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THE EFFECT OF CARBON TAXES, FOSSIL FUEL USE, AND GDP GROWTH ON CARBON EMISSIONS

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ABSTRACT

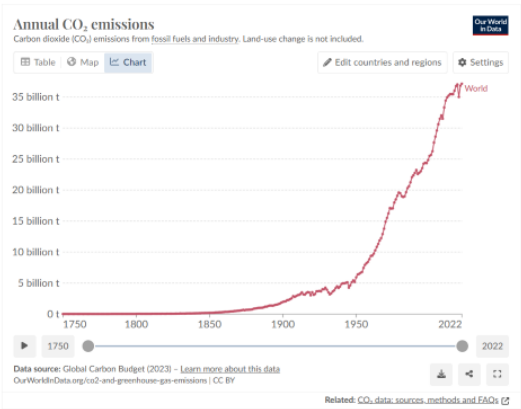
This study examines the effect of carbon taxes, use of fossil fuels, and GDP growth on carbon emissions. The sample that we used is 12 European countries in the period 2016 – 2020. The analytical method used in this study is multiple linear regression analysis using panel data. The results of the study show that the use of natural gas and oil is a variable that influences carbon emissions which cause global warming. A 1% increase in the use of natural gas will increase carbon emissions by 0.24% and a 1% increase in the use of petroleum will also increase carbon emissions by 0.71%. This research also provides recommendations on fiscal policies that can be implemented in Indonesia related to the government's efforts to reduce carbon emissions.

Keywords: *Carbon taxes, Carbon emissions, Natural gas, Oil.*

INTRODUCTION

The mobility of the earth's population has not been able to be separated from the use of fossil fuels. Many of the vehicles used by the inhabitants of the earth are fossil fuels, namely oil. In addition, fossil fuels in the form of coal, formed from plants that died 400 million years ago, are used by earthlings to turn on power plants (Eirin, 2022). The increasing intensity of the use of fossil fuels is directly proportional to the increase in the release of carbon into the earth's atmosphere, resulting in carbon emissions that increase the earth's temperature (Ritchie & Roser, 2020).

Figure 1. Annual CO2 Emissions



Source: Ritchie & Roser (2020)

By the figure 1 shows the growth in world emissions from 1750 to the present. At the beginning of the industrial revolution in 1760, it was seen that emissions were still very low, around 0 billion tons. Growth in world emissions began to accelerate in 1950 to 6 billion tons of carbon dioxide. Carbon emissions almost quadrupled in 1990, reaching more than 22 billion tons. Until now, carbon emissions have continued to increase, reaching more than 34 billion tons each year.

Qotrunnada (2022) explains that carbon emissions are one of the causes of climate change which has an impact on the environment, health, and the economy. In line with this, Aisyah et al. (2020) explained that the consequences of climate change have a negative impact on the quality of human life to the point of disrupting global economic activity. The visible facts show that carbon emissions continue to increase every year, in the end it will cause negative externalities in the form of polluted air that humans breathe every day and increasing earth's temperature or (global warming) (Marron et al., 2015). Air is a public good and is needed by all living things to support their survival, so that if a negative externality occurs, a joint contribution is needed to overcome it (Ratnawati, 2016).

One form of international agreement in efforts to prevent climate change is the Paris Agreement. A total of 196 countries agreed to limit global warming to below 1.5 degrees Celsius compared to pre-industrial levels (United Nations Climate Change, n.d.). The Paris Agreement was the background for the issuance of a price policy on carbon in the form of an emission trading system (ETS) and carbon tax collection in 57 countries (World Bank Group, 2019).

Finland was the first country in the world to implement a carbon tax in 1990. European countries followed this policy (Asen, 2020). According to Pandey et al. (2022), the European Union is the best example of implementing a cap-and-trade system, namely a system applied to limit greenhouse gas emissions. Under the European Union's carbon emission regulations, importers of high-emission goods are required to pay a fee in accordance with what has been paid by the manufacturer. As of September 2021, the price per tons of carbon under the EU Emissions Trading System was 62.45 Euros and continues to increase.

Allan et al. (2014) was interested in examining the effect of carbon taxes in Scotland on the economy and the

environment. The research results show that carbon taxes can simultaneously stimulate economic activity and reduce emissions. The results of research conducted by Khastar et al. (2020) also show that carbon tax policies can reduce carbon emissions in Finland. Marron et al. (2015) also found something similar, namely carbon taxes were able to reduce carbon emissions by 1.5% - 6% in several developed countries, including Finland, Denmark, and Sweden.

Alper (2017) examined the effect of carbon taxes, economic development, urbanization, use of natural gas and petroleum on carbon emissions with a sample of several European countries for the period 1995 – 2015. The results of research conducted by Alper (2017) showed that an increase of 1 % on the environmental tax will reduce carbon emissions by 0.9%. Furthermore, the use of natural gas and oil by 1% will increase carbon emissions by 0.1% and 0.7%, respectively. Meanwhile, urbanization that increases by 1% will reduce carbon emissions by 0.9%. Research conducted by Zeng et al. (2021) showed different results from Alpers's (2017). Zeng et al. (2021) found that urbanization, industrial development, forest destruction, and GDP growth were factors causing increased carbon emissions.

Based on several previous studies related to the application of carbon taxes, researchers are interested in conducting further research to determine the effect of income derived from environmental taxes, GDP growth, the use of natural gas and petroleum on carbon emissions in 12 European countries during the 2016 – 2020 period. Results This research is expected to be used to provide policy recommendations that can be applied in implementing carbon taxes in Indonesia.

Carbon Emissions

Carbon emissions are the total emissions produced by individuals or groups in a certain period as measured in tons of CO2 equivalent (tCO2e) or kilograms of CO2 equivalent (kgCO2e) (Ratnawati, 2016). Zhang et al. (2008) explained that carbon emissions continued to increase after the industrial revolution in 1751. According to Zhang et al. (2008), the majority of carbon emissions come from industry in developed countries, causing carbon emissions three times greater than developing countries in 1980.

Environmental Tax

According to Markandya (2012), environmental taxes are taxes applied to preserve the environment. Eurostat (2013) adds that environmental taxes are taxes imposed on activities that have a negative impact on the environment. Furthermore, Aisyah et al. (2020) explained that a carbon tax is a type of environmental tax that is imposed on the use of fuels including gas, coal and oil. Taxes on the use of fossil fuels will increase the price of these fuels so that in accordance with the law of demand, an increase in prices will have an impact on decreasing the demand for fossil fuels. According to Amalia (2018), by imposing taxes on fossil fuels, the government can maintain environmental sustainability.

Use of Gas and Oil

According to the IPCC in Client Earth (2022), the main factor causing global warming is emissions from the use of fossil fuels. In 2018 around 89% of total global emissions came from industry and fossil fuels. Natural gas is a fossil fuel composed of methane. The use of natural gas will release methane into the air and have an impact on increasing greenhouse gas emissions released into the atmosphere (MET Group, 2020).

Previous Research

Research conducted by Lin & Li (2011) has tested the mitigation impact of implementing a carbon tax using the difference-in-difference method with a sample of five countries in Northern Europe. The results of research by Lin & Li (2011) show that carbon taxes in Finland have a negative effect on increasing carbon emissions per capita. The results also showed a negative effect but not significant for Denmark, Sweden and the Netherlands. Subsequent research was conducted by Marron et al. (2015), found that carbon taxes reduced carbon emissions by 1.5% - 6% in Finland, Denmark, and Sweden.

Previous research has also examined industries that are highly dependent on energy. The research was conducted by Zhao (2011) using a gravity model and data obtained from 21 OECD countries for the period 1992 – 2008. The results showed that the imposition of a carbon tax had a negative impact on related sectors because it created competitive conditions that were detrimental to industries that used more energy. Lots.

Furthermore, Allan et al. (2014) was interested in examining the effect of carbon taxes in Scotland on the economy and the environment. The research results show that carbon taxes can simultaneously stimulate economic activity and reduce emissions. However, this only applies to income that has been subject to income tax.

Alper (2017) examined the effect of carbon taxes, economic development, urbanization, use of natural gas and petroleum on carbon emissions with a sample of several European countries for the period 1995 – 2015. The results showed that a 1% increase in environmental taxes would reduce emissions carbon by 0.9%. Furthermore, the use of natural gas and oil by 1% will increase carbon emissions by 0.1% and 0.7%, respectively. Meanwhile, urbanization that increases by 1% will reduce carbon emissions by 0.9%.

Research conducted by Zeng et al. (2021) showed different results from Alpers's (2017). Zeng et al. (2021) found that urbanization, industrial development, forest destruction, and GDP growth were factors causing increased carbon emissions.

Research conducted by Sadr et al. (2022) also showed slightly different results. Sadr et al. (2022) found that the Paris Agreement was only able to reduce carbon emissions by 1%, so the agreement was considered ineffective. In addition, Sadr et al. (2022) explained that an important factor influencing carbon emissions is the consumption of petroleum. If oil consumption increases by 1%, it will produce carbon emissions released into the atmosphere of 0.56%.

RESEARCH METHOD

This research uses quantitative research methods. The type of data used in this research is secondary data. Data sources were obtained from the OECD and World Bank websites as well as a review of world energy statistics for 2021 published by British Petroleum. The population used in this study is the European Union countries as many as 27 countries. However, until now, only 20 European Union countries have implemented carbon tax policies (Bray, 2022). So that the sample in this study was determined as many as 12 European Union countries including Spain, France, Netherlands, Austria, Poland, Norway, Sweden, England, Finland, Portugal, Switzerland and Hungary and the data used for the period 2016 - 2020. The analytical method used in this study, namely multiple linear regression analysis using panel data to determine whether carbon taxes (RE), GDP growth (GDP), use of gas (NG) and petroleum (O) affect carbon emissions (CO2). Calculation or

data processing in this study was carried out using STATA 16. The multiple linear regression analysis method was chosen because the independent variables used in this study were more than one variable. The multiple linear regression equation in this study is as follows:

$$CO2i,t = \beta0 + \beta1ETi,t + \beta2NGi,t + \beta3Oi,t + \beta4GDPi,t + \varepsilon i,t$$

Carbon emissions (CO2) are measured in million tons. Carbon tax (RE) revenue is derived based on the percentage of carbon tax revenue in the GDP of EU countries. The use of natural gas (NG) is consumption measured in billions of cubic meters. The use of petroleum (O) is measured in thousands of barrels per day. GDP growth (GDP) is the percentage annual GDP growth of a European Union country based on constant local currency.

In estimating the right model to use in panel data regression, it can be seen from the structure of the model, namely Pooled Regression (PLS), Fixed Effects (FEM), and Random Effects (REM) (Greene, 2002). The selection of the right model was carried out by the Chow Test, Hausman Test, and the Breusch-Pagan Test according to table 1 below.

Table 1. Panel Data Estimation Model Selection

UJI	H0	H1
Chow	PLS	FEM
Breusch-Pagan	PLS	REM
Hausman	REM	FEM

Source: Indrasetianingsih & Wasik (2020)

The most appropriate model is the model that meets all the assumptions that are the requirements of each model. The best model has the highest R2 value and the model is valid for use based on the F test that has been carried out (Indrasetianingsih & Wasik, 2020).

In panel data regression, if the estimator used is the Feasible Generalized Least Square (FGLS) then it will only carry out two estimation stages that are different from OLS. So that when testing the classical assumptions, only multicollinearity and normality tests will be carried out (Ekananda, 2016).

RESULTS AND DISCUSSION

Descriptive statistics in this study for all variables are as follows:

Table 2. Descriptive Statistics

Variabel	Mean	Max.	Min.	Std. Dev.
CO2	147,9067	416,4	32	129,1091
ET	2,1646	3,18	0,99	0,5214
NG	20,3633	80.7	1	22,4133
O	600,9667	1594	152	511,3465
GDP	0,9383	5,4	-10,8	3,5410

Source: Processed from https://stats.oecd.org ; https://data.worldbank.org ; and British Petroleum Co. (2021)

Based on table 1, it is known that the carbon emissions produced by 12 countries in Europe in the period 2016 – 2020 averaged 147.9067 million tons. With the lowest contribution of carbon emissions of 32 million tons and the highest of 416.4 million tons. This shows that the 12 countries in Europe that are the research samples still contribute to increasing carbon emissions in the period 2016 – 2020.

Table 3. Panel Data Estimation Model Selection Results

Test	H0	H1	PROB. VALUE F	Note
Chow	PLS	FEM	0,0000	FEM
Breusch-Pagan	PLS	REM	0,0000	REM
Hausman	REM	FEM	0,1547	REM

Source: Processed from https://stats.oecd.org ; https://data.worldbank.org ; and British Petroleum Co. (2021)

To estimate the regression model with panel data, you can use the Ordinary Least Square (OLS), Fixed Effect Model (FEM), or Random Effect Model (REM) models. Model selection was carried out through statistical testing, namely by using the Chow test, the Breusch & Pagan Langrange Multiplier test, and the Hausmann test. Based on the test results in table 3, it was decided that the most suitable panel data regression model to be used in this study was using the random effect model (REM).

The classical assumption test in this study uses the Feasible Generalized Least Square (FGLS) estimator. The normality test uses the CLT (Central Limit Theorem) test, namely if the specified number of observations is large enough (n>30), then the assumption of normality can be ignored (Gujarati, 2003). The sample in this study amounted to 60 (n> 30). So that the data can be said to be normally distributed and can be called a large sample. Next, a multicollinearity test was performed. The test results obtained a mean value of VIF = 2.32 (> α = 0.05) and less than 10. So, it can be concluded that the model is free from multicollinearity assumptions.

Table 4. Panel Data Regression Results

Variable	*Coefficient*	*t-stat.*	*Prob.*
C	-0,5195	-0,86	0,390
ET	0,0798	1,10	0,272
LNG	0,2469	3,28	0,001
LO	0,7185	6,25	0,000
GDP	0,0023	0,74	0,459
R2	0,9367		
Adj. R2	0,9386		
Prob(F-stat.)	0,0000		

Source: Processed from https://stats.oecd.org ; https://data.worldbank.org ; and British Petroleum Co. (2021)

In accordance with table 2, after testing the Goodness of Fit, an R-squared value of 0.9428 was obtained. This shows that variations in carbon emissions (CO2) can be explained by carbon taxes (ET), GDP growth (GDP), the use of gas (NG) and petroleum (O) of 94.28%. Meanwhile for the F test, the Prob(F-stat.) value using the REM model shows the number 0.0000 (<α = 0.05), so it can be concluded that simultaneously carbon tax (ET), GDP growth (GDP), gas use (NG) and petroleum (O) have a significant effect on carbon emissions (CO2). In addition, it can be concluded that the model used is fit enough to explain the dependent variable, namely carbon emissions (CO2).

The partial significance of each independent variable is indicated by the prob value. according to table 2. Based on the results of the REM panel model test, the independent variable with the prob. < α = 0.05 is the variable luseofNG (NG) and luseofoil (O). So partially the use of natural gas (NG) and petroleum (O) has a significant effect on carbon emissions (CO2).

The results of this study indicate that a 1% increase in the use of natural gas will increase carbon emissions by 0.24% and a 1% increase in the use of petroleum will also increase carbon emissions by 0.71%. The results of this study are in line with the research of Alper (2017) and Sadr et al. (2022). Alper (2017) shows that the use of natural gas and oil by 1% will increase carbon emissions by 0.1% and 0.7%, respectively. Sadr et al. (2022) also found that an important factor influencing carbon emissions is oil consumption. If oil consumption increases by 1%, it will produce carbon emissions released into the atmosphere of 0.56%. The use of natural gas and oil is an important factor affecting carbon emissions in 12 European countries in the period 2016 – 2020.

The variables of carbon tax policy and GDP growth do not affect the carbon emissions produced by the 12 countries in Europe in the time period studied. This is not in accordance with several previous studies conducted by Allan et al. (2014), Marron et al. (2015), and Zeng et al. (2021). The research results of Allan et al. (2014) show that carbon taxes can simultaneously stimulate economic activity and reduce emissions. Marron et al. (2015), found that carbon taxes reduced carbon emissions by 1.5% - 6% in Finland, Denmark and Sweden. Research conducted by Zeng et al. (2021) showed different results from Alpers's (2017). Zeng et al. (2021) found that urbanization, industrial development, forest destruction, and GDP growth were factors causing increased carbon emissions.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of research with a sample of 12 countries in Europe during the period 2016 – 2020, it shows that carbon taxes have no effect on carbon emissions. The GDP growth variable for 12 countries in Europe also shows no effect on carbon emissions. The use of natural gas and oil is a variable that affects carbon emissions that cause global warming. A 1% increase in the use of natural gas will increase carbon emissions by 0.24% and a 1% increase in the use of petroleum will also increase carbon emissions by 0.71%.

In accordance with the mandate in Law Number 7 of 2021 concerning Harmonization of Tax Regulations, one of Indonesia's steps to reduce the contribution of world carbon emissions is to implement a carbon tax policy (Republic of Indonesia, 2021). Carbon tax policies have been implemented by European countries which are also the sample in this study. The results showed that the factors influencing the increase in carbon emissions were the use of natural gas and petroleum, while carbon taxes had no effect on carbon emissions.

Fiscal policies that can be carried out by Indonesia before implementing a carbon tax include reducing fuel consumption and starting to switch to using modes of transportation with electric motorized vehicles. Until now, fuel in Indonesia is still provided with subsidized facilities by the government so that vehicle users are comfortable using fuel and continue to increase carbon emissions released into the atmosphere. In order to reduce carbon emissions, the government can start reducing or even removing fuel subsidies. This policy can then be followed by the provision of supporting facilities for electric vehicles in Indonesia, one of which is the provision of power plants. Power plants use new and renewable energy sourced from geothermal, water, bioenergy, sunlight and wind. It is hoped that Indonesia's energy needs in the future can be met by new and renewable energy to reduce carbon emissions.

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We have tried our best to complete this research, but of course there are still things that are less than perfect. Therefore, we expect suggestions and constructive input from various parties to achieve perfection in the future. Finally, we hope this research will provide benefits to the parties. Amen.

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