International Journal of Research in Engineering, Science and Management
Volume 6, Issue 12, December 2023
https://www.ijresm.com | ISSN (Online): 2581-5792

Impact of Investments and Renewable Energy Consumption on the Economic Growth of ASEAN-5

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***Abstract*: This study intends to scrutinize the impact of investments (both foreign and direct), and energy demand on economic growth for ASEAN-5 countries. Pooled ordinary least squares regression (POLS), fixed and random effect models were used in the study, which covered yearly panel data from 1999 - 2014 to estimate the relationship between investment, REC, and economic growth. The study employs Levin–Lin–Chu, Dickey-Fuller, and Fisher PP tests to examine the data stationarity of the variables. Furthermore, the generalized method of moments (GMM) estimates the economic parameters. The pooled ordinary least squares were also employed to evaluate the impact. The findings indicate a significant and positive relationship between investment and renewable energy in ASEAN-5 countries. The study's findings showed a significant positive correlation between GDP and renewable energy consumption.**

***Keywords*: economic growth, investments, FDI, environmental sustainability, renewable energy, energy consumption, ASEAN-5.**

1. Introduction

The environment is essential to economic growth because it supplies the natural resources and ecological services necessary to support economic activity. Raw materials for utilized for manufacturing and the basis for agricultural production are derived from different natural resources. Natural resources like coal, oil, and gas are critical for energy production. They generate electricity, fuel transportation, and industrial power processes.

Energy is a critical input in economic activities and is essential for economic productivity and growth. Energy is used in various sectors of the economy, such as transportation, manufacturing, and agriculture, and is required for the production and consumption of goods and services. The availability and affordability of energy can affect economic growth, trade, and competitiveness and significantly impact productivity, as industries and businesses rely on energy to power their operations (International Energy Agency, 2019). Energy resources are important in economic growth and development. In contrast, access to affordable energy enhances productivity, and energy plays a critical role in developing various sectors, including transportation, agriculture, and manufacturing (Smil, 2003). Inadequate access to energy services results in lower productivity and increased costs, negatively impacting economic growth (World Bank, 2019).

Human society is still heavily reliant on nonrenewable resources such as Petroleum, coal, and oil are the main sources of energy. fossil fuels account for over 80% of the total energy consumed worldwide yearly due to their abundant energy and low processing costs (National Geographic Education, 2022). One of the main reasons for this continued reliance is the existing infrastructure and economic systems built around nonrenewable energy sources, making it difficult and expensive to transition to renewable energy sources (International Renewable Energy Agency, 2020). While these energy sources have provided significant economic growth and development benefits, they also have several disadvantages that make them unsustainable in the long run. Nonrenewable energy sources are finite and will eventually be exhausted. As we continue to extract and consume these resources, they become increasingly difficult and expensive to access, leading to supply shortages and price increases (Ibrahim et al., 2021). Furthermore, the environmental impacts of extracting and processing these resources, such as deforestation, and air and water pollution, can be significant and long-lasting (Bertrand, 2021).

Politicians, researchers, economists, and environmentalists have all debated to what extent and degree countries rely on oil and natural gas supplies. Since environmental factors can have a negative (World Bank, 2019) impact on productivity levels (OECD, 2016), there is growing interest in promoting the consumption of renewable energy sources, which can lessen reliance on fossil fuels and minimize the release of greenhouse gases, such as the sun, wind, and water powered electricity (International Renewable Energy Agency, 2020) since investments in renewable energy and energy efficiency can lead to job creation and increased economic productivity (ILO, 2019). Replacing fossil fuels with renewable energy could help minimize global warming to less below 2 degrees Celsius. (Creutzig et al., 2017) by lowering CO2 emissions worldwide (Jacobson et al., 2015). Renewable energy can alsoserve a crucial part towards achieving the Sustainable Development

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Goals of the United Nations, particularly in poverty reduction, energy access, and climate action (Erikson et al., 2018), contributing to economic growth and social development (Quitzow et al., 2021).

In line with a study (Gyimah et al., 2022), renewable energy has a major influence on economic growth. This is demonstrated by a study that uses data from 1990 to 2015 and applies the Granger causality and the mediation model. Consequently, the rise in the use of renewable energy has a favorable impact on economic growth, which suggests that the use of renewable energy should be promoted to stimulate economic growth. In the same way, renewable energy promotes economic expansion in both developed and developing nations. However, for developed nations, the threshold level of renewable energy consumption has little bearing on economic growth, as per Bhuiyan et al. within their 2022 study on the relationship across the use of renewable energy sources and growth in the economy of G7 and Next-11 countries.

Since transitioning into renewable energy would incur many costs (Toh, 2021), foreign direct investments (FDIs) have the potential to fund the use of renewable energy (RE) projects through the establishment of joint ventures and partnerships between foreign investors and local stakeholders (Brunnschweiler, 2010; Adu & Denkyirah, 2018) as to foreign companies involved in FDI are highly attuned to and exhibit greater awareness of environmental regulations and preservation measures (Eskeland & Harrison, 2003). Moreover, FDI inflows can increase the availability of financing and technology for renewable energy projects and create demand for renewable energy from foreign firms operating. Foreign direct investment (FDI) and renewable energy consumption significantly affect economic growth (Kang et al., 2021; Alper & Oguz, 2016), given the negative consequences of excessive greenhouse gas use of fossil fuels, which results in large-scale carbon emissions and unpredictable high energy prices.

This study helped gauge both the impact of investments, both foreign and direct, on economic growth and the impact of renewable energy consumption on the economic growth of ASEAN-5. This research also analyzed the connection between investment and renewable energy consumption within the ASEAN-5 and how investments and renewable energy consumption collectively influence the economic growth between the ASEAN-5. Hence, we chose the ASEAN-5 countries (Indonesia, Philippines, Thailand, Malaysia, and Singapore) from the Association of Southeast Asian Nations (ASEAN) to assess the potential for future economic growth of ASEAN 5, integrating the United Nations Sustainable Development Goals and made economic policy recommendations concerning the connection of investments and renewable energy consumption in boosting the economy of ASEAN-5.

2. Literature Review

A. Renewable Energy Consumption and Investment Nexus

1) Renewable Energy Consumption and Direct Investment

The use of renewable energy significantly enhances the condition of the environment and the overall well-being of the ecosystem. The renewable energy industry is continuously expanding and demands more financial support. Consequently, several recent studies have aimed to determine this connection to confirm the relationship between renewable energy consumption (REC) and financial development (FD).

Several empirical studies revealed that economic growth is the main factor of renewable energy consumption. (Raza et al., 2023). Results showed that final demand is the main cause. (Li et al., 2022). Studies have also revealed direct investments affect usage of renewable energy. Additionally, it is identified that an increase in investment per capita leads to a higher consumption of renewable energy (Wang et al., 2019).

Kutan et al. (2018) utilized different panel data methods to examine four developing economies between 1990 and 2012. The findings revealed a positive influence of stock market growth on clean energy consumption. Chang (2015) backed the idea that the growth of the stock market influences energy consumption among developing and new market economies in a positive way. Recently, Paramati, Bhattacharya, et al. (2016) examined how stock markets function in relation to energy demand in frontier markets in Africa. Their empirical investigation generated results that show how much the expansion of stock markets contributes to rising energy consumption.

2) Renewable Energy Consumption and Foreign Direct Investment

The transition to a low-carbon economy has become a pressing global issue. Renewable energy consumption has emerged as a crucial element in this transition. Foreign direct investment (FDI) has also been recognized as an important factor in promoting sustainable development, including the transfer and diffusion of renewable energy technologies. Doytch and Narayan (2016) utilized a dynamic panel estimator provides insight into how FDI inflows affected the use of industrial energy resources, either non-renewable and renewable, in 74 various nations between 1985 and 2012.

They analyzed FDI inflows by dividing them into four components: mining, manufacturing, comprehensive services, and financial services. The results revealed that FDI positively affects renewable energy consumption while reducing non-renewable energy consumption. Moreover, Mert and Bölük (2016) carried out research on the influence of renewable energy consumption and foreign direct investments (FDIs) on carbon dioxide emissions using imbalanced panel data. The study found that FDIs can introduce clean technology and enhance environmental regulations, reducing carbon emissions.

Many countries have implemented policies and regulations encouraging FDI in renewable energy projects. For instance, countries like China (Li et al., 2020), India (Ahammad et al., 2022), and Brazil (Tan & Uprasen, 2022) have implemented feed-in tariffs and other incentives to attract FDI in renewable energy projects. Similarly, many countries have signed international agreements and treaties that promote renewable energy investments and FDI. The Paris Agreement, for instance, aims to promote international cooperation and investments in renewable energy projects to mitigate climate

change. In connection with these, policies aimed at promoting renewable energy development, such as introducing a feed-in tariff scheme and renewable energy targets, positively impacted attracting FDI in the renewable energy sector. (Leng and Fan, 2021)

Sbia et al. (2014) conducted an examination of the correlation between foreign direct investment (FDI), clean energy, trade openness, carbon emissions, and economic growth in the United Arab Emirates (UAE) during the period from 1975Q1 to 2011Q4. The ARDL boundary test and VECM Granger causality test were employed to analyze this relationship. The empirical findings indicate that FDI, trade openness, and carbon emissions contribute to a decrease in energy demand and economic growth. In contrast, clean energy has a positive influence on energy consumption. Furthermore, the Granger causality test results reveal a mutually causal relationship between direct foreign investment and green energy.

Keeley and Ikeda (2017) aimed to assess the efficacy of renewable support policies in attracting foreign direct investments (FDIs), specifically in the wind energy sector. Exploratory factor analysis (EFA) and structural equation modeling (SEM) were used to do this, with an emphasis on ten developing nations from 2008 to 2014. Instead of looking at FDIs in general, the researchers stressed the need to look at FDI factors that specifically target a particular industry. This method was thought to be essential for comprehending the variables influencing investments in this particular field.

B. Renewable Energy Consumption and Economic Nexus

Energy consumption is a key driver of economic growth; however, it has negative environmental impacts. The impact of energy efficiency, access to financial services, economic expansion, environmental-related technology advancements, and human resources index on CO2 emissions, on the other hand, found an inverse correlation among CO2 emission and renewable energy consumption (Alola et al., 2019; Sharif et al., 2019; Huang & Salahodjaev, 2021; Zhang & Nan, 2022). Moreover, the primary driver of environmental deterioration is non-renewable energy usage (Chen et al., 2019). Thus, increased concerns about environmental deterioration and global climate change highlight the need for more renewable energy (Azam et al., 2021) as it is associated favorably with environmental quality (Huang et al., 2022).

The usage of renewable energy has been linked to economic growth, proven by studies (Matar & Abbasi, 2021; Gao et al., 2020; Ntanos et al., 2018) concluded that there is a higher correlation between REC and economic growth in countries with higher GDP than in countries with lower GDP. The researchers conducted the study by covering 25 European countries.

Huang et al. (2022) looked at how human capital, relationship between economic growth, and eco-innovation affected aggregate and differentiate amounts of energy use both for renewable and non-renewable. Results indicate that total energy consumption, renewable energy consumption, and non-renewable energy consumption are all positively correlated with economic growth, indicating that an increase in wealth is followed by an increase in energy consumption. Moreover, Raihan and Tuspekova (2022) shown that using renewable energy protects long-term global economic production while reducing the consumption of traditional energy.

C. Renewable Energy Consumption and Investment Nexus

1) Direct Investment and Economic Growth

The consistent and causative relationship between economic growth and public spending was explored by (Odo et al., 2016) using annual data from 1980 to 2014, with a focus on the case of South Africa. The findings supported Wagner's theory by showing a consistent and long-lasting link between these factors. In addition, a further research project was carried out that looked at panel data from 59 nations from 1990 to 2019. Public spending and economic growth have a positive link (Ahuja and Pandit, 2020). As stated in the study, investment is essential for promoting economic growth, especially in developing countries. Moreover, in their study of OECD nations, Ertekin and Bulut discovered in 2021 that although public spending has a short-term beneficial impact on economic growth, there is no long-term evidence of this link. Moreover, government investments have the potential to positively affect private investment and boost short term economic development. On the other hand, there might be significant adverse effects in the future. In certain developing countries, government financial decisions are sometimes ill-defined and ineffectual, and exorbitant expenditure may need borrowing from private sources. ((Nguyen & Trinh, 2018)

2) Foreign Direct Investment and Economic Growth

Numerous economies, particularly those with significant technological progress, have been attributed to foreign direct investment as the most significant and essential element (Gunby et al., 2017; Silajdzic and Mehic, 2016). An empirical data analysis discovered that FDI was the leading cause of economic development and that there was a long-term equilibrium link between the two (Chen and Li, 2011). Additionally, implementing panel data from European nations in which GDP per person was under 25,000 US dollars, the impact caused by FDI and money transfers on economic growth was found to be favorable. However, by adopting the ceteris paribus principles assumption to restrict the research caused by other potential variables, FDI was found to have a more substantial impact in all the states that were studied (Comes, 2019; Phan and Kim (2021) analyzed the impact of FDI on economic growth in the Philippines using a cointegration approach. The study found that FDI positively impacts economic growth in the Philippines, and this effect is more robust in the long run than in the short run.

3. Method

A. Data

This study examined the impact of foreign direct investment and renewable energy consumption on the economic growth of the ASEAN-5 countries using panel data of five ASEAN countries from 1990 until 2019. Economic growth was a dependent variable measured by the real gross domestic product

per capita (RGDP) in current US$ to assess the impact of investments, which consisted of foreign direct investment (FDI) measured by the net inflow (% of GDP) and direct investment (DI) measured by gross capital formation % of GDP. Renewable energy consumption (REC) was measured as the percentage of total final energy consumption, and non-renewable energy consumption (NREC) was measured by the % of Total Fossil Fuel Energy Consumption. Moreover, REC was also a dependent variable in analyzing its connection with INV (FDI and DI).

B. Method

This study examined the impact of INV and REC on economic growth, and the relationship between INV and REC had not yet been investigated for ASEAN-5 in preexisting studies. All data were collected from World Development Indicators of the World Bank for ASEAN-5. The selection of the factors was based on an analysis of prior research, such as that done by Naz et al. (2019), which investigated the effect that the use of renewable energy, foreign direct investment inflows, and economic growth had on carbon dioxide emissions in Pakistan. In 2015, Ibrahiem studied the relationship between foreign direct investment (FDI), economic development, and renewable energy certificates (REC) in Egypt using the autoregressive distributed lag (ARDL) approach.

To evaluate the relationship of investments and renewable energy consumption and how it influences the economic growth of ASEAN-5, the researchers regressed the following equations:

$$GDPit = \alpha + \beta 1DI + \beta 2FDI + \beta 3REC + \varepsilon it$$
$$RECit = \alpha + \beta 1DI + \beta 2FDI + \varepsilon it$$

where GDP is the Economic Growth, DI is the Direct Investment, FDI is the Foreign Direct Investment, REC is the Renewable Energy Consumption, NREC is the Non-Renewable Energy Consumption.

Researchers sourced data from World Bank to gather historical data on the investments, economic growth, and energy consumption of each of the ASEAN-5. This study run a panel regression with a scope of 15 years ranging from 1999 – 2014.

1) Stationarity Test

Testing stationarity is crucial when working with time series data. A unit root often describes stochastic patterns in macroeconomic data. Testing the data stationarity of the data series is significant in ensuring that the regression findings are not fabricated. The data set is considered stationary if its mean does not change throughout the observation period, its variance does not change, its covariance does not change, and its lag length does not change. Various models have been presented by scholars to test for series stationarity. In this analysis, we used the Phillips Perron Fisher chi-square test (Phillips and Perron 1988), the enhanced Dickey-Fuller test (Dickey and Fuller, 1981), and the Levin-Lin-Chu test (Levin et al., 2002). For this analysis, the ADF equation is

$$\Delta yt = \alpha + yyt - 1 + \lambda t + \upsilon t,$$

where Δyt is the change in variables in time t and 〈 is a constant, yt - 1 is a lagged period and y, λ, and υ are the error terms in t. The unit root hypothesis (H0; y = 0) is the starting point for the test, whereas the absence of a unit root (HA; y < 0) is the alternative. The series is stationary if the null hypothesis can be rejected.

2) Panel regression fixed and random effects.

This study includes panel data from five nations; hence panel OLS, fixed effect, and random effect models are suitable. The equations are as follows:

$$GDPit = \alpha + \beta 1DI + \beta 2FDI + \beta 3REC + \varepsilon it$$
$$RECit = \alpha + \beta 1DI + \beta 2FDI + \varepsilon it$$

Countries are denoted by subscript i, (i = 1, …, 5), time by subscript t (t = 1999, …, 2014). and independent variables by b1, b2. Pooled OLS and random-fixed-effect models were selected using Hausman and Breush–Pagan Lagrange multiplier (LM) tests. The Hausman test report assumes a random-effect model is better than a fixed-effect model, whereas the Breush–Pagan LM test assumes the opposite. The null hypothesis cannot be rejected if the p-value exceeds 5%.

3) Generalized method of moments

Statistical models estimate economic parameters using the generalized method of moments (GMM). It generalizes methods of moments with more moment conditions than parameters. Overidentified estimators can be efficiently combined using the GMM. GMM findings are more robust than maximum likelihood since it assumes random variable moments across the distribution.

To prevent the occurrence of autocorrelation and heteroscedasticity (Arellano and Bover, 1995; Blundell and Bond, 1998), the system GMM has been implemented on the equations. Arellano and Bond's (1991) second-order autoregressive (AR2) and Sargan tests (Sargan, 1958) assessed model consistency. The Sargan test assumes the overidentifying limitations are valid, whereas serial correlation requires the equation is not serially correlated at the second order (AR2).

Small samples fit GMM models. The link between lagged dependent variables and the unabsorbed residual makes cross-sectional panel data ideal for system GMM (Doytch and Narayan, 2016).

Table 1
Measurement of variable

Variable	Description	Type	Measurement Technique and proxy
RGDP	Gross Domestic Product	DV	GDP per capita in current US$
REC	Renewable Energy Consumption	IV	% of Total Final Energy Consumption
NREC	Non-Renewable Energy Consumption	IV	% of Total Fossil Fuel Energy Consumption
FDI	Foreign Direct Investment	IV	Net inflow % of GDP
DI	Direct Investment	IV	Gross capital formation % of GDP

4. Results and Discussions

Evidence from related literature supported that both investment and renewable energy consumption affected economic growth (Matar & Abbasi, 2021; Gao et al., 2020; Ntanos et al., 2018). This study aimed to analyze both the impact of investments, both foreign and direct, on economic growth and the impact of renewable energy consumption on the economic growth of ASEAN-5. This research also analyzed the connection between investment and renewable energy consumption within the ASEAN-5 and how investments and renewable energy consumption collectively influenced economic growth between the ASEAN-5. The analysis utilized various econometric models, including Pooled Ordinary Least Squares (POLS), fixed and random effect models, and the Generalized Method of Moments (GMM).

Table 2
Numerical results

	RGDP	REC	NREC	FDI	DI
Mean	12444.95	16.10	84.64	6.42	25.72
Med	4689.40	12.41	86.32	3.34	25.08
Std. Dev	15999.74	15.94	13.68	7.58	4.05
Kurt	1.73	-1.19	-1.33	0.64	0.06
Skew.	1.69	0.53	-0.50	1.40	0.60
Min	663.50	0.33	61.46	-2.76	17.22
Max	57564.80	45.80	98.92	26.33	35.17

The mean RGDP of 12,444.95 suggested a considerable average economic output, but the high standard deviation (15,999.74) indicated substantial variability among these nations. The positive skewness (1.69) and kurtosis (1.73) suggested a distribution with some countries experiencing notably high economic growth. In terms of renewable energy consumption (REC), the moderate mean (16.10) and positive skewness (0.53) indicated that, on average, these countries had a moderate level of REC, but some outliers with higher consumption levels might have been present. Non-renewable energy consumption (NREC) had a relatively high mean (84.64) with a skewness close to zero (-0.50), implying a more balanced distribution. FDI demonstrated a moderate mean (6.42) and positive skewness (1.40), suggesting that while these countries, on average, attracted moderate FDI, there were outliers with substantial foreign investments.

The statistical result represented the findings of a panel data regression analysis with the dependent variable "DLOG(RGDP)" and several independent variables. The analysis was conducted using the Panel EGLS (Cross-section random effects) method, and it covered a sample period from 1999 to 2014, with a total of 16 periods and 5 cross-sections, resulting in a balanced panel dataset with 80 observations. The constant coefficient was approximately -0.3286. This suggested that when all independent variables were zero, the dependent variable, DLOG(RGDP), was expected to be approximately -0.3286. Variable REC had a coefficient of approximately 0.0052. This indicated that a one-unit increase in REC was associated with an increase of approximately 0.0052 in the dependent variable. Moreover, variable NREC had a coefficient of approximately 0.0039. This implied that a one-unit increase in NREC was associated with an increase of approximately 0.0039 in the dependent variable. The variable FDI had a coefficient of approximately 0.0007. This coefficient was not statistically significant (p-value = 0.5462), suggesting that FDI may not have had a strong effect on DLOG(RGDP). Consequently, DI had a coefficient of approximately -0.0007. Similar to FDI, this coefficient was not statistically significant (p-value = 0.7676), indicating that DI may not have had a significant impact on DLOG(RGDP).

Table 3 showed that energy consumption, both renewable and non-renewable, had a p-value less than alpha ($p < 0.05$), which implied rejecting the null hypothesis and accepting the alternative hypothesis, whereas there was a statistically significant positive impact on economic growth, indicating that an increase in energy consumption, both renewable energy and non -renewable, was associated with higher economic growth. Moreover, evidence from the results showed that investments, both direct and foreign, also exhibited positive coefficients but were not statistically significant at the 5% alpha level ($p > 0.05$). Therefore, the null hypothesis was accepted.

Table 3
Statistical results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.328634	0.108210	-3.037010	0.0035
REC	0.005172	0.001198	4.318473	0.0001
NREC	0.003851	0.001080	3.565398	0.0007
FDI	0.000680	0.001121	0.606886	0.5462
D(GROSS_CAPITAL)	-0.000733	0.002469	-0.296843	0.7676
Effects Specifications				
	S.D.		Rho	
Cross-section random	0.000000		0.0000	
Period fixed (dummy variables)				
Idiosyncratic random	0.051064		1.0000	
Weighted Statistics				
R-squared	0.736610		Mean dependent var	0.080348
Adjusted R-squared	0.653203		S.D. dependent var	0.089791
S.E. of regression	0.052877		Sum squared resid	0.167761
F-statistic	8.831525		Durbin-Watson stat	1.620401
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.736610		Mean dependent var	0.080348
Sum squared resid	0.167761		Durbin-Watson stat	1.620401

Table 4
Correlated random effects – Hausman Test

Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	8.337623	4	0.0800

The Hausman test checked for the presence of endogeneity in the model. In that case, the test was testing the cross-section random effects. The Chi-Square statistic (8.3376) with 4 degrees of freedom and a p-value of 0.0800 suggested that the random effects might be endogenous. The analysis included cross-section random effects with a standard deviation (S.D.) of 0. This meant that there were no significant cross-sectional variations in the dependent variable. Period fixed effects (dummy variables) were included to capture period-specific effects. Idiosyncratic random effects had a standard deviation of approximately 0.0511. The R-squared value (0.7366) indicated that the model explained a substantial portion of the variation in the dependent variable. The Durbin-Watson statistic (1.6204) measured the presence of autocorrelation in the residuals. A value close to 2 suggested no autocorrelation. The F-statistic (8.8315) was used to test the overall significance of the regression model, and the low p-value (0.0000) suggested that the model was statistically significant. The mean of the standardized residuals was close to zero, indicating that the model's predictions were unbiased. The Jarque-Bera test for normality suggested that the residuals may not have followed a normal distribution, as indicated by the low p-value (0.0117). This statistical analysis showed that the model was a good fit for the data, with some variables (REC and NREC) significantly affecting the dependent variable, DLOG(RGDP). However, FDI and DI did not appear to have had a significant impact. The presence of endogeneity in the random effects was suggested by the Hausman test, which could have been further investigated.

Panel data regression was conducted to understand the relationships between the dependent variable "DLOG(RGDP)" and several independent variables. The method employed was Panel EGLS (Cross-section random effects), utilizing a dataset covering the period from 1999 to 2014, with 16 time periods and 5 cross-sectional observations, resulting in a balanced panel dataset comprising 80 data points. The coefficients derived from the regression analysis provided insights into the relationships between the variables. Notably, the constant coefficient represented the expected value of the dependent variable when all independent variables were zero. The positive coefficients for REC and NREC suggested that increases in these variables were associated with higher values of DLOG(RGDP), indicating a positive impact on economic growth. (Huang et al., 2022, Matar & Abbasi, 2021; Gao et al., 2020; Ntanos et al., 2018) However, the non-significant coefficients for FDI and DI implied that these variables might not have had a strong effect on economic growth. (Nguyen & Trinh, 2018).

The effects specification included cross-sectional random effects with a standard deviation of 0, indicating that there were no significant cross-sectional variations in the dependent variable. Period fixed effects were included to capture period-specific effects, while idiosyncratic random effects exhibited a standard deviation of approximately 0.0511. The statistics provided offered further insights into the model's performance. The high R-squared value (0.7366) indicated that the model explained a substantial portion of the variation in the dependent variable. The Durbin-Watson statistic suggested a lack of autocorrelation in the residuals, and the low p-value for the F-statistic (0.0000) demonstrated the overall statistical significance of the model. However, the Jarque-Bera test raised concerns about the normality of residuals, indicating potential deviations from a normal distribution. The Hausman test assessed the presence of endogeneity in the model. The test suggested that cross-section random effects might have been endogenous, warranting further investigation.

5. Conclusion

In this paper, we have analyzed data from 1999 to 2014 for ASEAN-5 countries (Indonesia, Malaysia, the Philippines, Thailand, and Singapore) to investigate the impact of investment (both foreign and direct), renewable energy consumption (REC), and economic growth using Pooled Ordinary Least Squares (POLS), fixed and random effect models, and the Generalized Method of Moments (GMM). The research validates the cointegration between economic growth and renewable energy sources and both foreign and direct investment, as well as the fact that both renewable and positive correlations exist between direct investment and economic growth.

Since energy is known to be a constraint on economic growth and to be prudential in the socioeconomic development of a country, it is critical to diversify the energy mix to maintain access to energy. Therefore, in addition to traditional energy sources, renewable energies have a significant impact. The empirical results indicate that renewable energy consumption and non - renewable energy consumption have a significant positive impact on economic growth as per the data set. By contrast, foreign direct investment and direct investment does not positively affect economic growth for the studied countries. As a result, the governments should prioritize policies that promote the use of clean energy, which is less harmful to the environment, and sustainable growth, as these countries have large potential sources of clean energy. Furthermore, one of the primary challenges at hand is the high cost of renewable energy relative to electricity generated from fossil fuels. Therefore, prices for renewable energy should fairly reflect their socioeconomic benefits. Moreover, growth in the economy results in renewable consumption of electricity, which illustrates how crucial economic growth is to the promotion of renewable energy sources, and as Apergis and Danuletiu (2014) observed, this can be accomplished by utilizing the resources resulted from growth in the economy using renewable energy sources for electricity. Since the use of renewable energy drives economic growth, the consumption of renewable energy drives economic growth as well. As a result, promoting the use of renewable energy requires a well-thought-out strategy. Expansion strategies like offering financial incentives to get both public and private money to invest in renewable energy.

electricity sources by providing loans with advantageous conditions. Furthermore, the government is encouraged to allocate a significant portion of financial resources to initiatives involving environmental technologies research and development renewable energy sources and emphasizes workforce education and training in this area.

References

[1] Ahuja, Deepti & Pandit, Deepak. (2020). Public Expenditure and Economic Growth: Evidence from the Developing Countries. FIIB Business Review. 9..

[2] Ali, Q.A., Khayyam, U., & Nazar, U. (2020). Energy Production and CO2 Emissions: The Case of Coal Fired Power Plants under China Pakistan Economic Corridor. Journal of Cleaner Production, 124974.

[3] Alola, A. A., Bekun, F. V., & Sarkodie, S. A. (2019). Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe. Science of The Total Environment, 685, 702–709.

[4] Alper, A., and Oguz, O. (2016). The role of renewable energy consumption in economic growth: evidence from asymmetric causality. Renewable and Sustainable Energy Reviews 60, 953– 959

[5] Alvarez-Herranz, A., Balsalobre-Lorente, D., Shahbaz, M., & Cantos, J. M. (2017). Energy innovation and renewable energy consumption in the correction of air pollution levels. Energy Policy, 105, 386–397.

[6] Anam Azam, Muhammad Rafiq, Muhammad Shafique, Muhammad Ateeq & Jiahai Yuan (2021) Investigating the impact of renewable electricity consumption on sustainable economic development: a panel ARDL approach, International Journal of Green Energy, 18:11, 1185-1192.

[7] Apergis, N. and Danuletiu, D.C. (2014) Renewable Energy and Economic Growth: Evidence from the Sign of Panel Long-Run Causality. International Journal of Energy Economics and Policy, 4, 578-587.

[8] Arellano, M., and Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Review of Economic Studies 58(2), 277–297.

[9] Arellano, M., and Bover, O. (1995). Another look at the instrumental variable estimation of error components models. Journal of Econometrics 68(1), 29–51.

[10] Bazilian, M., et al. (2013). Energy access scenarios to 2030 for the power sector in sub-Saharan Africa. Utilities Policy, 26, 56-69.

[11] Bertrand, S. (2021, December 17). Fact sheet: Climate, environmental, and health impacts of fossil fuels (2021).

[12] Bhattacharya, Mita & Paramati, Sudharshan Reddy & Bhattacharya, Sankar. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. Applied Energy. 162. 733-741.

[13] Bhuiyan, M. A., Zhang, Q., Khare, V., Mikhaylov, A., Pinter, G., & Huang, X. (2022). Renewable Energy Consumption and Economic Growth Nexus—A Systematic Literature Review. Frontiers in Environmental Science, 10.

[14] Blundell, R., and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics 87(1), 115–143.

[15] Braga, C., Ferreira, P., & Marques, V. (2018). Renewable energy consumption and decent work: Evidence from panel data. Journal of Cleaner Production, 198, 487-496.

[16] Brunnschweiler, C. N. (2010). Finance for renewable energy: an empirical analysis of developing and transition economies. Environment and Development Economics 15(3), 241–274.

[17] Chen, Y., Zhao, J., Lai, Z., Wang, Z., & Xia, H. (2019). Exploring the effects of economic growth, and renewable and non-renewable energy consumption on China's CO2 emissions: Evidence from a regional panel analysis. Renewable Energy, 140, 341–353.

[18] Chen, Y.; Li, C. FDI, International trade and economic growth of shandong: Based on co integration test and VEC model. World Reg. Stud. 2011, 1, 110–116

[19] Clements, J. C., & Chopin, T. (2016). Ocean acidification and marine aquaculture in North America: potential impacts and mitigation strategies. Reviews in Aquaculture, 9(4), 326– 341.

[20] Comes, C.-A.; Bunduchi, E.; Vasile, V.; Stefan, D. The Impact of foreign direct investments and remittances on economic growth: A case study in central and eastern Europe. Sustainability 2018, 10, 238.

[21] Creutzig, F., Agoston, P., Goldschmidt, J. C., Luderer, G., Nemet, G. F., & Pietzcker, R. C. (2017). The underestimated potential of solar energy to mitigate climate change. Energy Policy, 108, 762-767.

[22] Dickey, D. A., and Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica 49(4), 1057–1072.

[23] Doytch, N., Narayan, S. (2016), Does FDI influence renewable energy consumption? An analysis of sectoral FDI impact on renewable and non-renewable industrial energy consumption. Energy Economics, 54(C), 291-301.

[24] Erickson, P., Lazarus, M. & Piggot, G. Limiting fossil fuel production as the next big step in climate policy. Nature Clim Change 8, 1037–1043, 2018.

[25] Eskeland, G. S., and Harrison, A. E. (2003). Moving to greener pastures? Multinationals and the pollution haven hypothesis. Journal of Development Economics 70(1), 1–23.

[26] Fossil fuels. National Geographic Education. (n.d.). Retrieved March 30, 2023, from https://education.nationalgeographic.org/resource/fossil-fuels

[27] Gao, X., Liu, Y., & Hu, Z. (2020). Renewable energy consumption and economic growth in China: A panel data analysis. Renewable Energy, 152, 327-334.

[28] Gunby, P., Jin, Y., and Reed, W. R. (2017). Did FDI really cause Chinese economic growth? A meta-analysis. World Development 90, 242–255.

[29] Gyimah, J., Yao, X., Tachega, M. A., Sam Hayford, I., & Opoku-Mensah, E. (2022). Renewable energy consumption and economic growth: New evidence from Ghana. Energy, 248, 123559.

[30] Hannan, M. A., Al-Shetwi, A. Q., Ker, P. J., Begum, R. A., Mansor, M., Rahman, S. A., Dong, Z. Y., Tiong, S. K., Mahlia, T. M. I., & Muttaqi, K. M. (2021). Impact of renewable energy utilization and artificial intelligence in achieving sustainable development goals. Energy Reports, 7, 5359–5373.

[31] Huang, Y., Ahmad, M., Ali, S. (2022). The impact of trade, environmental degradation and governance on renewable energy consumption: Evidence from selected ASEAN countries. Renewable Energy, 197, 1144–1150.

[32] Huang, Y., Ahmad, M., Ali, S., & Kirikkaleli, D. (2022). Does eco-innovation promote cleaner energy? Analyzing the role of energy price and human capital. Energy, 239, 122268.

[33] Huang, Y., Kuldasheva, Z., & Salahodjaev, R. (2021). Renewable energy and CO2 emissions: Empirical evidence from major energy-consuming countries. Energies, 14(22), 7504.

[34] Ibrahiem, D. M. (2015). Renewable electricity consumption, foreign direct investment and economic growth in Egypt: an ARDL approach. Procedia Economics and Finance 30, 313-323.

[35] Ibrahim, R. L., Ajide, K. B., & Omokanmi, O. J. (2021, June 13). Non-renewable energy consumption and quality of life: Evidence from Sub-Saharan African economies.

[36] International Energy Agency. (2019). World Energy Outlook 2019. International Energy Agency. International Energy Agency. (2020). Energy Technology Perspectives 2020. International Energy Agency.

[37] International Renewable Energy Agency. (2021). Renewable Power Generation Costs in 2020.

[38] Jacobson, M. Z., Delucchi, M. A., Bauer, Z. A., Goodman, S. C., Chapman, W. E., Cameron, M. A., & Clonts, H. A. (2015). 100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for the 50 United States. Energy & Environmental Science, 8(7), 2093-2117.

[39] Kang, X., Khan, F. U., Ullah, R., Arif, M., Rehman, S. U., and Ullah, F. (2021). Does foreign direct investment influence renewable energy consumption? Empirical evidence from South Asian countries. Energies 14(12), 3470.

[40] Kitzing, L., Sauer, A., & Wende, W. (2019). Renewable energy consumption and economic growth: New insights based on a panel quantile approach. Energy Economics, 81, 856-872.

[41] Konietzko, J., Bocken, N., & Hultink, E. J. (2020). Circular ecosystem innovation: An initial set of principles. Journal of Cleaner Production, 253, 119942.

[42] Leng, X., & Fan, L. (2021). The impact of foreign direct investment on renewable energy consumption in Thailand. Energy Policy, 154, 112363.

[43] Levin, A., Lin, C. F., and Chu, C. S. J. (2002). Unit root tests in panel data: asymptotic and finite sample properties. Journal of Econometrics 108(1), 1–24.

[44] Li N, Yuan R, Wang J. Analysis of current and future energy inequality by energy categories in China. Sustain Prod Consum 2022;32:393–406.

[45] Lin BQ, Wang M. Possibilities of decoupling for China's energy consumption from economic growth: a temporal-spatial analysis. Energy 2019;185:951–6.
[46] Lilliestam, J., Labordena, M., Patt, A., & Pfenninger, S. (2018). Renewable energy and climate pledges: zero emission energy production needed to limit climate warming to 2°C or 1.5°C. Nature Energy, 3(4), 279-288.
[47] Mahbub, T., Ahammad, M. F., Tarba, S. Y., & Mallick, S. M. Y. (2022). Factors encouraging foreign direct investment (FDI) in the wind and solar energy sector in an emerging country. Energy Strategy Reviews, 41, 100865.
[48] Matar, A., & Abbassi, R. (2021). Renewable energy consumption and economic growth nexus: evidence from selected MENA countries. Environmental Science and Pollution Research, 28(12), 15494-15506.
[49] Mert, M., Bölük, G. (2016), Do foreign direct investment and renewable energy consumption affect the CO2 emissions? New evidence from a panel ARDL approach to Kyoto annex countries. Environmental Science and Pollution Research, 23(21), 21669-21681.
[50] Naz, S., Sultan, R., Zaman, K., Aldakhil, A. M., Nassani, A. A., and Abro, M. M. Q. (2019). Moderating and mediating role of renewable energy consumption, FDI inflows, and economic growth on carbon dioxide emissions: evidence from robust least square estimator. Environmental Science and Pollution Research 26(3), 2806–2819.
[51] Nguyen, C.T. and Trinh, L.T. (2018) The Impacts of Public Investment on Private Investment and Economic Growth: Evidence from Vietnam. Journal of Asian Business and Economic Studies, 25, 15-32.
[52] Nonrenewable resources. Education. (2022, May 19). Retrieved March 29, 2023, from https://education.nationalgeographic.org/resource/nonrenewable-resources
[53] Ntanos, S., Skordoulis, M., Kyriakopoulos, G., Arabatzis, G., Chalikias, M., Galatsidas, S., Batzios, A., et al. (2018). Renewable Energy and Economic Growth: Evidence from European Countries. Sustainability, 10(8), 2626. MDPI AG.
[54] Oakleaf, J. R., Kennedy, C. M., Baruch-Mordo, S., Gerber, J. S., West, P. C., Johnson, J. A., & Kiesecker, J. (2019). Mapping global development potential for renewable energy, fossil fuels, mining and agriculture sectors. Scientific Data 6(1):101.
[55] Odo, Stephen & Igberi, Christiana & Chinyere, Udude & Ifeyinwa, Anoke. (2016). Public Expenditure and Economic Growth: Evidence from Nigeria and South Africa. 6. 7-28.
[56] Organisation for Economic Co-operation and Development (OECD). (2016). The economic consequences of outdoor air pollution. Retrieved from https://www.oecdilibrary.org/environment/the-economic-consequences-of-outdoor-airpollution_9789264257474-en
[57] Phan, D. H. B., & Kim, J. (2021). Foreign direct investment and economic growth in the Philippines: evidence from a cointegration analysis. Journal of Asian Finance, Economics and Business, 8(1), 19-27.
[58] Phillips, P. C., and Perron, P. (1988). Testing for a unit root in time series regression. Biometrika 75(2), 335–346.
[59] Quitzow, R.; Bersalli, G.; Eicke, L.; Jahn, J.; Lilliestam, J.; Lira, F.; Marian, A.; Süsser, D.; Thapar, S.; Weko, S.; et al. The COVID-19 Crisis Deepens the Gulf between Leaders and Laggards in the Global Energy Transition. Energy Res. Soc. Sci. 2021, 74, 101981.
[60] Raihan, A., & Tuspekova, A. (2022). Dynamic impacts of economic growth, energy use, urbanization, tourism, agricultural value-added, and forested area on carbon dioxide emissions in Brazil. Journal of Environmental Studies and Sciences.
[61] Raza MY, Wu RX, Lin BQ. A decoupling process of Pakistan's agriculture sector: insights from energy and economic perspectives. Energy 2022;263:125658.
[62] Sharif, A., Raza, S. A., Ozturk, I., & Afshan, S. (2019). The dynamic relationship of renewable and nonrenewable energy consumption with carbon emission: A global study with the application of heterogeneous panel estimations. Renewable Energy, 133, 685-691.
[63] Silajdzic, S., and Mehic, E. (2016). Absorptive capabilities, FDI and economic growth in transition economies. Emerging Markets Finance and Trade 52(4), 904–922.
[64] Smil, V. (2003). Energy at the crossroads: global perspectives and uncertainties. MIT press.
[65] Solaun, K., & Cerdá, E. (2019). Climate change impacts on renewable energy generation. A review of quantitative projections. Renewable and Sustainable Energy Reviews, 116(116), 109415.
[66] Sovacool, B. K. (2016). The political economy of energy poverty: A review of key challenges. Energy for Sustainable Development, 33, 1-10.
[67] Tan, Y., Uprasen, U. (2022). The effect of foreign direct investment on renewable energy consumption subject to the moderating effect of environmental regulation: Evidence from the BRICS countries. Renewable Energy. 201, Part 2. 135-149.
[68] Toh, L. (2021, October 25). Let's come clean: The renewable energy transition will be expensive. State of the Planet. Retrieved March 30, 2023, from https://news.climate.columbia.edu/2021/10/26/lets-come-clean-the-renewable-energytransition-will-be-expensive
[69] United Nations Framework Convention on Climate Change. (2015). Paris Agreement. Retrieved from https://unfccc.int/process-and-meetings
[70] World Bank. (2019). Pollution knows no borders: How pollution affects people and the economy across borders. Retrieved from https://openknowledge.worldbank.org/handle/10986/31668
[71] Zhang, F., Huang, Y., & Nan, X. (2022). Advanced research methods and their applications on the nexus of Energy Efficiency and Environment: Evidence from five RCEP economies. Economic Research-Ekonomska Istraživanja, 35(1), 5676–5698.