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How Do Education Spending and Economic Factors Affect Carbon Emissions in ASEAN Countries? The Moderating Role of Regulatory Quality and GMM Approach

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Abstract

Carbon emissions are an urgent global environmental issue, particularly for ASEAN countries such as Indonesia, Malaysia, Singapore, Thailand, and the Philippines, which face significant challenges in reducing them. This study examines the impact of Government Expenditure on Education, economic growth, foreign direct investment (FDI), foreign aid, and the Islamic Capital Market (ICM) on carbon emissions in ASEAN countries, while considering the moderating effect of regulatory quality. The research employs panel data analysis using the Generalised Method of Moments (GMM) to address potential endogeneity and dynamic relationships, and Moderated Regression Analysis (MRA) to examine the interaction effects of regulatory quality. Data were collected through purposive sampling for the period 2011 to 2021. The results indicate that FDI has a significant positive impact on carbon emissions, whereas Foreign Aid and Government Expenditure on Education have a mitigating effect on emissions. Interestingly, ICM has a positive influence on carbon emissions, contrary to expectations. This may reflect the limited integration of environmental considerations in Islamic financial instruments in the region. Regulatory quality significantly moderates only the relationship between Foreign Aid and carbon emissions, indicating its selective role in shaping environmental outcomes. The novelty of this study lies in its integrated examination of conventional and Islamic financial indicators, as well as regulatory quality, in the ASEAN context, an area that remains underexplored. Based on the findings, it is recommended that policymakers strengthen environmental regulations to mitigate the negative impacts of FDI, while encouraging reforms to enhance the ecological responsibility of Islamic capital market practices. Further research is needed to explore institutional and financial mechanisms that can align investments with sustainability goals.

Keywords: FDI, Aid, Islamic Capital Market, Education Spending, Carbon Emissions.
JEL Classification: F21, F35, G15, Q56

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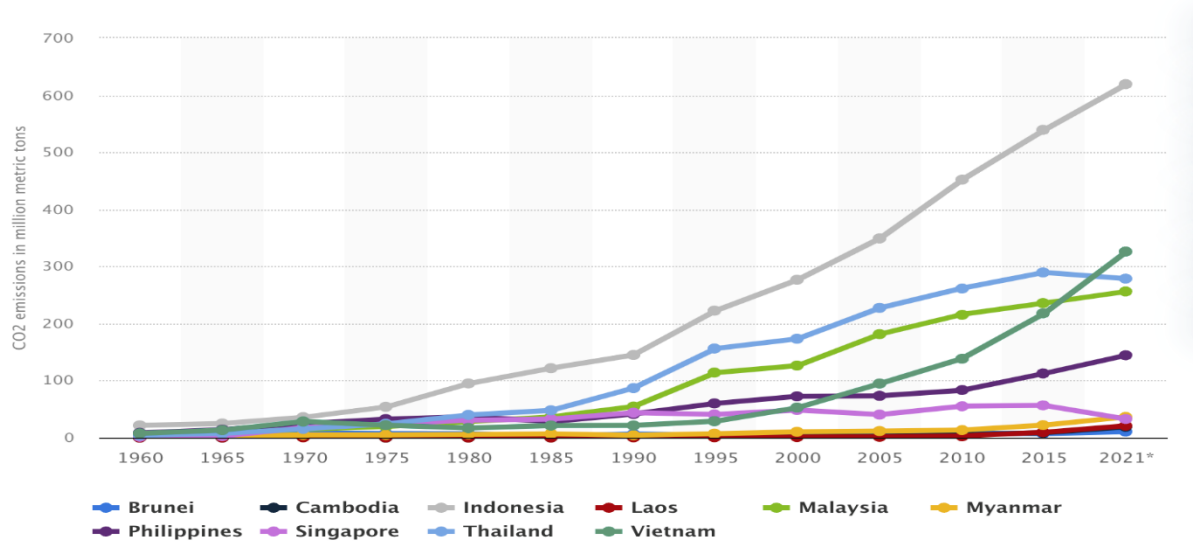
Managing carbon emissions is a critical global challenge, particularly for developing regions like ASEAN, where countries such as Indonesia, Malaysia, Singapore, Thailand, and the Philippines strive to balance rapid economic growth with environmental sustainability. The ASEAN region, characterised by accelerated industrialisation, urbanisation, and a significant rise in carbon emissions, which reached approximately 1.601 million metric tons of CO2 in 2021, faces unique pressures due to its diverse economic structures, reliance on foreign investment, and varying regulatory frameworks (Statista, 2023). This study examines the impact of economic factors, including Foreign Direct Investment (FDI), Foreign Aid, Islamic Capital Markets (ICM), Government Expenditure on Education (GEE), and economic growth, on carbon emissions in ASEAN countries, with regulatory quality serving as a moderating factor (Apergis et al., 2023a).

Education spending plays a pivotal role in fostering environmental awareness and promoting the adoption of green technology, potentially reducing carbon emissions by enhancing public knowledge and driving policy innovation. (Costantiello & Leogrande, 2023a)In ASEAN, where education budgets are increasing, this mechanism could play a crucial role in achieving the Sustainable Development Goals. Conversely, economic growth and FDI often exacerbate emissions due to energy-intensive industries and lax environmental regulations, aligning with the Pollution Haven Hypothesis. (Levinson & Taylor, 2008a). However, the effectiveness of these factors is contingent on regulatory quality, which can steer investments toward sustainable outcomes. (Huang et al., 2022a). The Islamic Capital Market, guided by Shariah principles that discourage environmentally harmful investments, offers a unique financial mechanism in ASEAN, particularly in countries like Indonesia and Malaysia, to support green initiatives. (Alam et al., 2017a).



Source: Statista (2023)

Figure 1. Territorial carbon dioxide (CO2) emissions in Southeast Asia from 1960 to 2021, by country (in million metric tons of CO2)

In this context, several economic factors such as Foreign Direct Investment (FDI) and Foreign Aid play an important role in regulating the relationship between economic growth and carbon emissions management. FDI can bring new technologies that are more efficient in energy use and reduce carbon emissions, while foreign aid can potentially be used to fund projects that support sustainable development. However, the effectiveness of these two factors often depends on the quality of regulation in recipient countries. (Huang et al., 2022)(Q. Wang & Zhang, 2022).

Despite extensive research on FDI, foreign aid, and economic growth, few studies have explored their combined impact in the ASEAN context, particularly with regulatory quality as a moderator, and using advanced econometric techniques such as the Generalised Method of Moments (GMM) and Moderated Regression Analysis (MRA). For instance, while (Yusril Izha Mahendra et al., 2022) Found that FDI increases emissions in ASEAN when regulations are weak, and the interplay of education spending and ICM remains underexplored. This study addresses this gap by employing a dynamic panel data analysis with GMM and MRA techniques to examine data from 2011 to 2021, providing a robust empirical framework for understanding these relationships. By focusing on ASEAN's unique socio-economic and regulatory landscape, this research offers actionable insights for policymakers aiming to align economic development with environmental sustainability.

Islamic Capital Markets are also starting to gain attention in ASEAN as an alternative to financing more environmentally-friendly projects. For example, the sector adheres to Shariah principles that prohibit investments in environmentally damaging sectors, making it a potential tool to support sustainable projects and the transition to a green economy. (Fitriyanto et al., 2021). In addition, ASEAN countries with high education spending can also improve people's understanding of sustainability and support environmentally friendly policies through more inclusive education.

LITERATURE REVIEW

The interplay between economic growth, foreign investment, and environmental sustainability in ASEAN countries can be understood through a synthesis of several key theories: the Pollution Haven Theory, Environmental Kuznets Curve (EKC), Corporate Social Responsibility (CSR), and Regulatory Compliance Theory. The

Pollution Haven Theory posits that lax environmental regulations in developing countries attract Foreign Direct Investment (FDI), which often employs polluting technologies, thereby increasing carbon emissions (Levinson & Taylor, 2008a). This is complemented by the EKC, which suggests that while early economic growth increases environmental degradation, higher income levels eventually lead to reduced emissions through technological advancements and policy shifts (Grossman & Krueger, 1991a). CSR theory, particularly in the context of Islamic Capital Markets (ICM), emphasises the role of ethical investments in mitigating environmental harm by prioritising socially and environmentally responsible practices (Bowen, 1953a). Regulatory Compliance

Theory ties these together by highlighting the critical role of effective regulations in ensuring that FDI, foreign aid, and economic activities align with environmental goals (Kagan & Scholz, 1984a). Together, these theories form a framework in which economic growth and investments can either exacerbate or mitigate carbon emissions, depending on the quality of regulation and societal priorities. This study leverages this framework to examine how FDI, foreign aid, ICM, government expenditure on education (GEE), and economic growth interact in ASEAN, moderated by regulatory quality, to influence carbon emissions.

Pollution Haven Theory

The Pollution Haven Theory (Levinson & Taylor, 2008a) Explains that countries with weaker environmental regulations attract FDI due to lower production costs, often leading to increased carbon emissions from less sustainable technologies. In ASEAN, this is particularly relevant as countries like Indonesia and Malaysia compete for FDI in energy-intensive industries. (Yusril Izha Mahendra et al., 2022) Found that FDI significantly increases CO2 emissions in nine ASEAN countries, emphasising the need for robust corruption control to mitigate environmental impacts. Similarly, Huang et al. (2022) Confirm that FDI inflows are positively associated with carbon emissions, necessitating stringent environmental policies. Studies like Apergis et al. (2023) on the BRICS countries and Auzairy et al. (2018) In Malaysia, this reinforces the point that FDI plays a role in increasing emissions when regulations are lax. However, the literature lacks a comprehensive analysis of how FDI interacts with education spending and ICM in ASEAN. This study addresses this gap by exploring these dynamics using GMM and MRA techniques.

Environmental Kuznets Curve (EKC)

Kuznets first introduced the Environmental Kuznets Curve (EKC) theory (Kuznets, 1955), which explains the relationship between economic growth and environmental conditions. This theory describes an inverted U-shaped relationship, where in the early stages of economic development, there is an increase in environmental pollution. However, after reaching a certain point, economic growth actually begins to reduce pollution levels. The position of this point is influenced by various factors, such as income levels, people's preferences, and government policies. The theory assumes that economic development drives changes in people's choices, technological innovation and financial structure, which in turn affect emission levels and their impact on the environment. (Grossman & Krueger, 1991)

Research from Mahalik et al., (Mahalik et al., 2021) Found that foreign aid flows, globalisation, and energy consumption significantly reduced CO2 emissions, while foreign energy aid flows, economic growth, FDI, and remittance flows actually increased CO2 emissions. Likewise, from Kretschmer et al., (Kretschmer et al., 2010) and Amin et al., (Amin et al., 2018) Foreign Aid tends to be effective in reducing the energy intensity of GDP (Gross Domestic Product) in recipient countries. This means that Foreign Aid can help improve energy efficiency in these countries. However, there are interesting findings that the carbon intensity of energy use is almost not affected by foreign aid.

This duality aligns with the EKC model, suggesting that economic components can simultaneously contribute to both the upward and downward slopes of the curve. In many ASEAN countries, the turning point remains uncertain due to uneven income levels and institutional quality, highlighting a gap that this study seeks to explore.

Corporate Social Responsibility Theory

Howard R. Bowen (Bowen, 1953) Proposed this theory, which emphasises that companies must consider the social and environmental impacts of their business activities. In the context of Islamic capital markets, companies that adhere to sharia principles tend to show a greater commitment to social and environmental responsibility, potentially helping to reduce carbon emissions. This theory is based on the assumption that a company's objectives are not only limited to achieving profits, but also to making a positive contribution to society and the surrounding environment.

The findings of Nazir & Khan support this theory. (Nazir & Khan, 2013) The Islamic capital market can play a crucial role in reducing carbon emissions. The Islamic capital market operates based on Islamic principles that prohibit investment in sectors that have the potential to damage the environment. In other words, the Islamic capital market tends to invest in companies that focus on socially and environmentally responsible business practices. Research findings from Mhadhbi et al., (Mhadhbi et al., 2021) Revealed that positive and negative impacts on stock market development indicators have different effects on carbon emissions. This means that fluctuations and changes in the stock market can affect carbon emissions in a way that is not linear or balanced. They suggest that policymakers in emerging countries implement strong environmental policies to reduce carbon emissions from industrial companies without hindering the development of financial markets. This is central to our study, which investigates whether the Islamic Capital Market (ICM) can serve as a mitigating mechanism for FDI-induced emissions in ASEAN economies.

Regulatory Compliance Theory

According to Kagan & Scholz, (Kagan & Scholz, 1984)Regulatory Compliance Theory explains that well-designed regulations can encourage companies to comply with environmental standards and reduce activities that harm the environment, including the release of carbon emissions. This theory posits that companies tend to comply with regulations if the benefits they obtain exceed the costs they must bear. The main focus of this theory is on the role of government in designing and implementing effective environmental regulations.

Mahalik et al., (Mahalik et al., 2021) and Kono & Montinola, (Kono & Montinola, 2019) Highlight how the effectiveness of foreign aid in reducing emissions depends on the strength of the regulatory framework. In ASEAN, where regulatory quality varies widely (e.g., Singapore vs. Laos), this theory helps explain the uneven environmental outcomes of aid and investment, an area directly addressed in this study through regulatory interaction analysis.

Foreign Direct Investment

Foreign Direct Investment (FDI) is a type of equity investment made by a multinational company outside of its home territory. Foreign Direct Investment (FDI) involves a company's strategic move to expand business activities into other countries through shareholdings in local companies. This investment grants the multinational company substantial control over the strategy and operational decisions of the host country. Some of the primary reasons for making these investments include expanding market access, capitalising on natural resources, acquiring new technologies, enhancing knowledge, and optimising production and distribution efficiency. In the context of globalisation, FDI plays an important role in accelerating economic integration between countries and driving global economic growth (Todaro & Smith, 2013b)

However, FDI activities can also have a negative impact on the environment, especially in the form of increased carbon emissions. This is often due to the use of environmentally unfriendly technologies and fossil fuels. Based on the Pollution Haven Hypothesis, developing countries tend to prioritise economic growth over environmental protection. (Levinson & Taylor, 2008) In the ASEAN context, FDI often flows into resource-intensive and manufacturing sectors, which increases the risk of carbon emissions.(Secretariat, 2023). Therefore, this study investigates how governance quality moderates the environmental effects of FDI within the region.

Foreign Aid

Foreign aid refers to international transfers of funds, either i by the government of one country to suppor n the form of grants or loans, provided t the development of another country. These transfers can be made directly between two governments, known as bilateral aid, or through multilateral institutions such as the World Bank. The primary purpose of this aid is to assist the recipient country in meeting its financial needs while promoting economic and social development. Additionally, foreign assistance plays a strategic role in strengthening cooperation between nations and supporting those facing resource constraints. Grants are given without repayment obligations, while loans usually come with repayment obligations and interest. Through this aid, recipient countries can access additional resources to undertake development projects, improve people's welfare, and address economic and social challenges. (Todaro & Smith, 2013b)

However, the environmental effectiveness of aid depends heavily on the recipient country’s governance and regulatory quality.Kono & Montinola (2019) Found that foreign aid is more effective in reducing emissions when combined with strong institutions. In ASEAN, where regulatory quality is uneven, foreign assistance can both help and harm environmental outcomes. This study addresses that variation by analysing how aid interacts with governance in influencing emissions.

Islamic Capital Market

The Islamic Capital Market is a financial platform that operates under Shariah principles, bringing together parties with excess funds, such as investors, companies, and governments, with those who need additional funds. Acting as a financial intermediary, this market enables the flow of funds from those with a surplus to those with a deficit. As an alternative to the conventional capital market, the Islamic Capital Market offers a solution for capital seekers and providers who wish to invest in accordance with Shariah values. This market is an integral part of the Islamic Financial System, where Shariah-compliant financial assets are traded. Furthermore, the Islamic Capital Market has an important contribution in supporting the growth of Islamic Financial Institutions as a whole. (Alam et al., 2017)

Islamic capital markets can play an important role in reducing carbon emissions. The Islamic capital market operates based on Islamic principles that prohibit investment in sectors that have the potential to damage the environment. In other words, the Islamic capital market tends to invest in companies that focus on socially and environmentally responsible business practices (Nazir & Khan, 2013). In the ASEAN context, Malaysia is a pioneer in developing Islamic green sukuk and sustainability-linked Islamic finance. This provides an empirical ground to assess whether ICM acts as a buffer to FDI-induced emissions in the region, a central question this paper explores (ADB, 2022).

Government Expenditure on Education

The theory of Government Expenditure on education stems from the concept of Public Expenditure Theory, developed by various economists. One significant early reference is the work of Professor Henry C. Adams of the University of Michigan, which discusses the importance of public spending in achieving social welfare. Adams emphasised that the principles of public budget management must reflect the collective needs of the community. This theory then became the basis for numerous studies that examined the influence of government spending on the education sector and its impact on various aspects of development, including environmental quality. (Adams, 1895)

Government spending in the education sector has a significant impact on environmental quality, especially through increased public awareness and participation in sustainability issues. Investing in education can raise public awareness of ecological problems, ultimately encouraging eco-friendly behaviour and reducing carbon emissions. Better education enables individuals to understand the importance of climate change mitigation measures, including energy efficiency, waste management, and air pollution reduction. (Costantiello & Leogrande, 2023)

Studies at the global and regional levels reinforce this relationship. (Nurrahmawati & Kusumawardani, 2021) Demonstrate that government budget allocation for education has a positive impact on reducing carbon dioxide (CO2) emissions by increasing environmental literacy. Additionally, research in Africa has found that educational spending focused on developing ecological skills significantly contributes to reducing carbon emissions and improving air quality. This demonstrates that education plays a crucial role in building community capacity to support sustainable environmental initiatives. In ASEAN, countries such as Indonesia, Vietnam, and the Philippines have increased their education budgets in recent years; however, the impact on ecological awareness remains underexplored. This study contributes to the examination of whether education spending helps reduce carbon emissions in the region through behavioural and policy pathways. (Global Education Monitoring Report, 2022; Nurrahmawati & Kusumawardani, 2021b).

Research by Onyinyechi & Olasupo, (2022) In Nigeria, research indicates that effective education budget management can catalyse the implementation of green technologies and emission reduction at the local level, while enhancing individual capacity and promoting innovative environmental policies. These findings are supported by (N. Wang & Chen, 2024) Researchers have found that education budget allocation plays a role in mediating the relationship between environmental spending and reducing carbon emissions by improving policy efficiency. Therefore, government spending on education not only enhances the quality of human resources but also plays a strategic role in promoting sustainable development and improving environmental quality, making it a crucial component of global development strategies.

Economic Growth

The Environmental Kuznets Curve can explain the relationship between economic growth and environmental quality. EKC explains that there is a non-linear relationship in the form of an inverted U-shaped relationship between economic growth and environmental degradation (Dinda, 2004). Recent studies indicate that the existence of the EKC remains relevant. (Ajmi et al., 2023; Anwar et al., 2022; Guo & Shahbaz, 2024; Leal & Marques, 2022; Mahmood et al., 2023; Q. Wang et al., 2022). (Ekonomou & Halkos, 2023) Explain that economic growth often leads to increased energy consumption and environmental degradation; however, energy efficiency and the use of renewable fuels can support sustainable development. With this strategy, the country can strike a balance between economic growth and environmental protection. Likewise, (Awan & Azam, 2022) In their study on G-20 countries, they found an N-shaped relationship between CO2 emissions and GDP per capita. In the early stages, economic growth tends to increase emissions, but at certain income levels, emissions decline due to the adoption of clean technologies. However, at very high income levels, environmental degradation can increase again due to overconsumption and weak regulations.

(Shafik & Bandyopadhyay, 1992) Demonstrate that the impact of economic growth on the environment varies according to the level of state income. Some environmental indicators improved with growth, while others, such as carbon emissions, deteriorated in the early stages of development. In conclusion, sustainable economic growth requires the integration of energy efficiency strategies, clean technologies, and strong environmental policies. However, ASEAN countries face different stages of economic development and technology adoption. This study examines whether the EKC relationship holds in the region and how the impact of economic growth on emissions varies when moderated by institutional and financial variables.

Regulatory Quality

Regulatory quality refers to the level of effectiveness and excellence of regulations implemented in a government system. This aspect encompasses various elements, including the quality of rules, policy-making processes, law enforcement, transparency, accountability, and the government's ability to manage and enforce regulations effectively. In general, regulatory quality reflects a country or institution's ability to create an environment that supports sustainable economic growth, protects consumers, ensures social justice, preserves the environment, and maintains financial stability. Assessment of regulatory quality typically involves analysing accuracy, consistency, efficiency, and the government system's ability to implement and enforce regulations fairly and effectively. High-quality regulations are expected to foster a conducive business climate, stimulate investment levels, drive innovation, and strike a balance between protecting public interests and mitigating risks. (Radaelli & Francesco, 2011a)

High regulatory quality enhances environmental enforcement, thereby influencing whether FDI and foreign aid lead to cleaner development or increased emissions. In ASEAN, where regulatory quality ranges from very strong (e.g., Singapore) to relatively weak (e.g., Cambodia), this variable becomes critical. This study includes regulatory quality as a moderating variable to understand its role in shaping the relationship between financial flows and environmental outcomes. (Radaelli & Francesco, 2011b; World Bank, 2023)

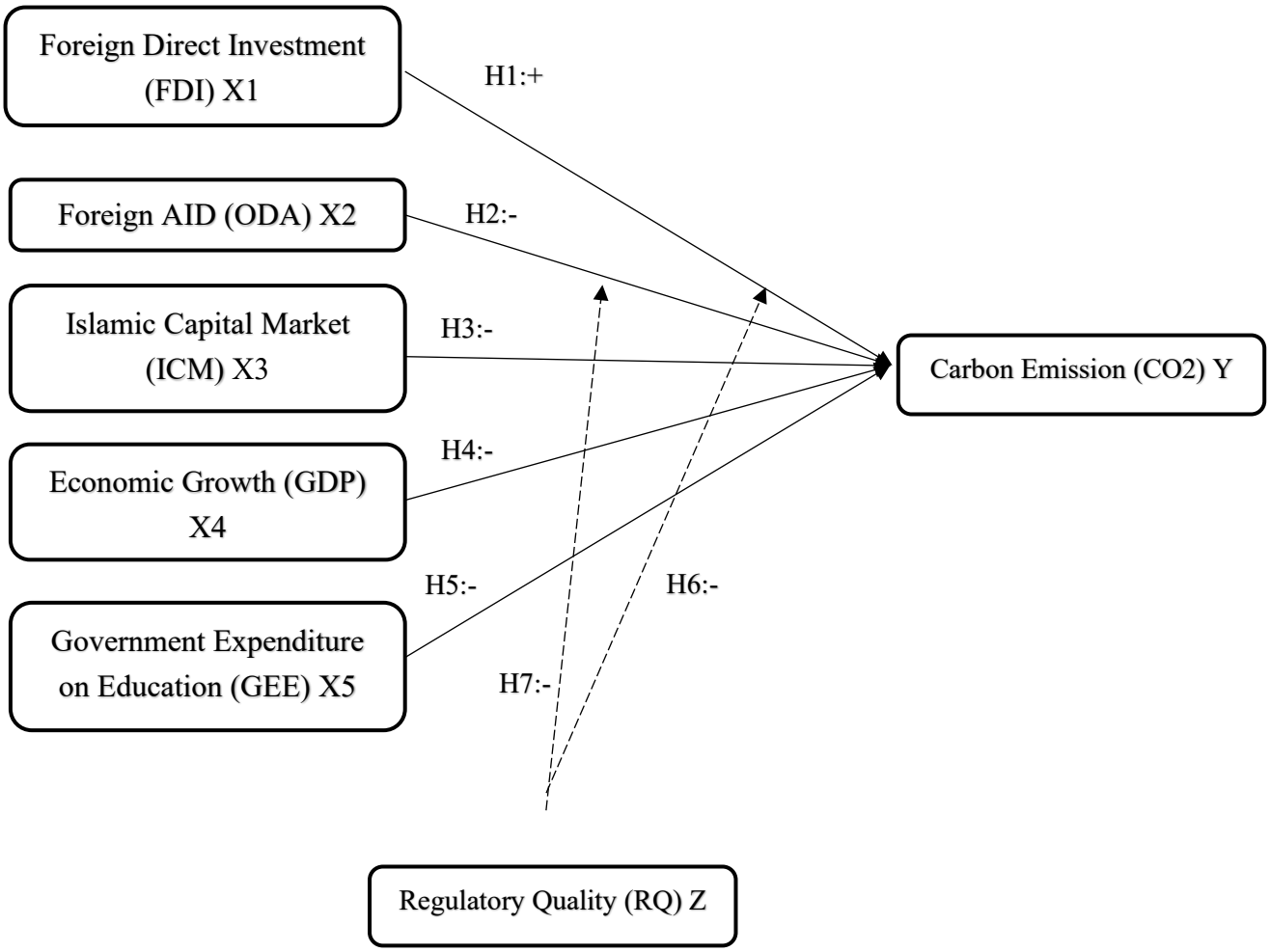


Figure 2. Framework of Thought

RESEARCH METHODS

Data and Variables

This research method utilises secondary data, specifically panel data. The data for this research comes from the World Bank, the United Nations Development Programme (UNDP), Our World in Data, Yahoo Finance, Investing.com, as well as various other official website sources that support this research.

A population is a complete group of elements, typically in the form of people, objects, transactions, or events that we are interested in making the subject of research (Kuncoro, 2013). In this study, the population used is the ASEAN countries. The sample is representative of the entire population because it is drawn from a subset of the population for the study (Sekaran & Bougie, 2016). This study employs a purposive sampling method, selecting ASEAN countries

with complete data on foreign aid, FDI, Islamic Capital Market, and Regulatory Quality over the eleven years from 2011 to 2021. The chosen countries are Indonesia, Malaysia, the Philippines, and Thailand, each of which has a representative Islamic stock index, the Indonesia Sharia Stock Index (ISSI) for Indonesia, the FTSE Bursa Malaysia EMAS Shariah Index, the S&P BMI Philippines Shariah Index, and the FTSE SET Shariah Index (FTFSTSH) for Thailand. These four indices represent the Islamic capital markets of the respective countries included in this study.

Foreign Direct Investment (FDI) refers to the amount of direct investment made by foreign investors in a country, in the form of capital, technology, and expertise. Measurement of this investment can be done using data provided by government agencies such as the World Bank or agencies that deal with foreign investment. The data can be analysed either in nominal value or as a percentage of the country's Gross Domestic Product (GDP) (Todaro & Smith, 2013b). In this research, the FDI data are presented in USD.

Foreign Aid refers to the amount of aid provided to the developing countries involved in this study. The relevant data can be accessed through the website of the OECD Development Assistance Committee (DAC), which serves as an organisation for economic cooperation among countries. To calculate the amount of this aid, annual data available on the OECD DAC website can be used. (Todaro & Smith, 2013b). This research utilises Official Development Assistance (ODA), which refers to financial support provided by official agencies of DAC member countries, multilateral institutions, or non-DAC countries, aimed at promoting economic development and welfare in developing countries listed by the DAC. The data are presented in current USD.

The Islamic Capital Market (ICM) is an integral part of the Islamic Financial System, where financial transactions are conducted in accordance with Shariah principles. To obtain opening price data, we used information sources from websites such as investing.com and Yahoo Finance. ICM has a very important role in supporting the growth of Islamic Financial Institutions (Alam et al., 2017). The ICM data used in this study consists of four indices, each representing one of the four countries mentioned earlier.

Government Expenditure on Education (GEE) refers to the allocation of the public budget intended for the education sector, which supports social welfare and meets the collective needs of the community. This concept, which is rooted in the Public Expenditure Theory by (Adams, 1895) Emphasises the importance of education budget management in promoting sustainable development, including improvements in environmental quality. The GEE data are presented as a percentage of total government expenditure and are sourced from the World Bank.

Economic Growth is an increase in a country's long-term economic capacity to produce goods and services. Based on Harrod (1939), growth is influenced by investment, capital accumulation, and the efficiency of the capital-output ratio. This theory emphasises the importance of maintaining a balance between investment and savings to prevent economic imbalances, such as unemployment or inflation, as well as differentiating between natural, actual, and desirable growth as a key component in growth analysis. In this research, economic growth is measured using the annual GDP growth rate sourced from the World Bank. This indicator represents the annual percentage growth rate of GDP at constant prices based on local currency.

Regulatory quality refers to the government's ability to design and implement policies and regulations that support efficient and equitable private sector growth. This includes elements such as transparency, accountability, participation, consistency, performance, and outcomes of the regulatory process. In addition, regulatory quality also provides protection of property rights, freedom of transaction, legal certainty, and fair and impartial application to business actors. Assessment of regulatory quality is conducted using various indicators sourced from business surveys, expert opinions, the Economic Freedom Index, the Ease of Doing Business Index, the Regulatory Quality Index, and other relevant sources. (Kaufmann et al., 2010). In this study, the regulatory quality data used is the percentile rank of regulatory quality obtained from the World Bank's Worldwide Governance Indicators (WGI). This measure reflects perceptions of the government's capacity to develop and enforce regulations that support private sector activity. The percentile rank ranges from 0 (lowest rank) to 100 (highest rank), indicating a country's relative position among all countries included in the WGI. These ranks are adjusted over time to account for changes in the composition of the countries assessed.

Analysis Techniques

The data collected were analysed using the Stata application with the Generalised Method of Moments (GMM) and Moderated Regression Analysis (MRA) approaches. This study utilises panel data comprising a cross-section of five ASEAN countries and a time series from 2011 to 2021. The dependent variable of Carbon Emission (Y) was analyzed against the independent variables of Foreign Direct Investment (X1), Net official development assistance and official aid received (X2), Islamic Capital Market (X3), Economic Growth (X4), and Government Expenditure on Education (X5), with Regulatory Quality (Z) as the moderation variable.

Estimation was carried out using Arellano-Bond GMM, both with FD-GMM (First Difference GMM) and SYS-GMM (System GMM), where SYS-GMM is used if the results of FD-GMM are not satisfactory (Firdaus, 2020). GMM, introduced by Hansen (1982), has the advantage of overcoming endogeneity problems and produces efficient estimates despite heteroscedasticity or serial correlation. In addition, GMM allows testing of models with moment conditions that exceed the number of parameters, making it ideal for dynamic panel data analysis (Hansen, 1982). To validate the suitability of the instruments used in the GMM estimation, the Sargan test is employed to assess overidentifying restrictions. A statistically insignificant Sargan test result indicates that the instruments used are valid and uncorrelated with the error term. Meanwhile, the Arellano-Bond test for autocorrelation (AR(1) and AR(2)) is used to detect serial correlation in the differenced residuals. For a consistent GMM estimator, the AR(1) is expected to be significant due to the nature of first differencing, while the AR(2) should be insignificant, indicating no second-order autocorrelation. MRA is used to evaluate the effect of Regulatory Quality moderation in strengthening or weakening the relationship between independent variables and carbon emissions.

$$CE = \alpha + \beta 1.FDI + \beta 2.\mathrm{ODA} + \beta 3.GDP + \beta 4.GEE \quad (1)$$

$$CE = \alpha + \beta 1.FDI + \beta 2.\mathrm{ODA} + \beta 3.GDP + \beta 4.GEE + \beta 5.FDI\ RQ + \beta 6.FAID\ RQ + e \quad (2)$$

$$CE = \alpha + \beta 1.FDI + \beta 2.\mathrm{ODA} + \beta 3.ICM + \beta 4.GDP + \beta 5.GEE + \beta 6.RQ + \beta 7.FDI\ RQ + \beta 8.\mathrm{ODA}\ RQ + e \quad (3)$$

Di mana:

CE	= Carbon Emissions
a	= Constant
b1-b8	= Regression Coefficient
FDI	= Foreign Direct Investment
ODA	= Net official development assistance and official aid received
ICM	= Islamic Capital Market
RQ	= Regulatory Quality
GEE	= Government Expenditure on Education

GDP = Economic Growth

e = Error Term

RESULTS AND DISCUSSION

Table 1. Unbiased Test

Variable	FEM	FD-GMM	SYS-GMM	PLS
Carbon (L1)	0.59193136***	0.59193136***	0.93920919***	0.9482599***
FDI	1.529e-10*	1.529e-10***	1.512e-10	1.192e-10*
ODA	2.298e-08*	2.298e-08**	2.191e-08*	2.291e-08
ICM	-0.00015464	-0.00015464	0.00022778*	-0.00001608
GDP	-6.403e-10	-6.403e-10	-5.557e-10	-2.304e-10
GEE	-1.110e-08**	-1.110e-08**	-1.207e-08*	-1.269e-08**
RQ	0.18596685	0.18596685**	0.07424594	0.09669801
FDI × RQ	-1.651e-26	-1.651e-26***	-1.355e-26	-2.030e-26
ODA × RQ	-3.802e-10	-3.802e-10**	-3.748e-10*	-3.724e-10
Constant	3.7671726	3.7671726	-2.7784196	-3.3356989
N	40	36	40	40

legend: * p<0.05; ** p<0.01; *** p<0.001

The decision regarding the non-bias test was made based on a comparison of the estimated results from the Pooled Least Squares (PLS), Fixed Effects Model (FEM), FD-GMM, and SYS-GMM. (Firdaus, 2020) Based on the results in Table 1, the estimates of FD-GMM and SYS-GMM exhibit irregularities, as the estimated values fall between those of PLS and FEM. However, SYS-GMM was chosen as the best estimation compared to FD-GMM, because it provides more stable results and is in accordance with the characteristics of the panel data. Detailed information about the estimated results is presented in the table above.

Table 2. Instrument Validity Test

chi2(36)	28.98321
Prob > chi2	0.7904

Sargan test of overidentifying restrictions
H0: Overidentifying restrictions are valid

Based on Table 2, the validity of the instrument was tested to ensure that there was no correlation between the instrument used and the error component. (Zuhroh & Amir, 2021) The validity test is carried out through the Sargan Test, where the decision regarding the validity of the instrument is determined based on the probability value (p-value). According to (Firdaus, 2020) An instrument is considered valid if the probability value is greater than 0.05; a value below 0.05 indicates that the instrument is invalid. The results of the analysis, as shown in Table 2, suggest that the probability value of the Sargan test is 0.7904, which is greater than 0.05. This indicates that the instrument used in this study is valid and does not correlate significantly with errors. Thus, the instruments used can be trusted in model estimation.

Table 3. Arellano-Bond Test Results for Consistency

Order	z	Prob > z
1	-1.9551	0.0506
2	-0.28128	0.7785

The consistency test of the estimated results in this study was carried out using the Arellano-Bond statistical method for autocorrelation at the first (m1) and second (m2) levels. According to Firdaus (2020), model consistency is achieved if the m1 test rejects the null hypothesis, while the m2 test does not reject the null hypothesis. Based on the results of the analysis shown in Table 3, the probability value on order 2 is 0.7785, which is greater than the significance level of 0.05. This result indicates that there is no autocorrelation at the second level, while the m1 test with a probability value of 0.0506 is almost close to the limit of significance. Thus, the estimation model used in this study can be declared consisten.

Table 4. SYS-GMM Test Results

Variable	Coefficient	Std. Error	z-Statistic	p-Value	95% Confidence Interval Lower Bound	
Carbon L1	1.067274	0.0752487	14.18	0.000	0.9197894	1.214759
FDI	1.78E-10	1.12E-10	1.59	0.112	-4.19E-11	3.99E-10
ODA	-1.46E-09	8.74E-10	-1.67	0.095	-3.17E-09	2.56E-10
GDP	6.06E-10	9.42E-10	0.64	0.520	-1.24E-09	2.45E-09
GEE	-1.15E-08	4.96E-09	-2.33	0.020	-2.13E-08	-1.83E-09
Constant	-2.720893	3.020273	-0.90	0.368	-8.640519	3.198733

Based on Table 4, the GEE (Government Expenditure on Education) variable has a significant negative effect, meaning that an increase in the value of GEE will decrease the carbon value. On the other hand, FDI, ODA, and GDP did not show a significant influence on carbon, as their p-values were greater than 0.05 (except for ODA, which was close to the 10% significance level). The constant coefficients were also insignificant, suggesting that other factors could not substantially explain the variation in carbon.

Table 5. MRA Test Results 1

Variable	Coefficient	Std. Error	z-Statistic	p-Value	95% Confidence Interval Lower Bound	
Carbon	1.042411	0.0631642	16.50	0.000	0.9186118	1.166211
FDI	1.96E-10	6.18E-11	3.17	0.002	7.47E-11	3.17E-10
ODA	1.96E-08	1.19E-08	1.64	0.101	-3.79E-09	4.29E-08
GDP	2.03E-10	1.41E-09	0.14	0.886	-2.56E-09	2.96E-09
GEE	-1.13E-08	4.24E-09	-2.66	0.008	-1.96E-08	-2.96E-09
FDI*RQ	-1.32E-26	1.11E-26	-1.19	0.233	-3.49E-26	8.47E-27
ODA*RQ	-3.36E-10	2.12E-10	-1.59	0.113	-7.52E-10	7.92E-11
Constant	-2.060173	2.493895	-0.83	0.409	-6.948116	2.827771

Based on Table 5, the FDI variable showed a significant influence (p-value = 0.002), indicating that the increased FDI flow contributed to the increase in carbon emissions. Meanwhile, the ODA and GDP variables had no significant effect on carbon, with p-values of 0.101 and 0.886, respectively. The GEE variable has a significant negative influence (p-value = 0.008), indicating that an increase in GEE will decrease the carbon value. On the other hand, RQ does not moderate the relationship between these variables and carbon (p-value 0.233). The interaction between FDI*RQ was also not significant (p-value 0.113), meaning there was no considerable moderation effect between the two on carbon. The insignificant constant coefficients suggest that other factors do not adequately explain the variation in carbon.

Table 6. MRA Test Results 2

Variable	Coefficient	Std. Error	z-Statistic	p-Value	95% Confidence Interval Lower Bound	
Carbon	0.9392092	0.0186657	50.32	0.000	0.9026251	0.9757933
FDI	1.51E-10	8.07E-11	1.87	0.061	-7.00E-12	3.09E-10
ODA	2.19E-08	9.49E-09	2.31	0.021	3.30E-09	4.05E-08
ICM	0.0002278	0.0001017	2.24	0.025	0.0000285	0.0004271
GDP	-5.56E-10	1.56E-09	-0.36	0.722	-3.62E-09	2.51E-09
GEE	-1.21E-08	5.06E-09	-2.39	0.017	-2.20E-08	-2.15E-09
RQ	0.0742459	0.0640304	1.16	0.246	-0.0512514	0.1997433
FDI*RQ	-1.35E-26	1.04E-26	-1.30	0.194	-3.40E-26	6.91E-27
ODA*RQ	-3.75E-10	1.65E-10	-2.28	0.023	-6.97E-10	-5.21E-11
Constant	-2.77842	4.748268	-0.59	0.558	-12.08485	6.528014

The results in Table 6 show a significant influence of several variables on carbon, where ODA, ICM, and GEE have a considerable effect, each with a p-value of less than 0.05. The GEE variable has a negative coefficient, indicating that an increase in the value of GEE will decrease the carbon value. FDI also had a positive influence, but its p-value was slightly higher (0.061), which means the impact was not significant at the 5% level. Similarly, the GDP variable did not show a substantial impact on carbon because its p-value was greater than 0.05.

Moderation testing revealed that the interaction between ODA*RQ had a significant effect on carbon, with a p-value of 0.023, suggesting that this interaction may influence the carbon value. In contrast, the interaction between FDI and RQ was not significant, with a p-value of 0.194, indicating that the moderation between FDI and RQ has no significant impact on carbon emissions. The constant coefficients are not important, suggesting that other factors are not strong enough to explain the variation in carbon.

Based on the results of statistical tests conducted, the findings of this study align with various theories that explain the relationship between investment, economic growth, and their impact on carbon emissions. This research supports several key theories, including the Pollution Haven Theory, the Environmental Kuznets Curve (EKC), Corporate Social Responsibility (CSR), and Regulatory Compliance Theory. It highlights the importance of government spending on education in reducing carbon emissions.

In this study, Foreign Direct Investment (FDI) was found to have a positive effect on carbon emissions, supporting the Pollution Haven Theory. Incoming FDI often brings cheaper but more polluting technologies, which can increase carbon emissions, especially if environmental regulations in recipient countries are less stringent. Therefore, it is important to develop policies that encourage green technology and sustainable investment. The findings of (Todaro & Smith, 2013a) The positive impact of FDI on technology transfer and the generation of new knowledge aligns with these findings, although adequate supervision is necessary to mitigate any negative environmental impacts.

However, the effects of FDI on carbon emissions are not always straightforward. Previous studies have shown that while FDI can exacerbate pollution, it can also enhance carbon emission efficiency under certain conditions. (Q. Wang & Zhang, 2022). The source of FDI plays a crucial role in determining its impact, as FDI flows from certain countries tend to lead to higher emissions. In contrast, others may reduce them, supporting both the Pollution Haven and Pollution Halo hypotheses. (Apergis et al., 2023c). For instance, FDI in China has had mixed effects on carbon emission performance, with regional variations reflecting the diverse impacts of FDI on environmental outcomes. (Song et al., 2021).

Interestingly, although lax environmental regulations may attract FDI to low-income countries, foreign firms often bring cleaner technologies compared to local companies. This can lead to a reduction in pollution levels despite the influx of FDI. (Kim & Adilov, 2012). These findings highlight the complex nature of FDI's impact on carbon emissions and underscore the need for policies that not only encourage sustainable investment but also consider factors such as the source of FDI, technological differences between foreign and local firms, and the regulatory environment in the host country. Therefore, developing policies that promote green technologies and sustainable practices is crucial for balancing the potential benefits of FDI with environmental protection.

Foreign Aid (ODA), which is seen as having the potential to reduce carbon emissions, was also found to have a significant influence in the study. Although often affected by donor economic interests, appropriately allocated ODAs can support recipient countries to improve more environmentally friendly infrastructure and technologies, which in turn can reduce carbon emissions. Regulatory Quality also moderates Foreign Aid relations. When the quality of a country's regulations is higher, foreign aid tends to be more effective in supporting sustainable environmental policies, which in turn can reduce the negative impact on carbon emissions. These findings are in line with the theory of Regulatory Compliance developed by (Kagan & Scholz, 1984), which emphasises the importance of quality regulation in ensuring that environmental policies are properly implemented. This study supports the opinion of (Mahalik et al., 2021) This indicates that effective supervision of the implementation of regulations can enhance the positive environmental impact of foreign aid.

The findings of this study indicate that the Islamic Capital Market (ICM) has a positive impact on carbon emissions, suggesting that developing sectors within the Islamic capital market can contribute to reducing carbon emissions. Although the Islamic capital market prioritises socially and environmentally responsible investments, some sectors financed through these markets may still use technologies or practices that are not environmentally friendly, or have not adopted clean technology that is sufficiently efficient. This is in line with the research of (Nazir & Khan, 2013), which stated that the Islamic capital market focuses on responsible investment, but there are still challenges in prioritising environmental sustainability. These findings also support (Alam et al., 2017), who emphasised the need for policies to support sustainable investment in the Islamic capital market.

Government Expenditure on Education (GEE), which focuses on increasing environmental awareness, was also found to have a negative effect on carbon emissions in this study. The theory of public expenditure, introduced by Henry C. Adams, suggests that investment in the education sector can enhance public knowledge about environmental sustainability, leading to more environmentally friendly behaviours. The findings of Nurrahmawati and Kusumawardani (2021), which show the impact of education spending on CO2 emission reduction, are in line with the findings of this study.

Finally, economic growth (as measured by GDP) plays a more complex role in relation to carbon emissions. This study confirms the findings of Ekonomou & Halkos. (2023b), which suggests that economic growth can lead to increased energy consumption and environmental degradation. However, with the right policies, such as the adoption of clean technologies, the country can achieve sustainable development without harming the environment. In fact, studies on economies such as the BRICS and G7 countries have found bidirectional causality between economic growth and carbon emissions, suggesting that efforts to reduce emissions may constrain growth in some cases. (Erdogan, 2024; Khalfaoui et al., 2023). A similar pattern has been observed in China, where, while economic growth continues to drive overall emissions up, there is evidence of a long-term coupling between economic growth efficiency and emissions reduction efficiency. (Sheng et al., 2020). This illustrates the complex interplay where economic development, while boosting emissions, can also lead to improvements in emissions reduction with the right technological advancements and policies.

Moreover, research has shown that emissions typically rise with per-capita GDP, with only weak evidence of decoupling at higher income levels. (Schröder & Storm, 2020). This supports the notion that as economies grow, they tend to increase energy consumption, which in turn leads to higher carbon emissions. This has been particularly true in emerging economies, where energy consumption is a significant driver of economic growth, leading to a substantial increase in carbon emissions. (Liu, 2020; Osobajo et al., 2020). However, in developed economies, increased domestic credit to the private sector has sometimes led to decreased emissions, indicating that the financial structure and technological development of the economy also influence the impact of economic growth on emissions. (Obiora et al., 2022).

Overall, the results of this study provide empirical evidence that supports various existing theories about the relationship between investment, economic growth, and their impact on carbon emissions. These findings emphasise the need for effective policies and strict oversight to ensure that economic growth can be achieved without compromising environmental quality.

CONCLUSIONS AND SUGGESTIONS

This study demonstrates that the relationship between investment, economic growth, and their impact on carbon emissions is significantly influenced by various factors, including the type of investment, the quality of regulations, and education policies. The results of the study support multiple theories, including the Pollution Haven Theory, the Environmental Kuznets Curve (EKC), Corporate Social Responsibility (CSR), and the Regulatory Compliance Theory, and demonstrate that government spending on education contributes to the reduction of carbon emissions. Foreign Direct Investment (FDI) has been found to have a positive effect on carbon emissions; however, with policies that support environmentally friendly technologies and strict supervision, the negative impact can be mitigated. Likewise, Foreign Aid (ODA), when managed properly, can reduce carbon emissions, especially with strong regulatory support. The Islamic Capital Market (ICM), despite its focus on responsible investment, can still contribute to an increase in carbon emissions if the sectors it finances have not adopted clean technology. Government Expenditure on Education (GEE) shows a positive impact on reducing carbon emissions through increasing environmental awareness. Economic growth (GDP), despite the potential to increase carbon emissions, can be achieved sustainably through clean technology policies. Overall, this study highlights the importance of implementing effective policies and oversight to achieve sustainable economic growth without compromising environmental quality.

Based on the findings of this study, it is recommended that governments and policymakers strengthen environmental regulations to ensure that foreign investment and foreign aid can have a positive impact on environmental sustainability. Additionally, it is crucial to promote the adoption of clean technology in emerging sectors, particularly in the Islamic capital market. Government spending in the education sector also needs to be increased to strengthen awareness and environmentally friendly behaviour among the public. Finally, policies that support sustainable economic growth, with a focus on green technologies, must be prioritised to maintain a balance between economic development and environmental quality.

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