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E-ISSN: 2721-298X
DOI: https://doi.org/10.33830/tjeb.v5i1

JOURNAL ECONOMICS BUSINESS

The Effect of Forest Area, Energy Consumption, Control of Corruption, and Economic Growth on Carbon Emissions in G7 Countries

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Abstract: *This research aims to determine the influence of Forest Area, Energy Consumption, Control of Corruption, and Economic Growth on Carbon Emissions. This study uses panel data published by the World Bank and Our World in Data for the 2014-2020 period in the G7 countries, namely America, Italy, United Kingdom, France, Japan, Canada and Germany. In this study, the carbon emissions variable is used as the dependent variable. Forest area, energy consumption, Control of Corruption, and economic growth as independent variables. The analysis technique for this panel research uses panel data regression with a fixed effect model (FEM) approach. The research results show that forest area, energy consumption simultaneously and partially influence carbon emissions in G7 countries. Meanwhile, control of corruption and economic growth have a positive and insignificant effect on carbon emissions.*

Keywords: *Forest area, Energy Consumption, Control of corruption, Economic Growth, Carbon Emissions*

1. Introduction

This study will discuss the influence of forest area, energy consumption, control of corruption, and economic growth on carbon emissions in G7 countries. The G7 countries consist of Canada, France, Germany, Italy, Japan, the United Kingdom and the United States. These factors have a significant impact on carbon emissions, which is a global environmental issue that requires serious attention. This study will investigate the relationship between these factors and carbon emissions in the G7 countries, with the aim of providing deep insight into how these factors are interrelated and how policies can be designed to reduce carbon emissions while maintaining sustainable economic growth.

Carbon emissions come from burning oil, coal and gas for energy use, burning wood and waste materials, and from industrial processes such as cement production. Emissions of carbon dioxide are only one measure of a greenhouse gas in a nation. Carbon dioxide and nitrous oxide are two examples of gases that need to be considered for a more comprehensive understanding of a nation's impact on climate change. These are especially crucial in an economy centred around agriculture.

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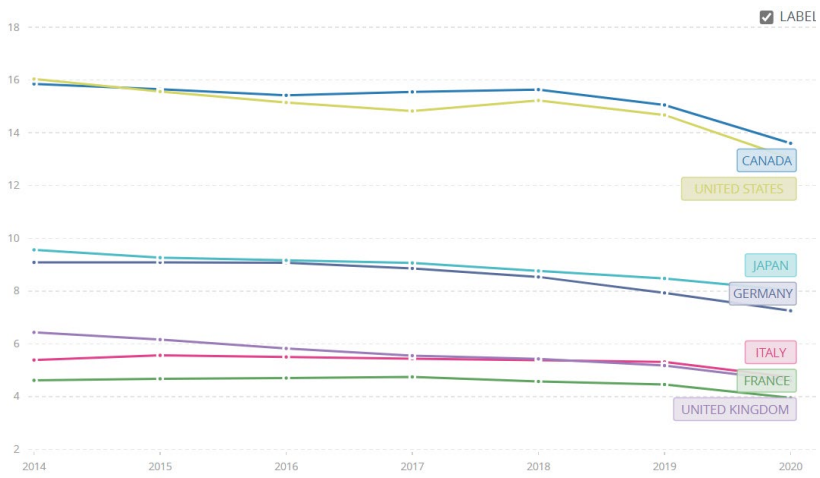

Figure 1. Carbon Emission Levels in G7 Countries

Global climate change is becoming an increasingly urgent issue to address, and the G7 countries have an important role to play in reducing global carbon emissions. One factor that can affect carbon emissions is forest area. According to data from Global Forest Watch, in 2020, the G7 countries had a total forest area of 3.7 billion hectares. The statistics show that forest area in G7 countries decreased by 0.08% per year from 2014 to 2020 (Klepacka, 2020).

Energy consumption is also an important factor affecting carbon emissions. According to data from the World Bank, in 2019, G7 countries had a total energy consumption of 2.8 billion tons of oil equivalent. High economic growth is often accompanied by an increase in energy consumption, which in turn increases carbon emissions. Therefore, efforts need to be made to reduce energy consumption and switch to more environmentally friendly energy sources. Statistics show that energy consumption in G7 countries decreased by 0.5% per year from 2014 to 2018 (Alanazi, Dmitriy, & Polyakova, 2020).

In addition, the level of corruption can also affect carbon emissions. According to data from Transparency International, in 2020, G7 countries had varying corruption perception indices, with Germany and the United Kingdom having higher indices than other countries. High levels of corruption can hinder the implementation of effective environmental policies and worsen environmental conditions. Statistics show that the corruption perception index in the G7 countries decreased by 0.3 points from 2014 to 2020 (Ivungu, Ganyam, Agbo, & Ola, 2020).

Finally, economic growth also has a significant influence on carbon emissions. According to data from the World Bank, in 2019, the G7 countries had a total GDP of 34.5 trillion US dollars. High economic growth is often accompanied by increased energy consumption and carbon emissions. However, efforts need to be made to develop a

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sustainable and environmentally friendly economic growth model. Statistics show that economic growth in the G7 countries decreased by 0.2% per year from 2014 to 2018 (Nguyen, Van Nguyen, & Van Nguyen, 2020).

Based on previous research, in order to control carbon emissions, G7 countries need to make efforts to preserve forests, reduce energy consumption, reduce corruption levels, and develop sustainable and environmentally friendly economic growth models. Statistical data shows that G7 countries have experienced a decline in these factors from 2014 to 2020, but further efforts are still needed to achieve more ambitious carbon emission reduction targets.

Forest Area

The impact of forest area on carbon emissions in the G7 will be the main topic of discussion in this literature review. According to research done in 2022 by Wilda Maulidina and Ilham Maulana, the amount of forest area significantly reduces carbon dioxide emissions (Maulidina & Maulana, 2022). The study's findings demonstrate how crucial forest preservation is to lowering carbon emissions in the G7. The industrial sector has a favourable impact on the level of emissions per capita, whereas the agricultural sector has a negative effect, according to a different study by Ali Farhan from 2021 (Farhan, 2021).This suggests that efforts to reduce carbon emissions in G7 countries need to pay attention to the industrial sector, which is the largest contributor to carbon emissions.

In addition, according to (Fadhli, Sugianto, & Syakur, 2021) shows that land cover analysis is an important part of determining the amount of potential carbon available. This suggests that preserving forests and land is critical to reducing carbon emissions in G7 countries.

Energy Consumption

Energy consumption is one of the most important factors affecting carbon emissions. According to data from the International Energy Agency (IEA), in 2020, the G7 countries had a total energy consumption of 2.9 billion tons of oil equivalent (TOE) (Pratama, Ramadhani, Lubis, & Firmansyah, 2022). Statistics show that energy consumption in the G7 countries decreased by 0.5% per year from 2014 to 2018.

Research conducted by Wang in 2021 shows that renewable energy development can help reduce energy consumption and carbon emissions. The research shows that renewable energy development can help create new jobs and promote sustainable economic growth. Wang argues that renewable energy development can help reduce dependence on fossil fuels and reduce carbon emissions (Sekar Palupi, Muchtar, & Sihombing, 2023). This research shows that renewable energy development can help reduce climate change risks and improve energy security.

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Consumption has a positive and significant effect on carbon dioxide emissions. This is because Indonesian society is still very dependent on the use of fossil fuels in economic activities, which increases fossil energy consumption. But over time, the increasing economy and energy consumption together produce carbon dioxide emissions (Salsabila, Amalina, Wahyudi, & Ciptawaty, 2023).

Control of Corruption

Control of corruption is an important factor in efforts to reduce carbon emissions because corruption can affect policies and implementation of environmental programs aimed at reducing carbon emissions. Control of corruption is one of the six governance indicators: voice and accountability; political stability, absence of violence/terrorism; government effectiveness; regulatory quality; rule of law and control of corruption. The control of corruption score is measured by assigning a value to the country on the aggregate indicator in normal distribution units ranging from -2.5 to 2.5. A large control of corruption value indicates that there are fewer cases of corruption and vice versa. Correspondingly, (Welsch, 2004) examined how corruption affects pollution emission levels both directly and indirectly. The findings demonstrate a direct and positive correlation between levels of pollution emission and corruption.

According to (Sekrafi, 2018) said that controlling corruption has a negative influence on environmental quality, including carbon emissions. This research shows that efforts to reduce corruption can help reduce carbon emissions and improve environmental quality. Besides, (Sri nawatmi, 2013) said that corruption can increase economic growth in Indonesia. However, research conducted by Dwi Susanto in 2019 showed that corruption has a negative influence on economic growth and environmental quality in Indonesia. This suggests that controlling corruption can help increase sustainable economic growth and reduce carbon emissions.

Economic Growth

Economic growth plays a crucial role in raising people's standard of living, it can also harm the environment by increasing carbon emissions. Research conducted by Rayhani in 2019 shows that economic growth has a positive but insignificant effect on the level of world carbon dioxide emissions. This study uses data on 180 countries in the world derived from the World Development Indicators (WDI) and the Global Carbon Atlas in 2013-2015. The results showed that the economic growth variable had a positive but insignificant effect on the level of world carbon dioxide emissions. Other research conducted by (Internasional, Emisi, Dioksida, Di, & Asean, 2021) indicates that ASEAN countries' carbon dioxide gas emissions are significantly impacted negatively by economic growth. Panel data from 2000 to 2014 is used in this study. The findings demonstrated that the ASEAN countries' carbon dioxide gas emissions are significantly and negatively impacted by the economic growth variable. According to (Zhang, 2021) The link between economic growth and carbon dioxide emissions requires further regulation to create low-carbon sustainable development. Arsyad (2010) says that changes in environmental conditions can complicate sustainable economic development, so everyone needs to pay attention to it. Environmental issues, particularly increased CO2 emissions, are

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influenced by economic growth. Economic growth and economic development can never be separated because economic growth will facilitate economic development while economic development will encourage economic growth.

2. Research Methods

Research methods are essential in providing answers to the objectives of the research to be carried out. This section details information related to data collection, data analysis techniques, modeling tests, application of classical assumption tests, and the coefficient of determination R^2.

Data

The researcher used data published by the World Bank and Our World in Data. Panel data is used in this study, which is a combination of time series and cross-section data. Cross section data is obtained by observing a number of subjects at the same point in time, while time series data is data obtained from observing one object over several periods of time. In estimating regression models with panel data, there are several common methods used, such as pooling least squares (common effect), fixed effects, and random effects.

The research data uses G7 country data for the 2014-2020 period, namely Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. This study uses carbon emission variables as dependent variables. Forest area, energy consumption, and control of corruption, and economic growth as independent variables.

Data Analysis Technique

Panel data regression is a regression used on panel data. The panel data regression model used in this study is formulated as follows:

$$CO_2it = \alpha + \beta 1FAit + \beta 2KEit + \beta 3COCit + \beta 4PEit + \varepsilon it$$

The following details are provided regarding the symbols in the panel data regression equation:
CO_2 = Carbon Emissions
FA = Forest Area
KE = Energy Consumption
COC = Control of Corruption
PE = Economic Growth
α = Constant
βn = Parameter (slope coefficient)
ε = Error term
i = Cross section dimension
t = Time series dimension

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Testing is required to determine whether or not the regression model is appropriate for use as an analytical tool. The common effect model, fixed effect model, and random effect model are the three techniques that can be applied in the panel data regression method.

Modeling Test

The selection of the panel data regression estimation model aims to select the best model that is appropriate and suitable from the three regression models including the Common effect Model, Fixed Effect Model, Random effect Model. In selecting the best panel data regression estimation model, the next test is carried out.

There are three types of tests to be performed. The first test performs the Chow Test. The Chow test is conducted to determine the best way to use between PLS and FEM. The decision to use FEM occurs if the Chow test results show the Cross-Section F-prob value is less than 0.05. Furthermore, the second test is the Hausman test to determine whether FEM or REM is more feasible in panel data regression. The decision to use FEM or REM can be seen from the Chi-Square probability value. If the probability value is less than 0.05 then the right choice is FEM, and if the probability level is more than 0.05 then REM is more appropriate.

Classical Assumption Test

The data normality test is carried out to evaluate whether the distribution of a data is normal or not, which is an indicator of the goodness of the regression model. The Jarque-Bera (JB) criterion in the Eviews output is used for the normality test in this study, with a significance level (α) of 5%. First, the data is deemed normal, or passes the normality test, if the computed JB value is less than the table value (chi-square) or the JB Test probability value is higher than the significance level (α = 0.05). In contrast, the data is deemed abnormal and fails the normality test if the computed JB value exceeds the table value or the JB Test probability value is smaller than the significance level. Next, multicollinearity testing is carried out using Matrix Correlation, which is the correlation between variables. It is possible to determine that there is no multicollinearity between independent variables if the correlation value between them is less than 0.80. Furthermore, a significance level (α) of 5% is used in the Glejser Heteroscedasticity test on the Eviews output. The data is considered to be non-heteroscedastic if the probability value for each independent variable is more than 0.05. On the other hand, heteroscedasticity in the data can be inferred if the probability value is less than 0.05.

Coefficient of Determination (R^2)

In essence, the coefficient of determination (R^2) expresses how well the model explains the variance in the dependent variable. Between zero and one is the range of the coefficient of determination. A low R2 value indicates that the independent variables' capacity to account for the variance in the dependent variable is severely constrained. When the independent variables almost entirely explain the variation in the dependent variable, the value is close to one.

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3. Results And Discussion

Determine the panel data regression analysis technique. Three different kinds of tests need to be run. The Chow Test is run in the first test. To ascertain which of PLS and FEM to use most effectively, the Chow test is performed. If the Cross-Section F-prob value is less than 0.05 according to the Chow test results, FEM is chosen. In addition, the Hausman test is the second test used to evaluate which panel data regression method is more practical: FEM or REM. The Chi-Square probability value indicates whether to use REM or FEM. FEM is the better option if the probability value is less than 0.05, and REM is a better option if the probability level is greater than 0.05.

a. Modeling Test

This modeling test explains the results of statistical tests in order to determine the best model in regression (Tirtana, 2023).The statistical value of panel data regression to see the contribution of forest area, energy consumption, control of corruption and economic growth to carbon emissions in G7 countries in 2014-2020.

Table 1. Chow Test Results

Effect Test	Statistic	d.f.	Prob.
(1)	**(2)**	**(3)**	**(4)**
Cross-section F	23,540734	(6,38)	0,0000
Cross-section Chi-square	76,007041	6	0,0000

Source: Eviews data processing results, 2023

Table 1 indicates that the probability of the cross-section Chi-square value is 0.0000, indicating a value less than 0.05 or 5%. The Fixed Effect Model (FEM) is the most effective model, as demonstrated by the test results. The optimal model between the fixed effect model and the random effect model will then be determined using the Hausman test.

Table 2. Hausman Test Results

Effect Test	Statistic	d.f.	Prob.
(1)	**(2)**	**(3)**	**(4)**
Cross-section random	16,800547	4	0,0021

Source: Eviews data processing results, 2023

Table 2 indicates that the probability of the cross-section randomness is 0.0021, indicating a value below 0.05 or 5%. After Hausman testing, the fixed effect model is the most effective model, it can be said. Furthermore, the fixed effect model is used in data processing and interpretation.

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Classical Assumption Test

Normality Test

The normality test is used to test whether a variable has a normal distribution or not. The results of normality testing using Jarque-Bera and histograms.

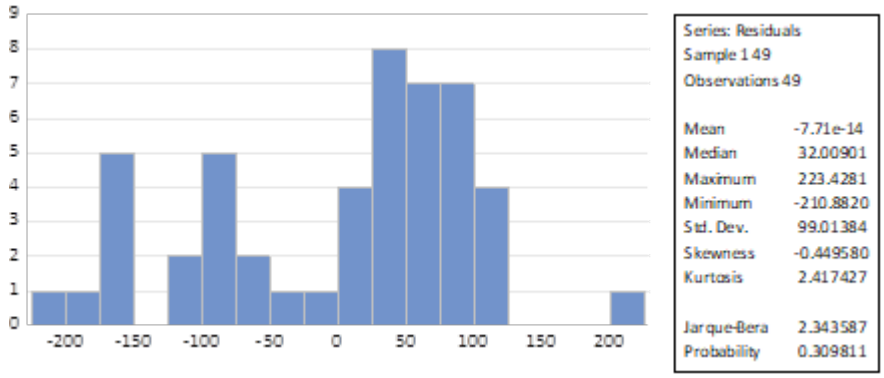

Figure 2. Normality Test Results

Figure 1 shows a Jarque-Bera value of 2.343587 with a probability of 0.309811. This result shows a probability above 0.05 or 5%. Therefore, H1 is rejected and H0 is accepted. So, it can be concluded that this model is normally distributed. Freeing the model from normality problems, the next test is heteroscedasticity.

Uji Heteroskedasitas

The heteroscedasticity test is carried out to determine whether in the model there is an inequality of variance from the residuals of one observation to another (Tirtana, 2023). In this test by looking at the probability value. The results are in the table below.

Table 3. Heteroscedasticity Test Results

Variabel Dependent Variable: RESABS2	Prob.
C	0,296
FA	0,311
KE	0,560
COC	0,205
PE	0,099

Source: Eviews data processing results, 2023

The probability values of the independent variables the energy consumption variable (KE), the control of corruption variable (COC), the economic growth variable (PE), and the forest

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area variable (FA) are above 0.05 or 5%, as Table 3 demonstrates. Thus, it can be said that there are no heteroscedacity issues with this model that need to be tested further.

Multicollinearity Test

The multicollinearity test is used to determine the perfect relationship between the independent variables (Kudus & Rahman, 2013). The criteria used to detect multicollinearity is the VIF value (Sriningsih, Hatidja, & Prang, 2018). VIF is smaller than 10, meaning there is no multicollinearity. The test results can be seen in the following table.

Table 4. Multicollinearity Test Results

Variabel	VIF
FA	1,005
KE	1,029
COC	1,019
PE	1,046

Source: Eviews data processing results, 2023

Table 4 shows that every independent variable's VIF value is less than 10. This finding indicates that multicollinearity does not occur in this model. The model satisfies the requirements for the classical assumption test because it does not exhibit any problems with heteroscedasticity, multicollinearity, or normality.

Panel Data Regression Model

In this study, the fixed effect model (FEM) approach is the appropriate model. The following are the findings of the panel data regression using FEM.

Table 5. Multiple Linear Regression Test Results

Variable Dependent Variable: CO2	Coefficient	Prob.
C	-169,6323	0,0022
FA	3,213760	0,0017
KE	0,208338	0,0000
COC	-13,26713	0,6301
PE	390,5088	0,4300
F-Statistic		3184,036
Prob-F (Statistic)		0,000000
R-squared		0,996557
Adjusted R-squared		0,996244

Source: Eviews data processing results, 2023

Based on table 5, the panel data regression results show that forest area and energy consumption variables have a significant influence on carbon emissions. While the variables of control of corruption and economic growth have an insignificant effect on carbon emissions. So the regression equation is as follows:

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$$CO2 = -169,6323 - 3,213760FA + 0,208338KE - 13,26713COC + 390,5088PE + \varepsilon it$$

From the multiple linear regression equation above, the constant value is -169.6323, which means that if forest area, energy consumption, control of corruption, and economic growth are 0, the value of carbon emissions is -169.6323. The regression value of forest area is negative, meaning that if the forest area increases, carbon emissions will decrease. The regression value of energy consumption is positive, meaning that if energy consumption increases, it can increase carbon emissions. The regression value of control of corruption is negative, meaning that if control of corruption increases, carbon emissions will decrease. The regression value of economic growth is positive, meaning that if economic growth increases, carbon emissions will increase.

Test t

This test shows the effect of one independent variable on the variable related to the test criteria with a confidence level of 95% or α = 0.05. If the probability value <0.05 then it has a significant effect. Conversely, if the probability value> 0.05 then it has no effect.

Table 6. Test t results

Variable Dependent Variable: CO2	t-Statistic	Prob.
C	-3,247126	0,0022
FA	3,338506	0,0017
KE	111,0554	0,0000
COC	-0,484945	0,6301
PE	0,796544	0,4300

Source: Eviews data processing results, 2023

Table 6 indicates that the energy consumption and forest area variables have probability values less than 0.05. However, there is a probability value above 0.05 for the variable controlling corruption and economic growth. According to this research, the dependent variable the carbon emissions of the G7 countries is influenced by 2 (two) independent variables: energy consumption and forest area. The other 2 (two) independent variables, which are economic growth and corruption control, have no effect on the dependent variable.

Test F

The F test is used to show the effect of the independent variable on the dependent variable simultaneously. The criteria for this test are by looking at the prob-F (Statistic) results. If the Prob- F (Statistic) value is smaller than 5% then it simultaneously has an effect. Conversely, if the Prob-F (Statistic) value is greater than 5%, there is no simultaneous influence.

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Table 7. Test F Resluts

Effect Spesification	
Indicator	**Value**
F-statistic	3184,036
Prob(F-statistic)	0,000000

Source: Eviews data processing results, 2023

As can be seen in Table 7, the F-statistic's probability value is 0.000000, which is less than 0.05. It follows that the factors of energy consumption, economic growth, corruption control, and forest area all have a big impact on the G7 countries' carbon emissions.

Coefficient of Determination (R^2)

A test used to estimate the percentage of the total variation in the independent variables in this model is the coefficient of determination (R2). Examining the regression test's R-squared coefficient of determination provides evidence of this. The R-squared value, which indicates how much of the independent variable on the dependent variable is explained by other variables outside the model, is 0.996557, or 99.6%, based on the regression results.

4. Discussion

a. Effect of Forest Area on Carbon Emissions (CO_2)

With a probability value of 0.0017, or less than 5%, the analysis demonstrates that the forest area (FA) variable has a significant negative impact on economic growth. According to the assumption of ceteris paribus, the coefficient of the forest area (FA) variable is 3.213760, meaning that a 1% increase in FA can result in a 3.213760% increase in carbon emissions.

Forest area is land under natural tree stands or planted with trees of at least 5 meters in height, whether productive or unproductive, and excludes tree stands in agricultural production systems (e.g., in fruit plantations and agroforestry systems) and trees in parks and urban gardens (The Global Economy, 2020). Forest area is one of the factors that affect carbon emissions. Every 1 (one) percent increase in the forest area of a country will be able to reduce the value of CO2 emissions by 0.04% (Fauzi, 2017). When a coefficient is negative, it indicates that the dependent variable's value will decrease as a variable's percentage value increases. Therefore, reducing the rate of deforestation and/or maintaining the amount of forest area will benefit a nation by lowering its CO2 emissions.

b. Effect of Energy Consumption on Carbon Emissions (CO_2)

With a probability value of 0.0000 for the energy consumption variable, which is less than 5% or 0.05, the analysis's findings indicate that the energy consumption variable (KE)

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significantly positively affects economic growth. With the assumption of ceteris paribus, the energy consumption variable's coefficient is 0.208338, meaning that a one percent increase in energy consumption will result in a 0.208338% increase in carbon emissions.

Energy is one of the main needs of various sectors, both for consumption and production activities. The world's current energy consumption pattern is still dominated by fossil energy in the form of oil, gas and coal (Kurniarahma, Laut, & Prasetyanto, 2018). The use of fossil energy will increase the concentration of greenhouse gases, especially carbon dioxide (Co2). This is in line with research conducted by (Tsandra, Sunaryo, Octaviani, Ekonomi, & Trisakti, 2021) the study concluded that bringing fossil energy consumption will increase carbon emissions per capita in G20 countries. In addition, (Puntoon, Tarkhamtham, & Tansuchat, 2022) also confirmed the result that the higher the consumption of fossil energy, the higher the amount of carbon emissions produced.

c. Effect of Control of Corruption on Carbon Emissions (CO_2)

The results of the analysis show that the control of corruption (COC) variable has a positive and insignificant effect on carbon emissions with a probability value of 0.6301 which is more than 0.05 or 5%. The coefficient of the control of corruption variable is -3.26713, which means that if the control of corruption increases by 1%, it can reduce carbon emissions by 3.26713% with the assumption of ceteris paribus.

These results are not in line with the research conducted by (Yusril Izha Mahendra, Marselina, Heru Wahyudi, & Ukhti Ciptawati, 2022) which says that the control of corruption variable has a significant effect on carbon emissions in 9 ASEAN countries. This is because the level of corruption in developed countries, especially G7 countries, has a lower level of corruption than developing countries. According to data from the World Bank, the average value of control of corruption in G7 countries is 1.37, which is high compared to developing countries. The control of corruption value is measured by assigning a value to the country on the aggregate indicator in normal distribution units ranging from -2.5 to 2.5 (Yusril Izha Mahendra et al., 2022). A large corruption control value indicates that there are fewer cases of corruption and vice versa. The mechanism by which corruption affects carbon emissions is through environmental regulations and policies (WELSCH, 2004). So when the level of corruption in the G7 countries is low and stable, it will not directly affect carbon emissions.

d. Effect of Economic Growth on Carbon Emissions (CO_2)

Based on the results of the analysis shows that the economic growth variable (PE) has a significant positive effect on economic growth with a probability value of the energy consumption variable of 0.4300 greater than 5% or 0.05. The coefficient of the economic growth variable is 390.5088, which means that if economic growth increases by 1 (one) percent, carbon emissions will increase by 390.5088% with the assumption of ceteris paribus.

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This is not in accordance with research conducted by (Kurniarahma et al., 2018) which states that the economic growth variable has a significant effect on carbon emissions in Indonesia. This is because economic growth in G7 countries has entered a stagnant phase, where economic growth tends to be low and stable compared to developing countries such as Indonesia. In addition, renewable energy development programs in developed countries result in more environmentally friendly economic growth (Norsujianto, 2015). Therefore, economic growth has no effect on carbon emissions in the G7 countries.

5. Conclusions

This study is about the effect of Forest area, Energy Consumption, Control of corruption, and Economic Growth on Carbon Emissions in G7 countries in 2014-2020. The findings of the research show that the variables of forest area, energy consumption simultaneously and partially affect carbon emissions in G7 countries. While the variables of control of corruption, economic growth have a positive and insignificant effect on carbon emissions. Based on the results of the study, it shows that forest area is able to reduce the value of CO2 emissions. So, by stopping the rate of deforestation and or keeping the forest area from decreasing will have a positive impact by reducing the value of CO2 emissions in a country.

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