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Analysis of Renewable Energy, Environment Quality and Energy Consumption on Economic Growth: Evidence from Developing Countries

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ABSTRACT

The stage of economic development of a country will have an impact on the essence of life in welcoming changes in the economic pattern in the future. Especially in the energy sector, currently almost all countries are actively trying to achieve an energy transition to support the sustainability of a clean and orderly environment. Therefore, this research focuses renewable energy, environmental quality and energy consumption on economic growth in 30 developing countries using panel data model with a Fixed Effects Approach. The results show that renewable energy and environmental quality variables contribute significantly to economic growth, while energy consumption does not have a significant effect. At this stage, facilities for developing renewable energy must be expanded in terms of infrastructure capacity and financing so that they are supported by government policy. Then, macroeconomic variables such as foreign direct investment and population have a significant effect on economic growth, while trade openness and labor force variables do not have a significant effect on economic growth in developing countries, adding to the indication and reference of the importance of balance in achieving the energy transition and macroeconomic policies that have an impact on progress economy.

Keywords: Renewable Energy, Environment Quality, Energy Consumption, Economic Growth

JEL Classifications: Q2, E0, O1

1. INTRODUCTION

Climate change and global warming are important issues in the 21st century. An argument that often arises in discussions regarding the impact of economic development on the environment during the massive extraction of natural resources carried out by a country. There is a belief among academics that the negative environmental impacts that occur are caused by carbon dioxide (CO₂), greenhouse gases, burning of fossil fuels, which causes the atmosphere to deplete damage the land, sea and air ecosystems (Khoshnevis Yazdi and Shakouri, 2018).

Decreased environmental quality is often caused by natural and human factors. There are many economic activities carried

out to meet needs that tend not to pay attention to aspects of environmental quality that are adequate for sustainable natural conditions (Amar et al., 2024). For this reason, in economic development there is still minimal awareness of paying attention to the environment without paying attention to the harmonious structure of nature side by side with humans as a social need. Basically, economic development is aimed at producing goods and services, but as time goes by, unrest arises due to the dwindling availability of energy, so it is necessary to change the perspective on economic development (Khoshnevis Yazdi and Shakouri, 2017; Yu et al., 2022).

This impact is very detrimental to the environment and public health, with excessive use of carbon dioxide leading to costs

for improving climate conditions, air pollution and disrupting infrastructure and economic mobility. Not only that, losses are also experienced such as floods, water scarcity, acid rain, erosion and food scarcity, making carbon emissions responsible for global warming, the effect of which is 60% (Xie et al., 2020).

Energy is considered a driver of economic growth because it supplies raw materials for the running of industry in production and distribution. This is an important force for formulating policies on environmental quality and reducing the huge dependence on energy use in the long term. In a global context, energy dependence will be a big challenge for all countries which theoretically do not ignore the role of energy, but the causal aspect between energy use and economic growth needs alternatives, one of which is renewable energy (Akbar et al., 2024; Benlaria and Almawishir, 2024).

Gradually, this alternative has become a global concern since the 1997 Kyoto Protocol recommended that countries reduce greenhouse gas emissions, especially CO₂. Then, it was further tightened by the 2015 Paris climate change conference, including the 2030 United Nations agenda where countries agreed to switch from dependence on fossil fuels to renewable energy. The use of renewable energy is believed to be a new model for achieving economic growth, where this dynamic leads to four hypotheses. *First*, the growth hypothesis explains that renewable energy is capable of achieving economic growth. *Second*, the conservation hypothesis states that the contribution of renewable energy to economic growth is still not significant. *Third*, the feedback hypothesis emphasizes that renewable energy and economic growth have a causal relationship. *Fourth*, the neutrality hypothesis believes that renewable energy has no impact on economic growth (Teklie and Yağmur, 2024; Venkatraja, 2020).

Therefore, alternative renewable energy can be relied on and contribute to reducing environmental damage, resulting in potential benefits such as reducing global warming, diversifying energy supplies and sources for carbon incentives. Furthermore, the trend in the development of renewable energy towards being more labor intensive makes this sector stimulate employment opportunities, especially in developing countries where serious problems of poverty, equality and unemployment are expected to be overcome (Tiwarei et al., 2015).

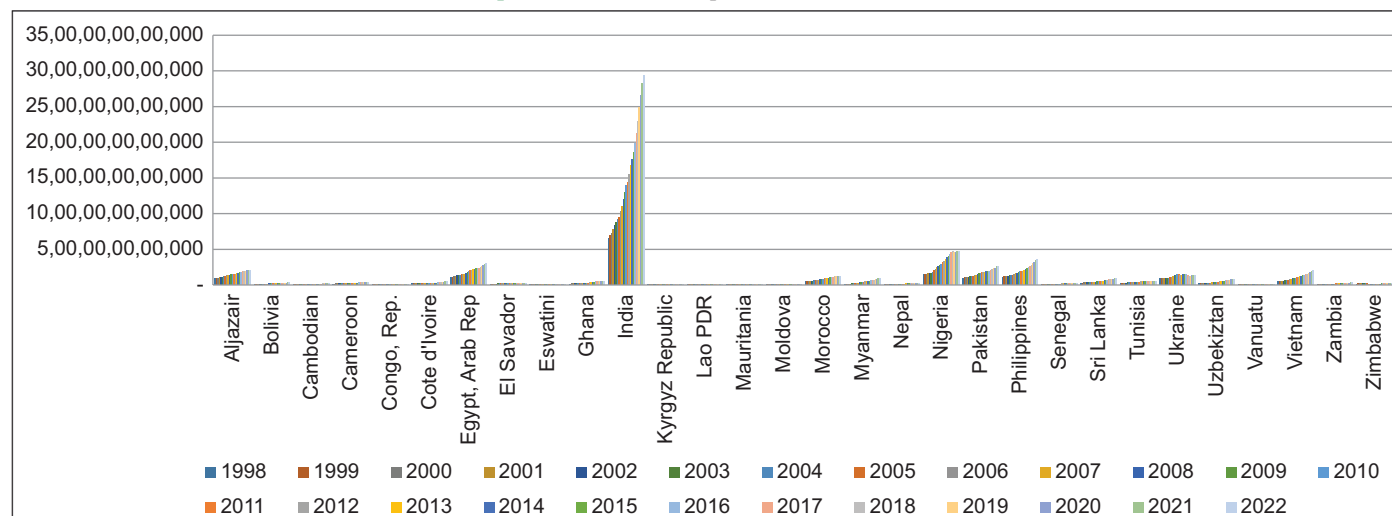
The main focus of renewable energy is essentially that it can increase energy consumption in the long term, it will encourage large levels of investment and technological progress will play an important role as long as countries have renewable energy as a source of development. In addition, investment provides costs for renewable energy projects that are based on policies that lead to improving environmental quality so that environmentally friendly development will be felt by various countries (Tahir et al., 2019).

If we refer to the Environment Kuznets Curve (EKC) hypothesis, massive economic development will increase pollution levels in the early stages, where this phenomenon is often explained as an inverted U curve when there is a balance between development and pollution. The issue of balancing economic development and the environment is of particular concern to stakeholders who

actively play a role in maintaining the balance of environmental quality caused by economic activities. This concern arises because many countries are still experiencing difficulties when the energy transition occurs, especially countries that do not have sufficient natural resources to achieve economic growth. The EKC explanation refers to three effects, namely the effects of scale, composition and technique. The scale effect explains that in the early stages of economic growth there must be more availability of natural resources as production inputs which causes an increase in energy consumption, pollution and carbon emissions. The composition effect focuses on the transformation of the production structure which includes a shift from the energy use model to modernization. Finally, technical effects act as a basis for supporting renewable energy so that increased production efficiency can be achieved (Schall, 2020; Shakouri and Khoshnevis Yazdi, 2017). Therefore, this research focuses on environmental variables such as carbon dioxide (CO₂), renewable energy, energy consumption and macroeconomic variables, namely foreign direct investment, international trade, labor force and population. In general, the GDP conditions of developing countries can be seen in the graph below:

Graph 1 above reflects that the GDP of developing countries has a different pattern from the countries studied. It can be seen that countries on the African continent are below India with the highest GDP, while countries on the American and Asian continents are still lower than countries on the African continent. It needs to be understood that developing countries are still facing a steep road and have been trapped in the middle income trap for several years, which makes it difficult for these countries to move up to become developed countries. For this reason, this research needs to underline the importance of a country achieving prosperity and prosperity for people's lives.

India with a total population of 1 billion, has its own strengths in terms of production with added value enjoyed from the economic sector. More than that, the Indian economy has indeed experienced rapid development over the last decade, in 2022 India GDP will be 2,940,156,656 US\$, of course maintaining this condition will not be easy. In Africa, there is Nigeria which is motivated to advance in the country production capacity with a GDP in 2018 of 461,850,352 US\$ with a significant increase from 2009 of 272,200,955 US\$. For the countries of Bolivia and El Salvador, this region of North America often experiences domestic economic and political turmoil so it is not yet able to stay at the forefront of economic development. In 1998 Bolivia GDP was 11,383,339 US\$ until in 2007 it only increased by 15,031,978 US\$. This condition also occurs in El Salvador with GDP in 1998 amounting to 14,233,323 US\$ only increasing by 16,480,135,825 US\$ in 2007. Developing country regions identical to ASEAN, such as Cambodia, Lao PDR, Myanmar, Philippines and Vietnam in this study provide an economic picture. This region is still not moving in a good direction, because it relies heavily on dependence from other countries. In Europe, Ukraine economic condition is much better compared to other countries with a 2022 GDP of 135,536,959 US\$, this condition is not much different from Algeria which has a 2022 GDP of 202,339,167 US\$.

Graph 1: Gross domestic product current 2010 US\$

Source: World development indicator

2. LITERATURE REVIEW

Renewable energy has undergone very complex changes for economic growth which is basically used as a reference in analyzing a country's economic development. Findings from Rehman (2019) believe that increasing the use of renewable energy has begun to be considered as a driver of economic growth. The parameters of this variable determine the economic conditions in an area that is specifically directly related to industry as an actor using renewable energy. Prasetyani et al. (2024) stated the same results as the impact of the use of renewable energy, economic growth in line with concern for environmental quality as a form of economic development from a new perspective and pushing towards more efficiency in increasing productivity.

Slimane (2024) found that the fact that renewable energy is closely and positively related to economic growth through energy efficiency which includes the heterogeneous development of cutting-edge technology is able to answer the challenges of climate change in the future. However, different results obtained from Gunarto et al. (2024) show the opposite fact, with the finding that renewable energy does not have a significant effect on economic growth. Developing countries are not able to carry out the energy transition as well as developed countries, which of course will hamper economic activity. Natto (2024) stated that not many developing countries have human and technological resources as a reference for energy transformation. This threat makes developing countries lag behind developed countries so that economic growth still relies on the real and financial sectors. Qayum et al. (2016) found that there were problems in environmental quality. So, to achieve economic growth it is not just about achieving high output, but also that environmental sustainability, which is an important issue, must be of special concern to economic actors.

Prempeh (2023) analyzed the impact of carbon dioxide CO₂ on economic growth. The research results show that carbon dioxide CO₂ has an insignificant impact on economic growth due to the emission of geothermal energy as a consequence of industrial areas. Polat (2021) emphasized that the many negative impacts

caused by carbon dioxide CO₂ on the environment in the long term will affect the level of economic growth. In addition, attention must be paid to the governance of clean energy policies so that strengthening the economic sector can become a driving factor for economic growth. Olubusoye and Musa (2020) is more concise in his research results showing that the amount of carbon dioxide CO₂ spread at the start of economic development will disrupt the air quality around the economic area, this will be a responsibility so that innovation in the energy sector can be designed as a form of concern for natural preservation so that economic development can run faster.

Liu et al. (2018) found evidence that energy consumption plays an important role in economic growth with the belief that the economic sector is able to implement sustainable energy efficiency in order to reduce environmental impacts that will disrupt the country's economy in the future. Lin et al. (2013) implies the importance of controlling energy consumption in carrying out production activities so that carbon emission reduction targets can be achieved. For this reason, this relationship is very close to the achievement of economic growth as a fundamental factor that supports the country's economy as a whole. Kayani et al. (2024) also emphasizes that energy consumption can have a positive impact on economic growth in the short and long term, fluctuatingly guarantees an improvement in economic conditions.

Okoro et al. (2020) uses international trade variables in economic growth analysis. The findings of this research show that the trade sector contributes significantly to economic growth by emphasizing the production of export-based goods and services of high quality and able to compete with trade from other countries. Sadiq et al. (2021) confirms that the scope of international trade is a positive driver for increasing domestic production so that economic growth can be achieved. Osano and Koine (2015) analyzes that foreign direct investment provides opportunities for the growth of new economic sectors by opening up employment opportunities, wages and the processing of natural resources contributes greatly to economic growth. Onafowora and Owoye (2019) focuses on capital flows in achieving economic growth.

The results show that there is a gap for the economic sector to utilize capital sources in the production process which requires a lot of costs and the latest technology as well as supporting distribution channels. This is very important for the economic sector to continue to grow and be competitive.

Lai and Cheung (2016) with a different approach analyzes the labor force on economic growth. The research results show that a workforce that grows evenly produces high added value of labor from production output so that it is able to meet the need for domestic goods production. Kaur et al. (2013) believes that a quality labor force is able to adapt well to face competition in the world of work. Apart from that, a high level of education is the main source of labor that is expected to innovate well. Iqbal Chaudhry et al. (2013) stated the demographic impact of population indicators as a driver of economic growth. Concretely explaining that a high population basically has the advantage of the amount of consumption of goods and services and the different characteristics of the population (education, health) play an active role in economic growth, the majority of which is supported by consumption. Hayat (2018) emphasizes that population has a positive contribution to the economy in the long term as a buffer for economic activity.

3. METODHOLOGY

3.1. Panel Data Model

Statistical method analysis with panel data is able to build to analyze the role of renewable energy, environment quality, energy consumption and macroeconomic variable to economic growth. Estimates from panel data are as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \varepsilon_{it} \quad (1)$$

Where Y is dependent variable, β is variable coefficient, X is independent variable, i is denote a country (where $i = 1, 2 \dots N$), and t is time period (where $t = 1, 2 \dots N$), and ε is error terms (Wooldridge, 2015). Based on equation 1, the panel data regression equation model in this study can be seen in equation 2:

$$GDP_{it} = \beta_0 + \beta_1 RE_{1it} + \beta_2 EQ_{2it} + \beta_3 EC_{3it} + \beta_4 TO_{4it} + \beta_5 FDI_{5it} + \beta_6 LF_{6it} + \beta_7 POP_{7it} + \varepsilon_{it} \quad (2)$$

Where GDP_{it} is gross domestic product Constant 2010 US\$, RE_{1it} is renewable energy, EQ_{2it} is environment quality, EC_{3it} is energy consumption, TO_{4it} denotes trade oppnes, FDI_{5it} denotes foreign direct investment, LF_{6it} denotes labor force, and POP_{7it} denotes population.

Table 1: Variable measurement

Variable	Indicator	Acronym	Measurement
Gross domestic product	Gross domestic product	GDP	Current 2010 US\$
Renewable energy	Electric power consumption	RE	KWH
Environment quality	CO ₂ emission	EQ	Metrics Ton Per Kapita
Energy consumption	Natural gas rents	EC	% of GDP
Trade openes	Trade % GDP	TO	% of GDP
Foreign direct investment	Foreign direct investment	FDI	% of GDP
Labor	Labor force total	LF	Person
Population	Population total	POP	Person

Source: Author

This research covers 30 developing countries 1998-2022. These countries include Algeria, Bolivia, Cambodian, Cameroon, Congo Republic, Cote d'Ivoire, Egypt Arab Republic, El Salvador, Eswatini, Ghana, India, Kyrgyz Republic, Lao PDR, Mauritania, Moldova, Morocco, Myanmar, Nepal, Nigeria, Pakistan, Philippines, Senegal, Sri Lanka, Tunisia, Ukraine, Uzbekistan, Vanuatu, Vietnam, Zambia and Zimbabwe. The data in this research was obtained from World Bank publications via the World Development Indicator (WDI) (Table 1).

3.2. Panel Data Selection Method

3.2.1. Chow test

The Chow test is a test to determine the model between common effect and fixed effect that will be used in the research model. With the following hypothesis:

- H0: *Commond effect* (prob >0.05)
- H1: *Fixed effect* (prob <0.05).

In making decisions in the Chow Test, it is based on the probability value, if the probability value is >0.05 then the model chosen is the Common Effect. However, if the probability value is <0.05 then the model chosen is Fixed Effect.

3.2.2. Hausman test

The Hausman test is a test to determine the model between Random Effect and Fixed Effect that will be used in the research model. With the following hypothesis:

- H0: Random effect (prob >0.05)
- H1: Fixed effect (prob <0.05).

In making decisions in the Hausman Test, it is based on probability values, if the probability value is >0.05 then the model chosen is Random Effect. However, if the probability value is <0.05 then the model chosen is Fixed Effect.

3.2.3. Lagrange multiplier test

The Lagrange Multiplier test is a test to determine the model between Common Effect and Random Effect that will be used in the research model. With the following hypothesis:

- H0: Commond effect (prob >0.05)
- H1: Random *effect* (prob <0.05).

In making decisions in the Langrange Multiplier Test, it is based on the probability value, if the probability value is >0.05 then the model chosen is the Common Effect. However, if the probability value is <0.05 then the model chosen is Random Effect.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistic

These results explain the data characteristics of each variable. The gross domestic product variable has an average of 107,957,149, a maximum value of 2,940,156 and a minimum of 455,282 (Table 2). India is the country with the highest economic capacity, while Lao PDR is the lowest. Renewable energy with an average of 678,542, a maximum value of 427,119 and a minimum of 396,356. This data is a reference for the use of renewable energy in developing countries. Environment quality has an average value of 1.261, a maximum value of 8.656 and a minimum of 0.097, reflecting concern for environmental sustainability for economic development. The average energy consumption value is 48,623, the maximum value is 20,201, the minimum value is -32,654 so that energy use in developing countries can be observed in this research.

Trade opportunities with an average of 24,124 include export and import trade which is the backbone for the industrial sector to continue to grow in global competition. The average value of foreign direct investment is 98,856 as a form of foreign capital flow which is useful for driving production activities to ensure their development. The average labor force value of 27,205,014 is very useful for the real economic and financial sectors in offering jobs with the skills they have so that added value can increase, such as in India which has a large labor force. The population has an average of 71,553,958 as a general description of demographic conditions in providing differences in economic, educational and occupational backgrounds with the aim of economic equality.

4.2. Results

The results in Table 3 present the selection of approaches in the panel data method.

4.2.1. Chow test

The results of Chow test show that this study uses the Fixed Effect Model (FEM). This can be seen from the probability value of the Chi-square of 0.000 which is <0.05. Based on this, the choice of the best approach is the Fixed Effect Model (FEM) compared to the Common Effect Model (CEM).

4.2.2. Hausman test

The results of Hausman test show that this study uses the random effect model (REM) (Table 4). This can be seen from the probability value of the Chi-square of 0.0000 > 0.05. Based on this, the choice of the best approach is the fixed effect model (REM) compared to the Common Effect Model (FEM).

Table 2: Variable description

Descriptive statistics	GDP	RE	EQ	EC	TO	FDI	LF	POP
MEAN	107.957.149	678.542	1.261	48.623	24.124	98.856	27.205.014	71.553.958
MEDIAN	22.746.124	427.119	0.855	1.802	74.587	2.096	7.625.196	18.233.293
MAX	2.940.156	396.356	8.656	20.201	175.233	36.957	494.732.705	1.366.417
MIN	455.282	13.513	0.097	-32.654	20.722	-11.624	67.014	168.158
STDV	3.023	760.077	1.359	172.793	156.354	154.268	783.858	210.705
KOV	280.090	112.016	107.727	355.366	648.1056154	156.053	288.130	294.470

Source: Author. GDP: Gross domestic product

4.2.3. Lagrange multiplier test

The results of Lagrange Multiplier test indicate that this study uses the Random Effect Model (REM). (Table 5) This can be seen from the probability value of the Chi-square of 0.0000 which is <0.05. Based on this, the choice of the best approach is the random effect model (REM) compared to the Common Effect Model (CEM).

4.3. Panel Data Estimation Results

The statistical estimation results below will describe the condition of the economic growth as the dependent variable which is analyzed with renewable energy, environment quality, energy consumption and macroeconomic conditions such as trade openness, foreign direct investment, labor force and population as independent variables (Table 6). With the aim of broader analysis, using the fixed effects model approach:

Based on the Table 6, the results of the panel data regression equation are as follows:

$$GDP_{it} = -2.141.165 + 0.232301 + 0.274012 - 0.005701 - 0.010787 - 0.023531 + 0.124062 + 1.541.072 + \varepsilon_{it} \quad (3)$$

On estimate get renewable energy has a regression coefficient of 0.232301. These results show that there is a positif influence on economic growth. That is, if 1% increase renewable energy will increase economic growth by 0.232301. Environment quality has a regression coefficient of 0.274012. These results show that there is a positif influence on economic growth. That is, if 1% increase environment quality will increase economic growth by 0.274012. Energy consumption has a regression coefficient of -0.005701. These results show that there is a negative influence on economic growth. That is, if 1% increase energy consumption will decrease economic growth by -0.005701.

Trade openness has a regression coefficient of -0.010787. These results show that there is a negative influence on economic growth. That is, if 1% increase trade will decrease economic growth by -0.005701. Foreign direct investment has a regression coefficient of -0.023531. These results show that there is a negative influence on economic growth. That is, if 1% increase foreign direct investment will decrease economic growth by -0.023531. Labor force has a regression coefficient of 0.124062. These results show that there is a positif influence on economic growth has a regression coefficient of 1.541.072. These results show that there is a positif influence on economic growth. That is, if 1% increase population will increase economic growth by 1.541.072.

Table 3: Chow test

Effect test	Statistic	d. f.	Probability
Cross-section F	121.449628	(29.672)	0.0000
Cross-section Chi-square	1298.293305	29	0.0000

Table 4: Hausman test

Test summary	Chi. sq statistic	Chi-sq df	Probability
Cross-section random	155.255574	7	0.0000

Table 5: Lagrange multiplier test

Lagrange multiplier tests for random effects			
Null hypotheses: No effects			
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided			
(All others) alternatives			
Information	Test hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	3700.956 (0.0000)	194.7471 (0.0000)	3895.703 (0.0000)
Honda	60.83548 (0.0000)	13.95518 (0.0000)	52.88498 (0.0000)
King-Wu	60.83548 (0.0000)	13.95518 (0.0000)	51.35475 (0.0000)
Standardized Honda	69.71117 (0.0000)	14.27763 (0.0000)	52.29576 (0.0000)
Standardized King-Wu	69.71117 (0.0000)	14.27763 (0.0000)	50.37671 (0.0000)
Gourieriou, et al.*	--	--	3895.703 (<0.01)
*Mixed Chi-square asymptotic critical values			
1%	7.289		
5%	4.321		
10%	2.952		

Table 6: Panel data estimation result

Variable	Coefficient	Std. error	t-statistic	Prob.
GDP	-2.141.165	0.445634	-4.804.759	0.0000
RE	0.232301	0.025937	8.956.510	0.0000
EQ	0.274012	0.027857	9.836.512	0.0000
EC	-0.005701	0.006291	-0.906109	0.3652
TO	-0.010887	0.008841	-1.231.469	0.2186
FDI	-0.023531	0.003367	-6.988.741	0.0000
LF	0.124062	0.159831	0.776205	0.4379
POP	1.541.072	0.165093	9.334.573	0.0000
Effects specification				
Cross-section fixed (dummy variables)				
R-squared	0.98898	Mean dependent var	1.049.233	
Adjusted	0.98839	S.D. dependent var	0.667047	
R-squared				
S.E. of	0.071875	Akaike info criterion	-2.377.013	
regression				
Sum squared	3.471.522	Schwarz criterion	-2.138.843	
resid				
Log	8.796.511	Hannan-Quinn criter.	-2.285.000	
likelihood				
F-statistic	1.675.255	Durbin-Watson stat	0.140449	
Prob	0.0000			
(F-statistic)				

GDP: Gross domestic product

4. DISCUSSION

This section will explain more concretely the research results from the estimated data that has been processed. Renewable energy with electricity consumption indicators has a significant effect on economic growth. As has been studied by many researchers, electricity power consumption with modern usage helps society and industry to implement more massive use of renewable energy to support production activities. Ulloa-De Souza et al. (2024) and (Yesbolova et al., 2024) emphasizes the reasons for renewable energy as an important factor for economic growth, because in the era of globalization the emphasis on the use of renewable energy is increasingly finding many technological innovations that are more efficient so that they can be enjoyed by many parties. This activity does attract a lot of investment costs, but with policies from the relevant countries it will be easier to organize a conducive environment for economic actors so that long-term plans for the clean energy movement can be achieved. For this reason, renewable energy production must continue to be carried out as a form of support for environmental safety that becomes more important and not just prioritizing the production of goods and services. The development of a market base for renewable energy must be carried out massively to increase electricity power consumption with the availability of raw materials and affordable prices for society and industry by promoting government policies, portfolio standards and improving environmental conditions from a macroeconomic perspective.

Environmental quality with the carbon dioxide CO₂ emission indicator has a significant effect on economic growth. The need for energy is very dependent on various natural resources which are believed to be an effort to preserve the environment in the long term will have a positive impact on the economy. Ikhsan and Amri (2024) and Kinda (2021) looked carefully at the use of CO₂ which is really needed by the economic sector to increase the production capacity of industry which supports the need for goods and services for a country. Thus, the effectiveness and efficiency of energy use must be considered as a form of collaboration in environmental conservation efforts based on nature conservation policies as appropriate law enforcement efforts. When this perception is implemented, the hope of the emergence of an economic region that grows in harmony with environmental sustainability will be enjoyed by countries that are focused on achieving economic and social progress. On the other hand, appropriate and responsive planning in an energy conservation mechanism can be carried out by involving many government and private parties to build an agreement regarding energy taxes as a form of burden on the industrial sector in order to reduce excessive use of CO₂ and curb fossil fuels from becoming widespread environment and have far-reaching economic impacts.

Energy consumption with natural gas rents indicators does not have a significant effect on economic growth. A study by (Khan et al., 2020; and Liu, 2021) suggests that the expansion of the energy sector serves as an impetus for industry to modernize and sustain itself in achieving an increasing economic level. To achieve economic growth, the resources needed are very large

and frequent shortages of gas, oil and coal and rising prices are the main problems. For this reason, adequate infrastructure needs to be developed as an effort to protect energy availability in encouraging the economic sector to continue to grow according to its corridors by increasing production capacity, increasing employment opportunities, distribution channels, information centers and guaranteeing economic strength. In addition, with regard to energy consumption, progressive targets must be set to minimize the environmental impact of conventional and non-conventional energy sources, which can have a positive influence on production and the marketing mix for industry and encourage accelerated economic growth.

Trade openness does not have a significant effect on economic growth as evidence that in the countries studied, trade is still not the basis for the running of the economy in a strong manner. Research from Fetscherin et al. (2012) and Khatun and Bist (2019) provides evidence that a small trade composition relative to economic growth tends to have a small international market, especially for developing countries that have difficulty marketing products with various important aspects that they do not have, such as export tax incentives and ease of regulation. This means that the cumulative trade balance is unstable and is on a smaller scale. International trade should be sought to increase global competitiveness, especially exports as state revenue in the form of bilateral and multilateral cooperation so that the market becomes wider. For imports, as a form of support in the production process, imports are used as a complement to raw materials as well as improving technology from developed countries to developing countries which primarily require the availability of quality resources. If this method is carried out by developed countries with a clear strategy, then in the long term it will contribute greatly to the economy which is the backbone of the country so that development, employment opportunities and output in the form of high and sustainable economic growth are equal.

Foreign direct investment has a significant influence on economic growth and has become a hope for developing countries that private development costs will be a driver of increasing the country's production capacity. Analysis from Amarasekara et al. (2022) and Tahir and Azid (2015) explains that foreign direct investment is an important part of the economy as a form of overall financial globalization in an effort to update technology, human resources, management and build harmonious relationships between government and capital owners. This condition is based on the fact that it is a priority for developing countries to increase potential which needs to be looked at by providing a simple bureaucratic flow, economic and non-economic policies as well as updating superior and competitive human resources. This is inseparable from the unavoidable integration of the world economy so that state activities and investors will act as a competitive advantage, not as a comparative advantage, in an effort to invest capital with the aim of gaining profits and increasing capital reserves. The contribution of direct foreign investment from the demand side is based on the fact that it will be a stimulus for the economy, while from the supply side direct foreign investment is a catalyst for financing economic activities. Thus, economic growth becomes a bargaining power that cannot be separated from

a country's progress so that foreign direct investment becomes one of the driving forces to achieve this goal.

Labor force does not have a significant effect on economic growth, reflecting that the available labor force has not been able to answer the challenges in prioritizing economic growth targets. A study from Abouelfarag and Abed (2019) and Asongu (2015) identified that the total labor force was not completely at the same level when entering the job market which has tended to have intense competition for decades and when economic globalization and free markets in many countries were carried out. Underutilization of labor is a common problem experienced by developing countries, the difference lies in specifications and proportions so that the characteristics of educational background and skills become challenges for the labor force. This problem tends to be slow to be resolved by developing countries with a high workforce, but job opportunities are relatively small and create unemployment which over time will become a burden for the country, affecting the social, political and psychological conditions of society, thereby worsening economic conditions. Furthermore, Azam et al. (2020) and Parmova et al. (2024) provides evidence that a labor force dominated by low-educated workers cannot be maximized as quality human resources. In the end, they will be pushed aside by qualified workers with high output potential and guaranteed understanding of the technology needed in economic activities.

Population has a significant effect on economic growth, indicating that the characteristics of a country's population are able to make maximum contributions in determining the direction of economic policy. Research from Ismail et al. (2024) confirms the finding that population has an important role in and is a reflection of a country's economic progress. In economic activities, residents will be involved in the process of producing goods and services with the level of expertise they possess so that they are able to work with high economic value. In addition, consumption by the population is a driving factor for national production by paying attention to per capita income so that price stability can be achieved. However, if a country has a high population, it will cause obstacles in the future, such as savings rates, foreign exchange reserves and economic equality. Ahmad et al. (2024) also found a significant influence of population on economic growth which becomes more attention when the population is in the same proportion in economic activities with attention to work-worthiness aspects, then the population gets the same opportunities, furthermore for business actors it will facilitate financing in the form of investment from bank and non-bank financial institutions so that capital accumulation can have an impact on economic growth.

5. CONCLUSION

This research seeks to explain renewable energy, environmental quality and energy consumption on economic growth in 30 developing countries 1998-2022. The estimation results of this research show that the renewable energy variable with the electricity power consumption indicator and environmental quality with the carbon dioxide CO₂ indicator has a significant effect on economic growth. Meanwhile, the energy consumption variable with the natural gas rents indicator does not have a significant

effect on economic growth. For developing countries, high dependence on energy must be optimized by implementing an energy structure that limits energy use in order to reduce pollution. The government as a stakeholder will be a bridge to accelerate this energy transition by providing the right development environment and promoting the development of green energy or clean country-based industries in order to save natural resources in the long term through a pro-active financing system that must dominate efforts to improve technology to achieve this goal this can be achieved.

Apart from that, macroeconomic variables are also analyzed to support broader research results. The foreign direct investment and population variables have a significant effect on economic growth in developing countries, indicating that investment is the basis for development with an emphasis on foreign financing and is expected to be able to stimulate the economy. Population is a strength for competitive human resources because a country will rely on domestic strength to achieve the goals of economic development. The trade opens and labor force variables do not have a significant effect on economic growth in developing countries. Trade capacity is still not extensive in developing countries, making it difficult for market players to access export activities to gain profits, not only that, limitations in producing goods and services caused by low product competitiveness are a current obstacle. The labor force is not necessarily able to become the foundation for the economic sector in recruiting a quality workforce so that economic problems will continue to encourage developing countries to make improvements to various aspects of state institutions.

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