehicles, inadequate infrastructure for sustainable transportation, and the necessity for stricter regulations to manage emissions.

Ultimately, the findings reveal that internet connection speed has a negligible impact on the Green Growth Index in Southeast Asia. This suggests that the rate of digitalization, as represented by internet speed, does not significantly advance the region's green growth objectives. However, the relationship between digitalization and green growth may be more complex than what internet speed alone indicates. The absence of a significant positive impact could stem from various factors. While digitalization can enhance efficiency and spur innovation, its direct contribution to environmental sustainability largely depends on how technology is applied. For example, if digital advancements are primarily utilized in sectors with substantial environmental footprints, such as heavy industry, the expected benefits for green growth may not materialize. Furthermore, the effects of digitalization on green growth can be indirect and not immediately observable. Enhanced internet connectivity can improve data collection and analysis, leading to more informed environmental policies and practices. It can also foster the development and implementation of green technologies and sustainable business practices through improved communication and collaboration. However, these potential benefits may be counterbalanced by challenges such as the digital divide, unequal access to technology, and the environmental ramifications of electronic waste. These issues include energy consumption in data centers and the disposal of outdated electronic devices, which could negate any positive effects on green growth.

Continuing with the analysis, a thorough investigation was undertaken employing the Continuously Updated Bias-Corrected and Fully Modified OLS estimators to reassess the signs of the coefficients. As depicted in Table 9, the outcomes affirm a positive impact of environmental investment, validating the crucial role of ESG investing in cultivating the Green Growth Index in the region.

Table 9 Robustness examination.

Variable	Fully Modified OLS		CUP-BC	
	Coefficient	Prob.	Coefficient	Prob.
Environmental Investment	0.242	0.012	0.342	0.064
GDP growth	−0.106	0.056	−0.143	0.073
Population size	−0.146	0.005	−0.187	0.023
Number of registered vehicles	−0.436	0.072	−0.378	0.049
Internet Connection Speed	0.106	0.339	0.158	0.036

Source: Researcher.

Summary of the research, policies and future development

This scholarly investigation explores the intricate relationship between ESG (Environmental, Social, and Governance) investing and the promotion of green growth in Southeast Asian nations, driven by the region's vulnerability to environmental pollution. The study emphasizes the critical need for adopting sustainable practices, with ESG investing emerging as a potentially effective policy tool for Southeast Asian countries striving to achieve sustainability goals. The empirical analysis, covering seven Southeast Asian countries from 2005 to 2020, reveals a significant and positive correlation between environmental investment and the Green Growth Index. A 1% increase in environmental investment corresponds to a 0.56% increase in the Green Growth Index, highlighting the tangible impact of intensified commitments to environmental initiatives. Conversely, the analysis identifies a negative impact of GDP growth on the Green Growth Index, illustrating challenges in aligning economic prosperity with sustainable development goals. Population size and the number of registered vehicles also demonstrate adverse effects on green growth, underscoring the need for targeted policy interventions. Interestingly, internet connection speed shows negligible influence, suggesting limited contributions of digitalization to the region's green growth objectives.

To propel green growth forward, Southeast Asian nations should implement a comprehensive suite of practical policies informed by this research's findings.

- A primary focus should be on fostering a conducive environment for Environmental, Social, and Governance (ESG) investing. Governments and regulatory agencies must establish frameworks that encourage businesses to embed ESG principles within their operations. This includes creating transparent reporting systems and providing tax incentives for sustainable practices. Furthermore, collaborating with financial institutions can help establish dedicated funds specifically aimed at advancing ESG initiatives.
- In light of the negative consequences that GDP growth can have on sustainable development, policymakers should prioritize separating economic expansion from environmental harm. This can be achieved through sustainable development strategies that promote resource efficiency, renewable energy use, and the principles of a circular economy, effectively aligning economic growth with ecological stewardship.
- To tackle the challenges posed by rising population levels and increasing vehicle ownership, strategic urban planning and sustainable transportation solutions are necessary. Public awareness campaigns that advocate for responsible consumption habits will also play a critical role in this effort.
- Although the impact of internet connection speed on green growth may appear limited, advancing digitalization is essential for enhancing sustainability. Governments should invest in technological infrastructure that supports green innovation, smart city initiatives, and robust environmental monitoring. Promoting digital literacy and ensuring equitable access to technology will be vital for fostering a more inclusive and sustainable development landscape across the region.

In charting the future course for this research, it is highly recommended to undertake a more comprehensive exploration into the nuanced impacts of green finance tools on the expansion of ESG (Environmental, Social, and Governance) investing within the Southeast Asian region. The imperative lies in gaining a deeper understanding of how specific financial mechanisms, including but not limited to green bonds or sustainability-linked loans, can not only stimulate but also sustain ESG investments. This multifaceted analysis should delve into their efficacy in mobilizing capital directed towards environmentally sustainable projects and businesses, providing invaluable insights into the intricate dynamics of promoting green growth. Furthermore, an avenue of paramount importance for future investigation involves an in-depth examination of the potential impacts of implementing a carbon tax system on the green growth trajectory of the region. This encompasses a meticulous assessment of the feasibility, effectiveness, and broader implications of integrating a carbon tax. Such an inquiry holds the potential to furnish invaluable insights into the mechanisms through which businesses can be incentivized to curtail carbon emissions and adopt sustainable practices.

Data availability

For access to the datasets generated or analyzed in the current study, please feel free to contact the corresponding author.

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Informed consent
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