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-RESEARCH ARTICLE-

DOES INDUSTRIALIZATION AND RENEWABLE ENERGY CONSUMPTION DETERMINE ECONOMIC GROWTH? EMPIRICAL EVIDENCE FROM ASEAN COUNTRIES

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─Abstract─

As a result of the uncertainty surrounding the environment and the economy, economic growth (EG) has become a global demand. Researchers and policymakers need to pay attention to this aspect. As a result, the current article examines how the EG of ASEAN countries is affected by industrialization, renewable energy (RE) output, RE consumption, inflation, and energy import. The study extracted the data from 2006 to 2020 using secondary sources like World Development Indicators (WDI). The association between the constructs was examined using the Methods of Moments-Quantile-Regression (MMQR) technique. The findings showed that the EG of ASEAN countries has a significant positive association with industrialization, RE output, RE consumption, energy import, and inflation. The study aids the regulatory agencies in creating policies using industrialization and RE consumption to achieve satisfactory EG.

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1. INTRODUCTION

Economic growth (EG), which is based on the total volume of goods and services produced, the size of the economy, and the soundness of the financial position, is crucial for a state and its residents. Due to reason, EG has long been a preferred subject of study for academics or scholars (Mardani et al., 2019). Global competition is rising as economies develop over time and grow more smart, innovative, and advanced. To compete in the global market, gain ground, and uphold a stellar reputation on the global stage, all nations must enhance and sustain the performance and growth of their economies. This will enable them to compete globally and surpass rival economies (Urbano et al., 2019).

Additionally, a country's higher EG elevates the standard of living for the inhabitants, enhances the delivery of public amenities, increases employment possibilities, fights poverty, and enhances community social well-being (Gründler et al., 2019). The rise of numerous economic sectors, such as industrialization and renewable energy (RE) like RE output, RE consumption, and energy import, is necessary for EG to be sustainable. The spread of manufacturing operations over a larger area is known as industrialization. Industrialization significantly affects EG. It quickens human capital growth, output level, innovation, infrastructural development, and technological advancement. Industrialization also expands employment prospects, fosters social cohesion, boosts education, and quickens global trade. These all support EG (K. Munir et al., 2020). Renewable energy originates from unrestricted, clean, and more economical sources. Thus, RE sources augment EG (Rahman et al., 2020).

The current study investigates the EG of ASEAN nations. Promoting regional EG, cultural development, and social frameworks is the goal of this association (Nawaz et al., 2019). Participating nations have more power and influence over the global economy thanks to the founding of the ASEAN than they otherwise would. The ASEAN partner countries' macroeconomic policies and regional co-operation activities improve the region's strong economic credentials. Since 2006, ASEAN has been able to sustain a 5.3 percent GDP growth rate. From US$1.81 trillion in 2010 to US$2.24 trillion in 2011, the ASEAN region's GDP expanded, exceeding both China's and the United States of America's GDP by around 15%. (Maneejuk et al., 2021). The overall GDP of all ASEAN members is expected to reach USD 3.08 trillion in 2020, a significant increase from the previous years. The GDP of the ASEAN region has been growing quickly for a long, demonstrating the region's thriving economy. From US$266 billion to US$1.1 trillion between 2000 and 2011, the stock of foreign direct investments (FDI) expanded by roughly four times. In the same year, total trade increased by an average of 16.8 percent to reach US$ 2.4 trillion. China, Malaysia, and Vietnam will each get impressive FDI of

$6230 million, $4159 million, and $3658 million, respectively, in 2022. The inflation rate dropped to 4.3%. (Haini, 2020). The improved FDI trends are closely related to multinational firms' improved perception of ASEAN countries. Regarding investment demand, Indonesia, Thailand, Vietnam, and Malaysia are among the top 20 destination economies from 2012 to 2014. Indonesia moved up two spots in the standings to take the top spot. Additionally, other ASEAN nations experience increased perception (Nasir et al., 2019).

Increased EG, significant internal and external investment, and a high employment rate are all present in ASEAN nations. The vast majority of individuals in these nations enjoy their lives. But due to a shortage of production resources, rising pollution, etc., sustainability is still a major problem in EG. The current study aims to investigate how inflation affects EG's RE consumption, industrialization, RE output, and energy import. Since EG is a measure of a nation's success on the international stage, academics have long debated it. However, the current work is original EG research. First, studies on the connections between industrialization, RE output, RE consumption, energy import, and inflation with EG can be found in earlier literature. However, the effects of industrialization, RE output, RE consumption, energy import, and inflation on EG were covered separately and with less in-depth analysis in earlier studies. The current study responds to the literature by simultaneously analyzing industrialization, RE output, RE consumption, energy import, and inflation as EG predictors. Second, in the earlier studies, authors were content to examine RE or RE consumption to determine their contribution to the acceleration and maintenance of EG. The current study significantly contributes to the literature because it analyzes RE output, RE consumption, and energy import to determine EG. Third, the impact of RE output, RE industrialization, RE output, energy import, and inflation on the EG of ASEAN economies has received little attention. The current study analyses the effects of industrialization, renewable energy production and consumption, energy imports, and inflation on EG for ASEAN countries.

The following sections make up the document. In the second section, we will discuss the prior literature to ascertain how industrialization, RE output, RE consumption, energy import, inflation, and EG are related. The methods used to gather data and determine results from data are described in the third section. Other comparable studies support the findings after the proper discussion. The significance of the study is then discussed, its explanation is provided in a succinct conclusion, and its limitations are discussed.

2. LITERATURE REVIEW

A country's EG rate, which ranks it at the top of the list of international economies, determines the extent of social advancement and the standard of life in that nation. EG is ultimately boosted by industrialization, which also fosters the expansion of other economic sectors and social welfare, and by using RE resources, which protects the environment and many types of natural resources (Amar et al., 2020). The role of RE

use, industrialization, RE output, energy import, and inflation in EG has been extensively studied in the literature. The relationship between industrialization, RE output, RE consumption, energy import, inflation, and EG has been examined in a few recent studies presented below.

2.1 Industrialization and EG

Industrialization helps EG grow because it encourages the creation of physical and human capital and trade even on a global scale. Opoku et al. (2019) examine how industrialization increases the EG rate. Using data from 37 African states from 1980 to 2014, the World Bank's World Development Indicators were used. To address the data and determine the precise relationship between industrialization and EG, the authors worked with the GMM method. The production of various goods for domestic use or use in other economic sectors rises due to industrialization. The products are exported but are only used to satisfy domestic needs. Therefore, industrialization encourages a variety of economic sectors as well as increases global trade. Therefore, it speeds up EG. (Q. Munir et al., 2020) asserts that industrialization increases the variety of rural areas' manufacturing facilities. As a result of industrialization, when manufacturing or related production techniques start, it encourages the efficient use of resources there and creates employment opportunities for people, improving their lives. Increased production, effective use of available resources, and rising living standards all hasten EG. The relationship between industrialization, urbanization, CO2 emissions, and EG is examined by Wang et al. (2019). China is used as a case study for the years 1990 to 2015. The data were analyzed using the Tapio model, the Granger causality test, and the Johansen co-integration theory. The findings demonstrated a beneficial relationship between industrialization and economics. Human capital grows as a result of industrialization, as do technologies. Therefore, it fosters a sustainable growing economy by generating a CO2-free economy.

2.2 RE Output and EG

The output of RE keeps the EG's engine running in this day and age when economies must deal with multiple environmental issues, worry about tarnishment, and lack of resources for production. The relationship between NRE consumption, RE output, R&D expenditures, trade openness, and EG is integrated by Zafar et al. (2019). The APEC nations were examined for connections between relevant elements from 1990–2015. The panel unit root test, Westerlund co-integration test, and CUP-FM techniques were used to verify the relationships. According to the study, when RE output lowers the likelihood of hazardous emissions from economic activity, it secures the production resources and upholds the nation's prestige. Therefore, it hastens sustainable EG. According to Mahmood et al. (2019)'s study, producers use many procedures to have RE. Even though natural materials were used in its construction, it is nonetheless likely to control its production. Humans are responsible for managing the energy supply at all times by creating RE. Consistency is developed in EG thanks to the reliable supply of energy,

which is a fundamental element of economic activity. The relationship between RE output, carbon emissions, and EG was discussed by Bilan et al. (2019). The research was conducted between 1995 and 2015 using a sample of possible EU association members. Data about the output of RE, carbon emissions, and GDP were acquired using the databases of Eurostat and the World Bank. The analysis comprises panel unit root tests, Pedroni panel co-integration tests, OLS, FMOLS, and VECM. The results of the research show that RE output is a crucial means of reducing CO2 emissions and sustaining economic growth.

2.3 RE Consumption and EG

The growing economic trend toward using energy from renewable resources prevents the economy from emitting dangerous gases like GHGs. Resources and environmental protection support EG The relationship between RE consumption, nuclear energy use, and EG is examined in the study by Luqman et al. (2019). The statistics of the Pakistani economy for nuclear energy, RE consumption, and GDP were taken into account for the years 1990 to 2016. For accurate results, the NARDL technique was used. The findings showed a beneficial relationship between RE consumption and EG because RE consumption lessens the negative economic and environmental effects of nuclear energy. According to Awodumi et al. (2020), as the use of RE sources rises, people will be able to conduct many social and economic activities without the need for fossil fuels like coal, oil, petroleum, and gas. Sustainable EG ensures that fossil fuels, whose supply is limited, are preserved for future urgent use and reduces the steadily rising harmful emissions from human activities. Using CO2 emissions as a proxy, Mohsin et al. (2021) discuss the energy transition and EG relationship. The panel data from 25 chosen emerging Asian countries for the years 2000 to 2016 for GDP, CO2 emissions, and energy consumption from non-renewable to renewable resources. Data were analyzed using a robust Random Effect (RE) approach and Hausman-Taylor Regression HTR. It is discovered that EG and energy consumption are positively correlated and that 1% more RE consumption results in a 0.193% decrease in CO2 emissions. The positive correlation between EG and renewable energy over the long and short term implies a valid and sound feedback hypothesis.

2.4 Energy Import and EG

Energy imports began to increase with the emergence of globalization and international trade. Importing clean energy, or resources for energy production, increases the energy supply and lessens the negative environmental effects of fossil fuel energy. As a result, EG's sustainability can be improved. According to Zhang et al. (2021), the impact of CO2 emissions, international travel, energy trade, and renewable energy on EG is integrated. To compile data on international tourism, carbon dioxide emissions, renewable energy, energy trade, and GDP, EU-28 was examined between 1995 and 2014. The data was analyzed using the panel FMOLS, DOLS, and fixed effects (FE). The results of the econometric analysis support the body of earlier research. The results

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show that energy import is positively correlated with EG because energy import speeds up EG in conjunction with preserving natural resources. Hdom et al. (2020) examine the connection between Brazilian energy production and international energy trade. Data for the years 1975 to 2016 were collected using the WDI database. For data analysis, the authors used grander causality tests, stationarity tests, co-integration tests FMOLS and DOLS, and stationarity tests. People need the energy to prepare the environment, produce goods, offer services, and transport people or goods from one place to another. Imports of energy help EG grow while meeting its energy requirements. The impact of urbanization, energy trade, and renewable energy on ecological footprint and EG are all identified by Nathaniel et al. (2020). Data were gathered between 1990 and 2016 and applied to the economies of the ASEAN. The relationship between the variables was examined using the unit root and co-integration tests. The study's findings demonstrate a favorable correlation between energy import and EG,

2.5 Inflation and EG

Inflation impacts EG in addition to industrialization, RE output, and consumer spending. Khan et al. (2020) look into the impact of energy, trade openness, and inflation on EG and environmental quality. 24 businesses that operated in ECD countries between 1980 and 2014 provided the information for the research's contributing factors. According to the study, businesses make more money and can afford environmentally friendly practices when there is inflation. Sustainable EG is ensured by improvements in productivity and environmental quality. In Indonesia, the relationship between EG and the money supply, investment, and export is examined by Kurniasih (2019). From 2001 to the end of 2014, Indonesian data for the quarterly time series of GDP, investment, export, money supply, and inflation were gathered. ECM multiple regression models are used to analyze data empirically. When there is inflation within a nation, the money supply is higher, which encourages more investment in the nation's overall development and raises the EG.

3. RESEARCH METHODS

The article investigates the impact of industrialization, RE output, RE consumption, energy import, and inflation on the EG of ASEAN countries. The study utilized secondary sources like WDI to extract the data from 2006 to 2020. The researchers developed the equation with understudy constructs given below:

$$EG_{it} = \alpha_0 + \beta_1 IND_{it} + \beta_2 REO_{it} + \beta_3 REC_{it} + \beta_4 EI_{it} + \beta_5 INF_{it} + e_{it} \quad \textbf{(1)}$$

Where;

EG = Economic Growth
t = Time Period
i = Countries
IND = Industrialization

REO = Renewable Energy Output
REC = Renewable Energy Consumption
EI = Energy Impor
INF = Inflation

The article used GDP growth (annual%) to measure EG as a dependent construct. The study also employed two predictors: industrialization, as measured by industry value, added (% of GDP), and RE usage, as measured by RE output (% of total energy output), RE consumption (% of total energy consumption), and energy import (% of energy use). Finally, the study employed a control variable, such as inflation, measured by annual percent changes in consumer prices. The measurements for the variables are shown in Table 1.

Table 1. Variables with Measurements

S#	Variables	Measurement	Sources
01	Economic Growth	GDP growth (annual %)	WDI
02	Industrialization	Industry value added (% of GDP)	WDI
03	Renewable Energy Usage	RE output (percentage of total energy output)	WDI
04	RE consumption	percentage of total energy consumption	WDI
05	Energy import	% of energy use	WDI
06	Inflation	Inflation, consumer prices (annual %)	WDI

The article applied descriptive statistics to check the variables' details. In addition, the article also applied the correlation matrix to examine the correlation between constructs. Moreover, the study also applied the variance inflation factor (VIF) to examine multicollinearity. The equations for the test are mentioned below:

$$R^2_Y \longrightarrow Y_{it} = \alpha_0 + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + e_{it} \quad \textbf{(2)}$$

$$j = R_Y^2, R_{X1}^2, R_{X2,}^2 R_{X3,}^2 R_{X4,}^2 R_{X5}^2 \quad \textbf{(3)}$$

$$Tolrance = 1 - R_j^2 \quad VIF = \frac{1}{Tolerance} \quad \textbf{(4)}$$

The article's final step used the MMQR technique to test the association between the constructs. Machado et al. (2019). This method can deal with outliers in the best possible way (Adebayo et al., 2022). Although the model is non-linear, this approach offers various circumstances and dynamic assessments. Additionally, it controls endogeneity and heterogeneity's impacts (Ike et al., 2020). As a result, the following is developed and mentions the "locational-scale alternate model":

$$A_{it} = \alpha_i + B_{it}\beta + (\delta_i + C_{it}\lambda)U_{it} \quad \textbf{(5)}$$

In the above equation, the probability is represented by $P\{\delta_i + C_{it}\lambda > 0\} = 1$, while the k-vector of component B is represented by C, and the components are changed with component l, which is given below:

$$Zl = Zl\,(Y), l = 1, \ldots\ldots, k \quad \textbf{(6)}$$

In the above equation, orthogonal to B_{it} represented by U_{it} that reliable to attain the moment conditions. Hence, in equation (5), the conditional quantile is developed as under:

$$Q\tau(\tau/B_{it}) = (\alpha_i + \delta_i q(\tau)) + B_{it}\beta + C_{it}\,\lambda\, q(\tau) \quad \textbf{(7)}$$

In the above equation, B_{it} represents the predictors such as IND, REO, REC, EI, and INF and A_{it} is the predictive variable, such as EG. Due to time invariants, the effects of heterogeneity are permitted for variations across the quantiles. So, $Q(\tau)$ is developed below:

$$Min_q = \sum_t \sum_i p\tau\,(R_{it} - (\delta_i + Z_{it}\,\lambda\,)q) \quad \textbf{(8)}$$

4. RESEARCH FINDINGS

To examine the specifics of the variables, the article used descriptive statistics. The results showed that the average figures for the EG are 4.940 percent, the average figures for the IND are 36.322 percent, and the average figures for the REO are 30.058 percent. The results also showed that the average data for the REC is 31.624 percent, the average figures for the EI are -32.586 percent, and the average figures for the INF are 4.150 percent. Table 2 provides these numbers.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
EG	150	4.940	3.668	-9.518	14.520
IND	150	36.322	12.037	18.51	74.113
REO	150	30.058	31.530	0.030	100.000
REC	150	31.624	25.974	0.010	85.710
EI	150	-32.586	135.352	-608.137	98.302
INF	150	4.150	5.107	-1.261	35.025

The article also used the correlation matrix to look at the relationships between the constructs. The findings showed that the EG of ASEAN countries has a significant, along with favorable association with industrialization, RE output, RE consumption, energy import, and inflation. Table 3 includes these numbers.

Table 3. Matrix of Correlations

Variables	EG	IND	REO	REC	EI	INF
EG	1.000					
IND	0.426	1.000				
REO	0.402	-0.394	1.000			
REC	0.517	-0.501	0.748	1.000		
EI	0.286	-0.879	0.203	0.240	1.000	
INF	0.426	-0.260	0.236	0.487	0.091	1.000

Additionally, the study used the VIF to look at the multicollinearity. The results showed that while VIF figures are less than five, their reciprocal values are greater than 0.20. These figures show that there are no multicollinearity problems. Table 4 includes these numbers.

Table 4. Variance Inflation Factor

	VIF	1/VIF
IND	4.323	0.231
EI	3.816	0.262
REC	3.548	0.282
REO	2.392	0.418
INF	1.398	0.715
Mean VIF	3.095	.

The article's final step used the MMQR approach to test the association between the constructs. The findings showed that the EG of ASEAN countries has a significant and positive association with RE consumption, industrialization, RE output, energy import, and inflation. Table 5 lists these relationships.

5. DISCUSSIONS

According to the findings, industrialization and EG are positively correlated. Pan et al. (2019)'s findings, also demonstrate the existence of industrialization, the propensity for innovation adoption, the acquisition of new knowledge, and the development of new skills—all of which boost output and raise EG—also support these findings. These findings are consistent with Rehman et al. (2021)'s claim that industrialization increases the number of production units at various remote locations throughout the nation. Beginning manufacturing or other forms of production in some new places fosters the efficient use of resources there and, using those resources, gives people a chance to raise their standard of living. Therefore, EG is accelerated by increased output, efficient use of national resources, and greater living standards.

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Table 5. Panel Quartile Estimation (MMQR)

Variables	**Method of Moments Quantile Regression (MMQR)**										
	Location	**Scale**	**Grid of Quartiles**								
			0.10	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**
IND	0.784***	0.633*	0.453**	0.434**	0.782*	0.638**	0.653*	0.903*	0.920*	0.093	0.522
EI	0.639**	0.839*	0.849**	0.754*	0.810*	0.201***	0.203**	0.201	0.120	0.281	0.122
REC	0.564***	0.736**	0.535**	0.720**	0.773*	0.309*	0.300*	0.767*	0.192*	0.729*	0.211*
REO	0.874**	0.277**	0.745**	0.849**	0.827**	0.748*	0.302*	0.244	0.383*	0.229*	0.243*
INF	0.645*	0.647**	0.768*	0.663**	0.721**	0.192**	0.029*	0.121	0.102	0.291	0.721*

***, **, and * show level of significant at 1%, 5%, and 10%.

The outcomes also demonstrated a favorable correlation between EG and RE output. These findings are consistent with Kahia et al. (2019)'s explanation that RE is formed using various techniques. Even though it is made from natural materials, men can control its output. The EG can be hastened because it can control the energy supply at any time, preventing the absence of energy, which is a crucial component of economic activity. He et al. (2019), who emphasize that RE production at a higher level aids in increasing affordable and pollution-free energy, also support these findings. Utilizing such energy promotes economic activity continuity and raises EG.

The findings suggested a beneficial relationship between RE consumption and EG. These findings are consistent with Saidi et al. (2020)'s research, which demonstrates that as the consumption of RE sources increases, people can conduct various social and economic activities without the need for fossil fuels like coal, oil, petroleum, and gas. Less reliance on finite fossil fuels ensures sustainable EG by preserving finite fossil fuel supplies and lowering harmful emissions from industrial operations. Baloch et al. (2019), who examine the role of RE use in EG, also support these findings. According to the study, the higher the propensity to use RE, the higher the EG rate.

The findings showed that energy import and EG have a positive relationship. These findings are consistent with Destek et al. (2020)'s thesis, which emphasizes the need for energy to prepare the context, the production of goods and services, and the movement of people or goods from one location to another. The import of energy satisfies the demand for energy and raises EG. These findings are also supported by Aydoğan et al. (2020). The ability to import energy enables people and organizations to buy energy from foreigners at lower prices and carry on with their regular business. Energy is easily and inexpensively available, which supports EG and keeps economic activity going despite a national energy crisis.

The findings suggested a beneficial relationship between inflation and EG. These findings support the assertion made by Armeanu et al. (2021) that inflation encourages the development of the nation's infrastructure. Building new centers for manufacturing, trading, or energy production and expanding highways and transportation hubs promotes economic activity. Sustainable EG results from it. These findings are also supported by Tien (2021), which shows that during inflation, government revenues are high in amount and that they can support national development for the welfare of the public as well as subsidies to support economic practices. The nation has high economic development as a result.

6. IMPLICATION

Other researchers can benefit from the authors' significant literary contributions. With inflation as a control variable, the current study illuminates the effects of RE consumption, industrialization, RE output, and energy import. The authors empirically examine the relationship between RE consumption, industrialization, RE output, energy

import, inflation, and EG over a long enough period. The current study selects ten ASEAN nations representing various economic forms to analyze the relationship between energy consumption, industrialization, output, energy import, and inflation with EG.

A developing economy would greatly benefit from the current study. It has several empirical repercussions. It advises the government officials in charge of the nation's welfare on how to increase and maintain the EG rate. According to the study materials, for the EG rate to rise, industrialization must have predominated in the nation, and people must be persuaded to accept industrial revolutions. It implies that the government can create the conditions for achieving higher EG by implementing policies to support the RE output level. Similar to how EG should be increased, RE consumption should be encouraged and facilitated through various financial and administrative policies. The analysis aids the regulatory agencies in creating policies using industrialization and RE to attain satisfactory EG. The study also suggests that the ability to import energy may help raise EG. Furthermore, the study clarifies that for the economy to grow strongly during inflation, the government and economists must act responsibly.

7. CONCLUSION

The authors' goal in conducting this study was to examine the effects of EG, industrialization, RE output, and energy import. They also decided to examine the impact of inflation in this context. Data based on empirical research were gathered from ASEAN nations. Data analysis findings indicate a positive correlation between EG, industrialization, RE output, energy import, and RE consumption. The findings demonstrated that industrialization boosts overall output and maintains it through rising awareness, technological advancement, inventiveness, efficient resource use, and increased employment rates. Industrialization is essential to EG in this way. The findings also demonstrated that increasing RE output and RE consumption promotes economic development by safeguarding human resources, boosting energy reserves, and promoting global trade. Therefore, it foretells EG's sustainability.

Similarly, people or businesses are permitted to obtain energy from abroad, they can give the economy sustainable fuel, and EG is high. Additionally, inflation promotes national development by enhancing business financial health and bolstering government assistance. The expansion of economic practices ultimately causes EG.

8. LIMITATIONS

The current study has some limitations that should be noted. Here, the authors' focus is necessary. The study evaluates a country's EG using a few predictors, including RE consumption, industrialization, RE output, and energy import. Other elements, including energy efficiency, green investments, and technological advancements, are also important in EG. However, since these are absent, the study is less thorough and,

therefore, less useful. To broaden the scope of the study, the authors must feel it is their responsibility to examine these additional factors. The statistics of ASEAN economies were examined to quantify the relationship between RE consumption, industrialization, RE output, energy import, inflation, and EG. Future researchers will need to gather data from nations in various world regions to achieve general results.

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