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Analysis of Factors Causing CO2 Emissions in Developed, Developing, and BRICS Countries

Analisis Faktor-Faktor Penyebab Emisi CO2 di Negara-Negara Maju, Negara-Negara Berkembang, dan Negara-Negara BRICS

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ABSTRACT
As time goes by, technological facilities are experiencing rapid progress; this can encourage the growth of the industrial and transportation sectors, which can increase consumption of fuels, especially fossil fuels. The more humans use fossil fuels, the more CO2 emissions in the world will increase. Co2 emissions are believed to trigger climate change and global warming. In this study, time series and cross-section techniques are used to collect secondary data utilizing quantitative approaches. This research examines the level of CO2 emissions in developed countries, developing countries, and BRICS countries in 2013–2022. The research results show several things, namely (1) forest areas do not have a substantial impact on CO2 emissions in developed, developing, and BRICS countries. (2) The use of renewable energy has not completely reduced the problem of CO2 emissions because there remain a number of nations that have not optimized renewable energy. (3) Fossil energy consumption is not significant in CO2 emissions in several developed countries and BRICS countries because most countries are starting to implement low-carbon energy so they can reduce CO2 emissions. (4) The use of technology is not significant for developed countries and BRICS because they have implemented advanced efficiency technology that is environmentally friendly. (5) Economic growth has a major impact on CO2 emissions in BRICS, developing, and industrialized nations since the larger the income per capita, the greater the use of technology that uses fossil fuels.
Keywords : *CO2 emissions, forests, renewable energy, fossils, technology, GDP.*

1. Introduction

The use of mainly fossil fuels will continue to grow and result in an increase in CO2 gas production. The earth's temperature is now twice as high as it has been in the last 50 years. CO2 emissions cause climate change, environmental destruction, and changes in weather patterns. This adversely affects humans, especially those living in poverty, who are most vulnerable to its effects (Syafitri & Putri, 2022). Fossil energy, including gas, oil, and coal, is still the mainstay of every human activity. The world's dependence on these energies has caused serious environmental damage. Gas, oil, and coal are non-renewable because they are limited natural resources. In this regard, it can lead to the fear of primary energy exhaustion. The high demand for primary energy that is not accompanied by an increase in energy reserves can cause prices to soar.(Dwisari et al., 2023).

The development of the financial sector can cause and impact environmental damage in the long term. The government should provide policies that are able to pay attention to environmental conditions and the level of financial development (Vo et al., 2021). Almost all sectors that support the economy rely on limited resources to meet the various needs of every human being, such as activities in the industrial, transportation, and power generation sectors. The existence of this phenomenon raises international awareness, especially for the largest group of CO2 emitting countries, namely BRICS, which has a large population and rapid

economic development. These countries are allied to deal with CO2 emissions and greenhouse gases (Mu Tashim & Rudatin, 2024).

In developed countries, high GDP is followed by high economic growth, which is assumed to be due to the large number of people using primary energy. The high consumption of fossil energy in developed countries causes a significant increase in CO2 emissions. Compared to middle-income countries, the fossil energy consumption of developed countries is much more dominant, which can lead to large environmental pollution. Forests are one of the contributors to the world's carbon and hydrological cycle problems. Land use and the forestry sector cause greenhouse gases; this is due to deforestation due to forest fires and illegal logging. Arbitrary conversion of forest land for settlements, agriculture, and plantations that do not pay attention to the interests of many people also has a negative impact on ecosystem balance and causes climate change (Kurniarahma et al., 2018).

Based on research by Putri et al. (2022), they explained that economic growth, both in the short and long term, has no significant effect on carbon dioxide emissions. In contrast to research (Kurniarahma et al., 2018) that found a significant negative effect of economic growth on carbon dioxide emissions, both in the short and long term, this is because under certain conditions environmental damage has decreased as economic growth increases. Meanwhile, according to Mu Tashim & Rudatin (2024) in their research analyzing the economy of BRICS countries on carbon dioxide emissions, they state that economic growth and energy use have a positive influence on the level of carbon dioxide emissions in BRICS countries. Efforts to reduce emissions with renewable energy encourage many studies, including Zulaicha et al. (2018) resulting in an insignificant negative effect of renewable energy consumption compared to carbon dioxide emissions because its utilization is not optimal. As research (Audrey et al., 2017) shows that renewable energy has a negative and insignificant effect on the level of carbon dioxide emissions, this can occur if the use of renewable energy is maximized; it will be able to reduce the high consumption of fossil fuels so as to reduce the level of carbon dioxide emissions in developed countries. Research (Sharif et al., 2019) also supports renewable energy has a negative and insignificant effect on carbon dioxide emissions because, with new energy, environmental damage will be prevented, especially in affecting the level of carbon dioxide emissions. Reducing the level of carbon dioxide emissions by reducing the use of non-renewable data sources has resulted in several studies, such as Zulaicha et al. (2018) which resulted in a significant positive effect of fossil energy on carbon dioxide emissions. The study stated that the use of fossils consumed to meet energy needs to support economic growth continues to increase. In accordance with research (Nadeak & Nasrudin, 2023) that suggests fossil energy also has a significant positive effect on carbon dioxide emissions in developing countries such as Indonesia, according to him this is due to several main sectors of emission sources, such as energy, industrial activities and product use, waste, agriculture and land use, and so on. Efforts to control carbon dioxide emissions with technology triggered several studies. The results of research (Ganda, 2019) show technology has a significant positive effect on the level of carbon dioxide emissions in some developed countries because the use of environmentally safe technology can reduce the level of carbon dioxide emissions. Supported by research (Cheng et al., 2019), technology has a significant positive effect on carbon dioxide emissions in several developed countries. This is because the higher the country's income, the more innovative the technology used will be, which in turn can reduce CO2 emissions. The factor of forest area is also very influential on CO2 emissions (Jurnal et al., 2024). In their research, they state that forests have a significant positive effect on carbon dioxide emissions in the long term. This is due to deforestation, which causes a weakening of the forest's ability to absorb carbon produced by various types of human actions and can hinder the SDGS 13 program in stabilizing the climate. The findings are in line with Fauzi (2017) that forest area is very important because it plays a role that can minimize the increase in CO2 in the atmosphere. The increasing percentage of forest

area, the lower the level of carbon dioxide emissions in developed countries and developing countries.

In contrast to previous studies, this research seeks to compare the influence of forests, renewable energy, fossils, technology, and GDP on emissions in BRICS countries, which are the largest emitters. Developing countries that find it difficult to reduce emissions due to their emphasis on economic growth and developed countries that are considered to have an awareness of the importance of reducing environmental damage by using technology to utilize renewable energy. Based on this problem, we offer a solution to replace non-renewable energy with renewable energy such as geothermal energy, hydropower, and biomass. This study aims to identify the influence of forest variables, renewable energy, fossil consumption, technology use, and GDP on emissions in BRICS countries, developed countries, and developing countries.

2. Literature Review

The EKC hypothesis theory explains the relationship between economic growth and environmental degradation, especially carbon dioxide emissions, which can increase along with economic growth and decrease in certain periods due to advances in technology and a shift to a service-dependent economy (Musyarof & Qomari, 2023). During the initial phase of economic growth, it has a negative impact on environmental degradation, then in the next phase it enters the industrial economy stage, and in the last phase it enters the post-industrial economy, which focuses on prioritizing environmental degradation, causing the curve to decline, and the decline in environmental conditions can be controlled as economic capacity increases (Maulidina & Maulana, 2022).

In previous research, related to the relationship and the number of studies on how environmental indicators are affected by economic development with different methods and time periods of research. Although many studies produce a positive relationship between environmental damage and economic development, there are also some studies that show the results of a correlation that has a negative and insignificant effect. Research by Mendoza et al. (2021) shows that European Union member countries and also China based on ECM analysis show that CO2 emissions have a negative influence on economic growth. Meanwhile, a study conducted by Allen (2017) concluded that economic growth is not significant to carbon dioxide emissions because economic growth, especially in Indonesia, is influenced by domestic consumption, while domestic consumption only has a small contribution to CO2 production. Research conducted (Reneri Arista & Amar, Department of Economics, Faculty of Economics, State University of Padang, Jl Hamka Air Tawar Padang, 2019) states that the relationship between economic growth and non-renewable energy is not significant. This is because developing countries still depend on non-renewable energy, especially fossils, in development activities. Currently, the government is making contributions to encourage increased infrastructure development for the advancement of economic growth. Therefore, fossil energy consumption is an important element in realizing advanced economic growth.

Energy is essential for achieving sustainable national development goals in terms of social, economic, and environmental aspects. If a country's economy can develop faster, the demand for energy consumption will also increase (Musyafiq & Purwanto, 2021). In terms of demand (demand side), the increase in oil prices occurs due to world economic growth. Meanwhile, from the supply side, the high oil price is caused by the production and supply of producing countries, both OPEC and non-OPEC members. The high consumption of petroleum causes petroleum reserves to deplete, so that it can cause petroleum to rise (Syafitri & Putri, 2022). The use of energy in this way causes consumption of fossil fuels to continue to increase and causes pollutant emissions, which can cause problems with air quality and human health (Yana et al., 2021).

Research by Syamsuddin et al. (2023) explains that the demand and potential for renewable energy in several countries have increased at the same time. Since energy

consumption will increase by 50%, ASEAN members issued a policy with the aim of protecting 23% of primary energy from renewable energy sources by 2025. This can be done by revitalizing the energy sector, issuing policies, and significant investment. Currently, several countries, especially ASEAN member countries, have adopted the use of renewable energy resources such as solar, wind, water, and waste. According to research (Noor & Rahman, 2023), non-renewable energy resources have various negative impacts that can lead to increased utilization of new renewable energy sources; these energy sources offer considerable potential to reduce CO2 emissions and fossil fuel dependence. However, renewable energy sources have temperamental and unpredictable characteristics, such as depending on weather conditions and seasons, so this instability presents a challenge to protect the balance between energy supply and demand.

3. Research Method

This research was conducted using a quantitative approach, using secondary data derived from various sources, such as Global Forest Watch (GFW), the World Bank, Our World in Data, and Institute Energy, in the period 2013-2022. In this study, the dependent variable used is CO2 emissions, while the independent variables used include forests, renewable energy, fossil energy use, technology use, and GDP. This study uses a panel test with three different methods, namely (FEM), (CEM), and (REM), by combining time series and cross section with a unit of analysis using 30 countries, which include BRICS countries, developed countries, and developing countries. To determine the best model, the Chow test, the Hausman test, and the Langrange multiplier test are used. The program used in this research is the Eviews 12 application.

The econometric model used in this study is as follows:

$$CO2_{it} = \beta_0 + \beta_1 KH_{it} + \beta_2 RA_{it} + \beta_3 EF_{it} + \beta_4 TECH_{it} + \beta_5 GDP_{it} + \epsilon_{it}$$

where:

CO2 : carbon dioxide emission
KH : forest area
RA : renewable energy
EF : fossil energy use.
TECH : use of technology
GDP : economic growth
I : cross-section dimension
t : time series dimension
εit : annualized

The selection of econometric models in this study aims to test theoretical hypotheses as well as future trends in energy use that can contribute to carbon dioxide emissions in various countries.

4. Results and Discussion

Developing Countries

The first step in panel data regression analysis is to compare the modeling between CEM and FEM. The initial test is conducted using the chow test. The following are the results of the Chow test shown in tabular form.

Tabel 1.1. Chow test results

BEffects Test	Statistic	d.f.	Prob.
Cross section F	2,672268	(12,105)	0.0036
Cross Section Chi Square	32,780864	12	0.0010

The chow test results in table 1.1 obtained a cross-section Chi-Square probability value of 0.0010 less than 0.05, so it can be concluded that FEM is the most suitable model to be used in panel data regression estimation. Since the chow test rejected the hypothesis, the next step

that can be taken is to conduct the Hausman test. The following are the results of the Hausman test that has been carried out.

Uji Hausman

Table 1.2 Hausman Test Results

Test Summary	Chi Sq. Statistic	Chi Sq. d.f.	Prob.
Cross-section random	25.104245	5	0,0001

The results of the Hausman test in table 1.2 show that the cross-section probability of 0.0001 is less than 0.05, so it can be concluded that REM is the best model to use in panel data regression estimation. From the results of the Chow test with the Hausman test, because both have a probability of less than 0.05, the best model for panel data regression in developing countries is FEM.

Developed Countries

Tabel 2.1. Chow test results

Effects Test	Statistic	d.f.	Prob.
Cross section F	0,156003	(15,139)	0.9999
Cross Section Chi Square	2,671154	15	0.9998

The chow test results in table 2.1 obtained Prob.Cross section Chi-Square of 0.9999 more than > 0.05, so it can be concluded that FEM is less suitable for use in estimating data from this developed country, so the Hausman test must be carried out in the next test.

Uji Hausman

Table 2.2 Hausman Test Results

Test Summary	Chi Sq. Statistic	Chi Sq. d.f.	Prob.
Cross-section random	0,478554	5	0,9929

The results of the Hausman test above obtained a prob. cross-section of 0.9929 more than > 0.05, so it is necessary to do further testing, namely the lagrange multiplier test, to choose the best model between CEM or REM.

Table 2.3 Lagrange Multiplier Test Results

	Cross-section	Time	Both
Breusch-Pagan	6,421683	0,560502	6,982186
	(0,0113)	(0,4541)	(0,0082)

The results of the lagrange multiplier test above obtained Prob. Breusch-Pagan of 0.0113 are less than < 0.05. So, it can be concluded that the best modeling test for analyzing data in developed countries is REM.

BRICS Countries

Tabel 3.1. Chow test results

Effects Test	Statistic	d.f.	Prob.
Cross section F	0,313963	(4,40)	0,8669
Cross Section Chi Square	1,545676	4	0,8185

The chow test results in table 2.1, obtained Prob.cross section Chi-Square of 0.8185 is more than > 0.05, it can be concluded that FEM is less suitable for use in estimating this developed country data, so the hausman test needs to be done for the next test.

Uji Hausman

Table 3.2 Hausman Test Results

Test Summary	Chi Sq. Statistic	Chi Sq. d.f.	Prob.
Cross-section random	5,395605	5	0.3695

The results of the Hausman test above obtained a prob. cross-section of 0.3695 more than > 0.05, so it is necessary to do the next test, namely LM, to choose the best model between CEM or REM.

Table 3.3 Lagrange Multiplier Test Results

	Cross-section	Time	Both
Breusch-Pagan	2,202745	1,388860	3,591605
	(0,1378)	(0,2386)	(0,0581)

In the results of the lagrange multiplier test above obtained, Prob. Breusch-Pagan of 0.1378 is more than > 0,05. So it can be concluded that the best modeling test for analyzing BRICS country data is CEM.

Discussion

Developing Countries

Table 4.1 Panel Data Analysis Model

Variabel	CEM		FEM		REM	
	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.
Constant	2.608120	0.0103	4.542025	0.0000	2.822939	0.0056
Hutan	-0.514619	0.6078	-0.678371	0.4990	-0.557005	0.5786
Renewable	1.073939	0.2851	-4.243743	0.0000	1.162395	0.2474
Fosil	0.254821	0.7993	2.060012	0.0419	0.275810	0.7832
Teknologi	-4.065392	0.0001	-1.672604	0.0974	-4.400239	0.0000
PDB	4.083428	0.0001	3.560370	0.0006	4.419761	0.0000
R-square	0.263265		0.435626		0.263265	
F-stat	0.231780		0.344251		0.231780	
Prob.stat	0.000001		0.000000		0.000001	

From the table above, the FEM model shows that renewable, fossil energy, technology, and GDP have a significant influence on increasing carbon dioxide emissions in developing countries because both have a prob. value less than alpha (<0.05). The adjusted R square value is 0.344; it can be concluded that the independent variables affect the dependent variable simultaneously by 34.4%, while the remaining 65.6% is influenced by other variables.

In the t-test, forests have no effect on CO2 emissions in developing countries because it has a probability of 0.4990; this figure shows a value greater than 1.0 (> 0.05) and shows a negative relationship with CO2 emissions because it has a t-stat value of -0.6783, meaning that every increase in forest area by 1 hectare can reduce CO2 emissions by -0.6783 percent. The renewable variable has a negative correlation to carbon dioxide emissions because it has a t-stat value of -4.2437, which means that if renewable energy increases by one percent, it can reduce carbon dioxide emissions by -4.2437 percent. The fossil variable is positively related to emissions with a t-stat value of 2.0600, meaning that every increase in fossil energy by 1 ton can increase CO2 emissions by 2.0600 percent. Technology variable The use of technology has a negative relationship to carbon dioxide emissions with a t-stat of -1.6726, which means that an increase in technology by 1 percent can reduce the level of carbon dioxide emissions by -1.6726 percent. Meanwhile, GDP has a positive influence on carbon dioxide emissions with a t-stat value of 3.560, meaning that every economic growth rate increase of 1 US$ can increase carbon dioxide emissions by 3.5603 percent.

In the f test, the prob . value of the simultaneous F test on prob (F-Statistic) obtained the results of 0.000000; the value is less than 0.05. It can be concluded that forests, renewable, fossil energy, technology, and GDP simultaneously affect the variable growth of CO2 emissions in developing countries, especially in 14 countries, namely (Brazil, India, South Africa, Indonesia,

Brunnai Darusalam, Cambodia, Laos, Malaysia, Myanmar, the Philippines, Thailand, Vietnam, Romania, and Hongary).

Developed Countries

Table 4.2 Panel Data Analysis Model

Variabel	CEM		FEM		REM	
	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.
Constant	-0.852998	0.3950	0.141073	0.8880	-0.817184	0.4151
Hutan	-0.110605	0.9121	0.180913	0.8567	-0.105962	0.9158
Renewable	1.704468	0.0903	-0.011724	0.9907	1.632905	0.1045
Fosil	1.409403	0.1607	0.244288	0.8074	1.350229	0.1789
Teknologi	-0.881838	0.3792	-0.487754	0.6265	-0.844814	0.3995
PDB	3.445820	0.0007	3.054308	0.0027	3.301147	0.0012
R-square	0.094128		0.109126		0.094128	
F-stat	0.064716		-0.019058		0.064716	
Prob.stat	0.008891		0.647854		0.008891	

From the table above, the REM model shows that renewable, fossil energy, technology, and GDP have a significant effect on increasing carbon dioxide emissions in developed countries because both have a prob. value less than alpha (<0.05). The adjusted R square value is 0.064, so it can be seen how the influence of the dependent variable and the independent variable works simultaneously as much as 0.64%. While the remaining 99.36% is influenced by other variables.

In the t-test, forests have a negative relationship with increasing carbon dioxide emissions, having a t-stat value of -0.1059, which means that an increase in forest area of 1 hectare can reduce carbon dioxide emissions by -0.1059 percent. Renewable variables have a positive influence on carbon dioxide emissions with a t-stat of 1.6329, which means that a 1% increase in renewable energy can increase CO2 emissions by 1.6329%. The fossil variable has a positive correlation with CO2 emissions with a t-stat value of 1.3502, which means that an increase in fossil energy by 1 ton can increase CO2 emissions by 1.3502 percent. The technology variable has a negative correlation with CO2 emissions with a t-stat value of -0.8448, which means that an increase in technology by 1 percent will reduce carbon dioxide emissions by -0.8448 percent. While the GDP variable contributes significantly to carbon dioxide emissions in developed countries because it shows a prob. value of 0.0012 less than 0.05 and has a positive correlation with carbon dioxide emissions with a t-stat of 3.3011, which means that an increase in gross domestic product by 1 US dollar will increase carbon dioxide emissions by 3.3011 percent.

In the f test, the probability (F-Statistic) of 0.008891 is less than 0.05, and it is concluded that forests, renewables, fossil energy, technology, and GDP simultaneously have an influence on the growth variable of carbon dioxide emissions in developed countries, especially in 16 countries, namely Russia, France, China, Poland, Portugal, Singapore, Germany, the Netherlands, Italy, Sweden, Slovania, Finland, Denmark, Austria, Ireland, and Lithuania.

BRICS countries

Table 4.3 Panel Data Analysis Model

Variabel	CEM		FEM		REM	
	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.
Constant	-1.221562	0.2284	0.036080	0.9714	-1.300331	0.2003

Hutan	-0.193875	0.8472	-0.524012	0.6032	-0.094645	0.9250
Renewable	0.363648	0.7179	-0.600001	0.5519	0.347820	0.7296
Fosil	-0.255974	0.7992	0.406049	0.6869	-0.257804	0.7978
Teknologi	1.011980	0.3171	-0.015638	0.9876	1.070506	0.2902
PDB	5.461188	0.0000	4.994019	0.0000	5.925636	0.0000
R-square	0.495346		0.510708		0.534152	
F-stat	0.437999		0.400617		0.481215	
Prob.stat	0.000009		0.000309		0.000002	

From the table above, the CEM model shows that renewable, technology, and GDP have a significant influence on the increase in carbon dioxide emissions in BRICS countries. The adjusted R square value is 0.437, thus the simultaneous effect of independent variables on the dependent variable is 43.7%, while additional variables affect the last 56.3%.

In the t-test, forest has a negative relationship with a t-stat value of -0.1938, which means that an increase in forest area of 1 hectare can reduce CO2 emissions by 0.1938 percent. The renewable variable has a positive correlation to carbon dioxide emissions with a t-stat of 0.3636, which means that an increase in renewable energy by 1 percent can increase carbon dioxide emissions by 0.3636 percent. There is a negative correlation between fossil fuel consumption and carbon dioxide emissions, with a t-stat value of 0.2559, which means that an increase in fossil energy by 1 ton can reduce CO2 emissions by 0.2559 percent. The use of technology has a positive correlation on carbon dioxide emissions with a t-stat of 1.0119, which means that an increase in technology by 1 percent can increase carbon dioxide emissions by 1.0119%. While gross domestic product has a significant effect on carbon dioxide emissions in developed countries because it has a probability of 0.0000 less than 0.05 and has a positive correlation on carbon dioxide emissions with a t-stat of 5.4611, which means that an increase in gross domestic product by 1 US dollar will increase carbon dioxide emissions by 5.4611%.

In the f-test, the adjusted R square value is 0.437, thus the simultaneous influence of the independent variables on the dependent variable is 43.7%, while additional variables affect the last 56.3%.

Forest Effect on CO2 Emissions

Based on the results of the above research on the panel data analysis test, forests have no significant effect on CO2 emissions in developing countries. The same thing with research conducted (Adrian, 2024) shows that the insignificance of forest damage to CO2 emissions in developing countries, especially ASEAN, because the level of deforestation has changed because people have learned about the importance of maintaining the natural environment through reforestation, which can reduce CO2. In contrast to research (Arshad et al., 2020), it was found that forest deforestation in the long term has a positive impact on environmental damage and shows significant results on CO2 emissions because with a one percent reduction in tree cover, it can have the effect of increasing CO2 emissions. In developed countries, research (Aji et al., 2024) explains that if there is an increase in forest area, then CO2 emissions will decrease. According to Begum et al. (2020) the insignificance of forests on CO2 emissions in developed countries is because most people have begun to realize the importance of the forestry sector to reduce ozone-depleting substances and also contribute to overall environmental sustainability. Therefore, it can provide further support for the preservation and expansion of forest areas in developed countries. Whereas in BRICS countries, activities in the agricultural or forestry sector are said to have no significant effect on increasing carbon dioxide emissions because agricultural or forestry activities in most countries are decreasing compared to industrial activities in the current era. This condition is proven by the increasing number of agricultural land or forests that

have been converted to industrial use. This can happen because there are many other factors or sectors that are more influential in increasing CO2 emissions (Di & Jawa, 2024).

The Effect of Renewables on CO2 Emissions

Based on the results of the above research on the panel data analysis test, renewable energy has a significant negative effect on carbon dioxide emissions in developing countries. This is in line with research (Adinew, 2020) and Chandra Voumik & Sultana, 2022) that renewable energy has a significant effect on reducing CO2 emissions. Renewable energy resources have an increasing trend because they have been widely accepted in the world, and many countries have established the use of renewable energy to meet electricity and energy needs. In developed countries, panel data analysis tests produce a positive effect on carbon dioxide emissions. There are differences in research results by Zulaicha et al. (2018) that show the use of renewable energy has a negative relationship, but both show insignificant results on increasing carbon dioxide emissions due to several factors such as not optimal utilization of renewable energy, lack of government support, and the high selling price of renewable energy because subsidies to renewable energy are still low. The results of this study contradict the results of research (Cahyani & Aminata, 2020) that increasing renewable energy consumption can reduce high CO2 emissions in BRICS countries. This happens because, along with the times, experts continue to create new energy innovations that prioritize environmental sustainability and as a form of perfecting previous energy in accordance with the concept of sustainable development. Renewable energy includes wind power, hydroelectricity, solar power, and geothermal. The existence of renewable energy is expected to reduce the increase in CO2 emissions in BRICS countries.

The Effect of Fossils on CO2 Emissions

Based on the results of the above research on the panel data analysis test, fossils have a positive influence on carbon dioxide emissions in developing countries. Supported by research (Rahmayani, 2021), it states that developing countries such as Indonesia still favor fossil energy to increase economic growth, even though the high consumption of fossil fuels can produce environmental waste, one of which is an increase in CO2 emissions. In accordance with the results of research (Syafitri & Putri, 2022), industrialized countries, which include Russia, China, Japan, the United States, and other developed countries, are declared to be the largest geothermal-producing countries in the world. This happens because people in developed countries have consumption patterns and lifestyles 10 times higher than those in developing countries. While the results of the above research show a negative correlation between fossil fuel consumption and carbon dioxide emissions. In line with research (Simarmata et al., 2023) in his research shows that one of the BRICS member countries, namely India, is starting to have a commitment to go to net zero emission status with an estimated time of no later than 2050. India began to utilize its tropical climate to process solar energy into electrical energy through solar power plants, so that the level of CO2 emissions in the country could be reduced. While in China, a significant increase in fossil energy is still supported by the use of non-renewable energy resources, such as natural gas, coal, and petroleum. Although it has a negative impact on increasing CO2 emissions, it is still a driver of economic growth in China (Alanazi et al., 2020).

Effect of Technology on CO2 Emissions

Based on the results of the above research on the panel data analysis test, technology has a negative relationship with carbon dioxide emissions in developing countries. According to research (Jufri & Bahri, 2022), in developing countries it is important to focus on the transfer of modern environmentally friendly technology to strive for a good and clean environment so as to reduce waste pollution such as increased carbon dioxide emissions. According to Subekti (2022), developed countries are currently committed to pursuing government planning

regarding major transformations, especially in the transportation sector, towards advanced efficiency technologies by switching to low-carbon energy sources. Electric vehicle (EV) technology is one of the needs of society to be able to adapt to climate change. Switching conventional vehicles to EVs is believed to reduce carbon dioxide emissions in developed countries. Meanwhile, in BRICS countries, as explained (Kim, 2020), energy-saving technology and CO2 reduction are currently in the process of further development by the manufacturing industry. It is possible that industrial growth will lead to an increase in demand for non-renewable energy such as petroleum, which in turn can result in an increase in the amount of carbon dioxide gas in the atmosphere. On the other hand, it can create large-scale waste that can pollute the environment. Therefore, industrial activity can be a determinant in both increasing and decreasing carbon dioxide emissions.

Effect of GDP on CO2 Emissions

Based on the results of the above research on panel data analysis tests, gross domestic product has a positive influence on carbon dioxide emissions in developing countries. According to Godil et al. (2020) and Nathaniel et al. (2021) in developing countries, economic growth accompanied by increased consumption of natural resources and energy can be a factor in environmental pollution; moreover, the energy consumed uses non-renewable energy, so this can produce high CO2 emissions. Developed countries have a significant effect on carbon dioxide emissions. These results contradict the findings (Nikensari et al., 2019) that the theory of the inverted U-shaped EKC hypothesis in high-income or developed countries is said to have started running; the more a country's economy increases, the lower the level of carbon dioxide emissions. This happens if the country has a rapidly growing economy; then the country can reduce carbon dioxide emissions by considering the environment supported by government policies. Therefore, it can affect the quality of human life and be able to reduce a country's CO2 emissions (Febriyastuti Widyawati et al., 2021). Meanwhile, BRICS countries have a significant effect on increasing carbon dioxide emissions. According to research (Salsabila Nur Amalina et al., 2023), this happens because the government focuses only on generating more production income for the welfare of the community by ignoring environmental conditions. This is in accordance with the theory of the Environmental Kuznets Curve (EKS) hypothesis explaining that an increase in GDP can be followed by damage to the environment (Kuznets, 1955). Meanwhile, according to Majeed & Tauqir (2020) economic growth in low-income countries tends to rely on traditional technologies that have a direct impact on pollution and often sacrifice environmental sustainability to increase economic growth. Meanwhile, for high-income countries, economic growth has a good impact on environmental conditions. This is because the country is still thinking about natural conditions and has begun to apply environmentally friendly technology.

5. Conclusions

The panel data analysis conducted across developed, developing, and BRICS countries highlights both similarities and differences in the factors contributing to CO2 emissions from 2013 to 2022. The findings show that forest areas had an insignificant or negative impact on emissions in all regions, while renewable energy significantly reduced emissions in developing countries but had an insignificant and positive correlation in developed and BRICS countries. Fossil energy consumption showed a positive relationship with emissions in both developed and developing nations, while technology use had no significant impact on emissions in developed and BRICS countries but a negative relationship in developed and developing regions. Economic growth had a positive and significant effect on CO2 emissions across all regions, indicating that developed countries have yet to follow the Environmental Kuznets Curve (EKC) model, where increased income should lead to more environmentally friendly energy use and lower emissions. Future research should explore additional variables that influence CO2 emissions and consider policies promoting the use of green technology and renewable energy to mitigate

environmental damage. Expanding the research to include more countries could also offer a more comprehensive understanding of these factors.

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