



From Subsidies to Sustainability: Unveiling the Economic Forces Shaping Renewable Energy Adoption in Emerging Economies

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Abstract. This study investigates the combined impact of fossil fuel subsidies, foreign direct investment (FDI), and GDP per capita on renewable energy consumption in Southeast Asian countries, focusing on Indonesia, Vietnam, Malaysia, and Thailand. By employing panel data regression analysis from 2017 to 2022, the research explores how these economic variables shape the region's transition towards renewable energy. The results reveal that fossil fuel subsidies significantly hinder renewable energy adoption, confirming that government support for fossil fuels creates market distortions that favor non-renewable energy sources. On the other hand, FDI and GDP per capita show a positive and significant relationship with renewable energy consumption, indicating that both foreign investments and economic growth are crucial drivers of the green energy transition. The findings suggest that reducing or eliminating fossil fuel subsidies, while attracting more foreign investments in renewable energy, will be key to accelerating the clean energy transition in Southeast Asia. Future research should explore the impacts of specific types of FDI and more targeted subsidy reforms to gain deeper insights into policy effectiveness.

Keywords: Renewable energy, Fossil fuel subsidies, Foreign direct investment, GDP per capita, Southeast Asia.

1 Introduction

The transition to renewable energy has become an essential goal for countries worldwide to mitigate climate change and foster sustainable development. However, this transition faces numerous challenges, particularly in developing economies, where dependency on fossil fuels is high, and economic growth often takes precedence over environmental concerns. Renewable energy, which is defined as energy derived from natural resources that are replenished on a human timescale, such as solar, wind, and hydropower, plays a crucial role in reducing carbon emissions and enhancing energy security. Despite its importance, the adoption of renewable energy remains low in several Southeast Asian countries due to factors such as government subsidies for fossil fuels, economic constraints, and reliance on foreign investments [1].

Fossil fuel subsidies, in particular, have been identified as a significant barrier to renewable energy adoption. These subsidies, intended to keep energy prices low and

stimulate industrial growth, distort energy markets by making fossil fuels more economically attractive than renewable alternatives [2]. In developing countries such as Indonesia, Malaysia, Vietnam, and Thailand, fossil fuel subsidies account for a substantial portion of government expenditure, making it difficult for renewable energy technologies to compete [3]. Previous studies have extensively documented the negative impact of fossil fuel subsidies on renewable energy in developed economies [4]. However, research in developing economies, especially in Southeast Asia, remains limited, particularly concerning how these subsidies interact with other factors such as economic growth and foreign direct investment (FDI) [5].

Foreign direct investment is another critical factor that influences renewable energy development. FDI can provide the necessary financial resources and technological expertise to support renewable energy projects. For instance, international investment in renewable infrastructure projects can accelerate the adoption of cleaner energy by transferring knowledge and reducing the technological gap [6]. However, FDI in many Southeast Asian countries remains concentrated in traditional energy sectors, such as oil and gas, rather than renewable energy [7]. This misallocation of foreign capital further exacerbates the reliance on fossil fuels and delays the green energy transition.

Furthermore, the economic growth of a country, measured by its GDP per capita, plays a dual role in influencing renewable energy consumption. On the one hand, higher GDP per capita provides greater financial resources for both the government and the private sector to invest in renewable energy technologies [8]. On the other hand, economic growth in developing countries is often accompanied by increased energy consumption, which is typically satisfied by fossil fuel energy sources [9]. Therefore, understanding how economic growth interacts with subsidies and FDI is crucial for developing effective policies to promote renewable energy.

While previous studies have extensively explored the individual effects of fossil fuel subsidies, foreign direct investment, and GDP per capita on renewable energy adoption, there remains a significant gap in understanding the combined impact of these variables in developing economies, particularly in Southeast Asia. The existing literature predominantly focuses on developed nations, where energy policies, economic conditions, and investment flows differ substantially from those in developing regions [10, 11]. Moreover, little attention has been given to the interaction between fossil fuel subsidies and FDI in shaping renewable energy trajectories in countries where fossil fuel industries dominate the economy. This research aims to address this gap by examining the joint effects of energy subsidies, GDP per capita, and FDI on renewable energy consumption in Indonesia, Malaysia, Vietnam, and Thailand, providing new insights into the barriers and drivers of the green energy transition in Southeast Asia.

2 Literature Review

The transition to renewable energy has been widely discussed within the framework of sustainable development theory, which advocates for economic growth that meets current needs without compromising the ability of future generations to meet their own needs. This theory is particularly relevant for developing countries, where

economic growth is often prioritised over environmental sustainability. In this context, fossil fuel subsidies and their role in hindering renewable energy adoption have been extensively studied. Fossil fuel subsidies are governmental financial supports provided to lower the cost of fossil fuels to consumers, making them more competitive than renewable energy sources [12]. However, these subsidies are widely criticised for distorting energy markets and creating barriers to the adoption of cleaner energy technologies [13].

Fossil fuel subsidies reduce the economic competitiveness of renewable energy by artificially lowering the cost of fossil fuel energy. Studies have demonstrated that fossil fuel subsidies delay the transition to renewable energy by creating a price differential that favours fossil fuel consumption. Coady et al. argue that eliminating these subsidies could reduce global carbon emissions by up to 10%, highlighting the significant environmental benefits of subsidy reforms [14]. However, removing fossil fuel subsidies is politically challenging, particularly in developing countries where these subsidies are seen as essential for maintaining affordable energy prices and fostering industrial growth [15]. High levels of fossil fuel subsidies have been negatively correlated with renewable energy adoption in both developed and developing countries. In countries like Indonesia, Vietnam, and Malaysia, fossil fuel subsidies represent a significant portion of government spending, thereby limiting budgetary flexibility to support renewable energy initiatives [16]. Accordingly, we hypothesise that an increase in fossil fuel subsidies is likely to exert a detrimental influence on the consumption of Eco-friendly energy in developing countries.

Foreign direct investment (FDI) has been identified as a crucial driver of renewable energy development, especially in emerging markets [17]. FDI provides the capital and technological expertise required to scale renewable energy projects, which are often capital-intensive and technologically complex. Several studies have noted that FDI is positively correlated with renewable energy adoption, particularly in countries that have favourable regulatory environments [18]. However, FDI flows in Southeast Asia remain predominantly concentrated in the fossil fuel sector, which further entrenches the region's reliance on non-renewable energy [19]. This misallocation of foreign capital hinders the transition to a green economy, as investments in fossil fuels create long-term infrastructural and economic dependencies that are difficult to reverse. We propose the hypothesis that increased levels of foreign direct investment (FDI) in the renewable energy sector will have a positive effect on renewable energy consumption in Southeast Asian countries.

The relationship between GDP per capita and renewable energy consumption is complex. Higher GDP per capita is often associated with increased investments in renewable energy, as wealthier countries have more resources to allocate toward environmental initiatives [20]. However, in developing countries, economic growth is frequently accompanied by rising energy demand, which is typically met through fossil fuel consumption [3]. This dual effect can create a paradox in which economic growth both enables and constrains renewable energy adoption. In Southeast Asia, the positive effects of economic growth on renewable energy consumption may be offset by the region's dependence on fossil fuel subsidies. For example, Malaysia and Indonesia have experienced rapid GDP growth, but this has not necessarily translated into increased renewable energy consumption due to the entrenched subsidy systems [7]. Thus, we hypothesise that higher GDP per capita will have a positive implication

on renewable energy consumption, but this effect may be moderated by the presence of fossil fuel subsidies.

The theoretical framework for this study is grounded in sustainable development theory and the concept of energy transitions, which emphasises the need to shift from fossil fuel-based energy systems to renewable energy sources in order to achieve long-term environmental and economic sustainability [8]. The energy transition model suggests that countries must gradually reduce their reliance on fossil fuels by investing in renewable energy technologies and reforming fossil fuel subsidies. In the context of Southeast Asia, where economic growth is tied closely to energy consumption, the interaction between subsidies, FDI, and GDP per capita is crucial for understanding how the energy transition can be achieved. Based on the literature reviewed, the following hypotheses are proposed: (1) higher fossil fuel subsidies will negatively impact renewable energy consumption, (2) higher levels of FDI will positively influence renewable energy consumption, and (3) higher GDP per capita will have a positive effect on renewable energy consumption, but this effect may be moderated by the presence of fossil fuel subsidies.

Hypotheses: Based on the literature reviewed, the following hypotheses are proposed:

H_1 : Higher fossil fuel subsidies will negatively impact renewable energy consumption in developing countries.

H_2 : Higher levels of foreign direct investment (FDI) will positively influence renewable energy consumption in Southeast Asian countries.

H_3 : Higher GDP per capita will have a positive impact on renewable energy consumption, but this effect may be moderated by the presence of fossil fuel subsidies.

3 Methodology

This study employs a quantitative approach using panel data regression analysis to investigate the impact of fossil fuel subsidies, foreign direct investment (FDI), and GDP per capita on renewable energy consumption in Southeast Asian developing countries: Indonesia, Vietnam, Malaysia, and Thailand. The period of analysis spans from 2017 to 2022, based on data availability for the selected countries. Panel data analysis allows the examination of both cross-sectional and time-series variations, which is crucial for capturing the dynamics of clean energy adoption over time and across different countries.

The data used in this study are obtained from reputable international sources. The dependent variable, renewable energy consumption (expressed as a percentage of total final energy consumption), is obtained from the World Bank. This indicator reflects the share of energy consumption derived from renewable sources such as wind, solar, and hydropower, serving as the primary measure of the green energy transition. The independent variables in this study include: (1) fossil fuel subsidies and other transfers (as a percentage of government expenditure), sourced from the International Energy Agency (IEA). This variable measures the proportion of government spending allocated to subsidies and transfers that reduce the cost of fossil fuels, thereby

incentivising their consumption; (2) GDP per capita (constant 2015 US dollars), also obtained from the World Bank, which represents the economic capacity of the selected countries to invest in Eco-friendly energy infrastructure; and (3) foreign direct investment (net inflows as a percentage of GDP), also sourced from the World Bank, which reflects capital investment from foreign entities that could potentially support renewable energy projects.

This study employs both fixed effects (FE) and random effects (RE) regression models to estimate the impact of the independent variables on renewable energy consumption. The choice between fixed and random effects models is determined using the Hausman test, which evaluates whether country-specific effects are correlated with the explanatory variables. If the Hausman test favours the fixed effects model, this indicates that differences across countries are captured by unobserved heterogeneity. If random effects are preferred, country-specific effects are considered random and uncorrelated with the independent variables.

The regression model to be estimated is as follows:

$$\mathfrak{R}_i = a + B_1 \text{Subsidies}_i + B_2 \text{FDI}_i + B_3 \text{GDPpc}_i + \epsilon_i \quad (1)$$

where \mathfrak{R}_i represents renewable energy consumption in country i at time t , Subsidies_i represents fossil fuel subsidies in country i at time t , FDI_i represents foreign direct investment in country i at time t , and GDPpc_i represents GDP per capita in country i at time t , ϵ_i representing the error term.

To ensure the robustness of the results, robust standard errors are employed to address potential heteroskedasticity in the error terms. This is crucial because the variance of errors may not be constant across countries due to differences in economic size or policy environments. Furthermore, multicollinearity among the independent variables is tested using the variance inflation factor (VIF). Variables with a VIF exceeding 10 are considered to exhibit multicollinearity, and adjustments are made if necessary.

The model is estimated using ordinary least squares (OLS) with both fixed and random effects. The significance of the coefficients is tested at the 5% significance level using t-statistics to determine the strength of the relationships between the independent and dependent variables. The R-squared value is reported to assess the explanatory power of the model, while the F-statistic is used to test the overall significance of the model. The results are then interpreted in light of existing literature to evaluate whether fossil fuel subsidies, FDI, and GDP per capita significantly impact renewable energy consumption in the selected Southeast Asian countries.

4 Result and Discussion

4.1 Regression Analysis

The results of the fixed effects regression are summarised in Table 1. The dependent variable, renewable energy consumption, is regressed against fossil fuel subsidies, foreign direct investment (FDI), and GDP per capita. The R-squared value of the model is 0.73, indicating that 73% of the variability in renewable energy consumption

is explained by the independent variables in the model. The F-statistic is significant, showing that the model is statistically valid overall. The results are summarised in the table below:

Table 1. Descriptive Statistic

Variable	Coefficient	Standard Error	t-Statistic	p-Value	Significant
Fossil Fuel Subsidies	-0.215	0.092	-2.34	0.024	Significant
FDI GDP per capita	0,84375	0.054	03.24	0.003	Significant
Constant	0,617361111	0.045	0,109722222	0.011	Significant
	1.403		1,2875	05.26	0.000 Significant

Source: Author own estimation (2024)

The results of the regression analysis indicate significant relationships between fossil fuel subsidies, foreign direct investment (FDI), and GDP per capita with renewable energy consumption in the selected Southeast Asian countries. The negative coefficient for fossil fuel subsidies (-0.215) suggests that as fossil fuel subsidies increase, the consumption of renewable energy decreases. This finding is statistically significant with a p-value of 0.024, indicating that fossil fuel subsidies act as a barrier to the adoption of renewable energy in the region. This result aligns with the broader literature on energy markets, which argues that subsidies for fossil fuels distort market dynamics by making fossil fuels more economically attractive compared to renewable energy sources. Consequently, removing or reducing these subsidies is likely to promote a transition towards cleaner energy alternatives.

The analysis also reveals that FDI has a positive and significant effect on Clean energy consumption, with a coefficient of 0.1215 and a p-value of 0.003. This indicates that foreign direct investment plays an important role in promoting Green energy in the region. As FDI inflows increase, countries are more likely to invest in Green energy infrastructure, which can lead to a rise in the consumption of clean energy. This finding supports the argument that foreign investments, particularly in sectors related to clean energy, are crucial for scaling up renewable energy projects in developing countries. Attracting more FDI into the Eco-friendly energy sector could be a key strategy for Southeast Asian countries to accelerate their energy transitions.

The positive and significant coefficient for GDP per capita (0.0889) with a p-value of 0.011 suggests that higher levels of economic development are associated with increased Eco-friendly energy consumption. As countries grow wealthier, they are better positioned to invest in renewable energy technologies and infrastructure. However, this relationship must be viewed within the context of overall energy demand, as economic growth in developing countries often leads to higher energy consumption. The challenge for these countries will be to ensure that the additional energy demand generated by economic growth is met through renewable sources rather than through increased consumption of fossil fuels. These results collectively underscore the complex dynamics of energy transitions in Southeast Asia, where economic growth, foreign investment, and government policies regarding fossil fuel subsidies interact to shape renewable energy adoption.

4.2 Discussion

These findings are consistent with the theoretical framework of energy transitions, which posits that fossil fuel subsidies hinder the adoption of renewable energy, while FDI and economic growth can drive progress toward sustainability [10]. The negative relationship between fossil fuel subsidies and renewable energy consumption confirms that these subsidies are a major barrier to green energy adoption in Southeast Asia. Policymakers in Indonesia, Vietnam, Malaysia, and Thailand should consider reforming their subsidy schemes to reduce their dependency on fossil fuels and encourage cleaner alternatives.

The positive relationship between FDI and renewable energy consumption highlights the importance of attracting foreign investments in the energy sector. Governments should focus on creating favourable regulatory environments that incentivise foreign capital to flow into renewable energy projects rather than fossil fuel industries. This could include tax incentives, streamlined approval processes, and robust legal protections for investors.

Finally, the positive impact of GDP per capita on renewable energy consumption underscores the importance of economic growth in supporting the green energy transition. However, as noted earlier, this growth can also drive up overall energy demand, which must be carefully managed to avoid increasing fossil fuel consumption [7]. Governments in the region must strike a balance between fostering economic growth and ensuring that the additional energy demand is met through renewable sources.

The findings of this study suggest several policy interventions that could help accelerate the transition to renewable energy in Southeast Asia. First, reducing or eliminating fossil fuel subsidies should be a priority for governments. This could be done gradually to avoid public backlash and ensure energy security for the population. Second, promoting FDI in renewable energy by providing incentives and creating a stable investment climate will be essential to scaling up clean energy projects. Lastly, as economies grow, policymakers should focus on integrating renewable energy into national energy strategies to ensure that the benefits of economic development are not offset by increased fossil fuel consumption.

5 Conclusion

This study has demonstrated that fossil fuel subsidies, foreign direct investment (FDI), and GDP per capita significantly influence eco-friendly energy consumption in Southeast Asian countries. The findings highlight that fossil fuel subsidies have a negative impact on the adoption of renewable energy, reinforcing the need for policy reforms aimed at reducing these subsidies to promote cleaner energy alternatives. Additionally, the positive effects of FDI and GDP per capita on renewable energy consumption suggest that both foreign investments and economic growth are crucial drivers of the green energy transition. These results underline the importance of creating a favourable investment climate for renewable energy and ensuring that economic development is aligned with sustainability goals.

However, this study has some limitations that should be addressed in future research. First, the analysis is limited to four Southeast Asian countries, which may not fully capture the broader dynamics of renewable energy adoption in other developing regions. Future research could extend the scope to include a wider range of countries, particularly in regions such as Africa or Latin America. Second, the study focuses on aggregate measures of FDI and subsidies without distinguishing between different types of investments or subsidy programmes. Further research could explore how specific forms of FDI (e.g., renewable vs. non-renewable) and targeted subsidy reforms impact the green energy transition. Lastly, the study uses data from 2017 to 2022, and incorporating longer time frames or more granular data could provide deeper insights into long-term trends and the effectiveness of policy changes.

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