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The Effects of Energy Consumption, Economic Growth, and Financial Development on CO_2 Emissions in Greece

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Abstract

This study aims to assess the effects of energy consumption, economic growth, and financial development on co2 emissions in Greece. This study has adopted a quantitative design where data has been gathered from World Bank and Greek Government's website from 1990 to 2018. The variables include renewable and fossil fuel energy consumption, domestic credit to the private sector, GDP growth rate and CO2 emission in metric tons. Data is analysed using ADF, VECM and Granger Causality tests applied through STATA. The results have revealed a long-run relationship effect of financial development on CO2 emissions in Greece, whereas a short-run effect of economic growth on CO2 emissions is also determined. The results are applicable to Greece only since the data was taken specifically from Greece

Keywords

Energy consumption, economic growth, ADF, VECM, financial development, CO2 Emission, Granger Causality

1. Introduction

This research paper concentrated on assessing the impact of energy consumption, economic growth, and financial development on carbon dioxide emissions in Greece. Climate change is one of the important issues that the world is currently facing. Since the industrial revolution, the emission of greenhouse gasses has increased (Victor et al., 2017). As the global economy is developing increasingly, environmental problems have become more serious. Air, water, and land have been polluted. Resources are being wasted, and fossil fuels are being burnt to meet the growing energy needs, and the depletion of resources at this rate may mean that there are no resources left for future generations. Greenhouse gases are the major reason behind global warming that is currently destroying the ecological balance on the ground (Cook et al., 2016), and the major greenhouse gas is carbon dioxide.

The emission of greenhouse gases directly impacts the environment and harms humankind, animals, vegetation, and the whole biotic environment (Bessou et al., 2011). It is the reason that groups across the world and international forums are advocating for practices that promote sustainability and oppose all the practices responsible for environmental degradation. The link between energy consumption and the growth of the economy the carbon dioxide emissions is therefore important to evaluate the impact these factors have on greenhouse gases so that measures can be devised according to the impact these factors are having and how much these factors are responsible for CO_2 emissions.

The relationship between energy consumption, economic growth, and financial development with carbon dioxide emissions has been a widely discussed research topic in the past two decades. There have been various kinds of research on this exact topic in the context of different countries, different periods, and different geographical regions and set of countries (Saidi & Hammami, 2015). However, this research has been concentrated in the country of Greece. Previous research has been conducted taking into view all the European and EU countries (Bölük & Mert, 2014), but there is no specific research that has discussed the impact of energy consumption, economic growth, and financial development on the emissions of carbon dioxide in the particular context of Greece. This is a research gap that this study will be attempting to exploit and fill.

Europe is the region where carbon dioxide emission has decreased over the past few years; although Europe still stands third in worldwide contribution to CO_2 emissions, as shown in the graph below, the European countries have been shifting their energy sources to clean and renewable energies and are moving towards sustainable practice (Moreno et al., 2012).

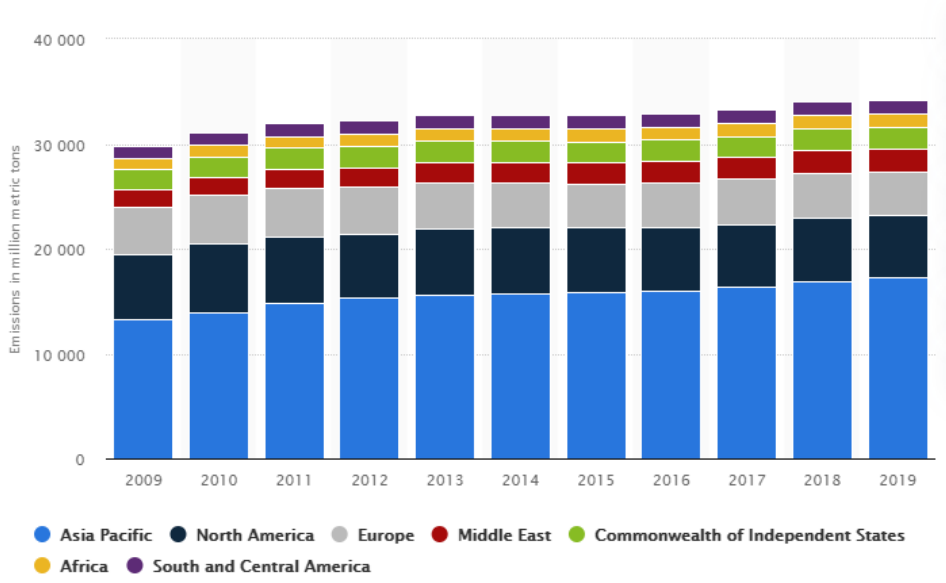

Figure 1: World CO_2 Emissions by Region (Statista, 2020)

Moreover, Greece has also reduced CO_2 emissions over the past few years. The country has recently gone through a severe financial crisis, and the scope of sustainability among the general population has increased during this debt crisis. Plus, the impact of climate change is going to be felt by Greece as Giannakopoulos et al. (2011) report that in the next 30 years, Greece will face impacts of climate change with extreme weather, spells of drought, and fire risks.

The scope of this study is wide, and it will benefit people from different backgrounds. The study will benefit the government and its agencies, especially in Greece and Europe, that are actively working against climate change and will be an eye opener for those who are not working for it. NGOs and environmental protection groups can benefit from the study as these groups hold economic growth and major business corporations to be contributing to climate change. Moreover, businesses and economists can use this study to evaluate how they are impacting the environment and what changes they can bring to their practice. Moreover, many researchers are working on or planning to conduct researches in a similar context. This study can serve as secondary data for these studies.

2. Literature Review

There has been an evident relation between energy consumption to add the economic growth of a country or a region. According to Esen & Bayrak (2017), the energy that is consumed per capita is one of the major indicators that is considered while measuring the growth of an economy. The economy of the world today is dependent upon energy as industrial processes, agricultural practices along with the daily business operations and the service sector are dependent upon electricity and

energy. The dependence of energy has increased in all production units of business with energy being considered as one of the important units of production alongside labour and capital. This is the reason that higher energy consumption is linked with the higher GDP for the country and thus increased economic growth. Research conducted by Shaari et al., (2013) in Malaysia using data of 30 years concluded that a relationship exists between energy consumption and economic growth with higher energy consumption leading to an increase in GDP.

Another important relationship that is relevant to this study is the relationship between economic growth and CO_2 emissions. Past studies have shown that a positive relationship exists between these two variables (Aye & Edoja, 2017). The growth of GDP and GDP per capita has resulted in environmental degradation. Three types of relationships between energy consumption and GCO_2 emissions have been suggested by previous researches. The relationships between the two factors can be described as a linear relationship, n-curve relationship, or an inverted u-curve relationship (Jian et al., 2019). The inverted u-curve relationship or the Environmental Kuznets Curve states that the income per capita and greenhouse gas emission are positively correlated to a certain point after which the relation turns opposite (Cederborg & Snöbohm, 2016). A linear relation states that an increase in GDP per capita will increase environmental damage while the n-curve relationship explains that the inverted u-curve relationship cannot sustain in the long term which means that beyond a certain point the relationship between the two variable will turn opposite but after a certain time this will become positive again and the cycle will go on (Allard et al., 2018). Although there exists a difference of opinions on the type of relationship, economic growth, and environmental degradation are correlated.

Another relation that this study will be exploring is the relation between energy consumption, economic growth, and CO_2 emissions. The study conducted by Khan et al., (2020) found that energy consumption and economic growth both are factors that are responsible for the CO_2 emissions in the country. The study was carried out using ARDL. Similarly, recent reaches have also focused on the variable of financial development and find a relation between the financial development of the country to the CO_2 emissions (Jiang & Ma, 2019) alongside the previously discussed factors, energy consumption, and economic growth.

H_1: There is a significant influence of economic growth on carbon emission.
H_2: There is a significant influence of financial development on carbon emission.
H_3: There is a significant influence of renewable energy consumption on carbon emission.
H_4: There is a significant influence of fossil fuel consumption on carbon emission.

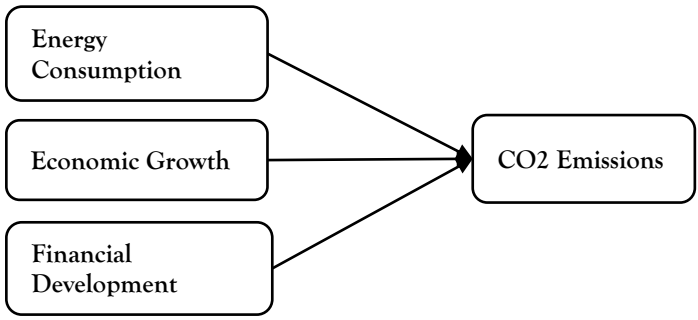

Figure 1: Conceptual Framework

3. Theoretical Framework

The Environmental Kuznets Curve or the EKC explains the relationship between economic growth in form of income per capita and the CO_2 emissions in form of environmental degradation. The model as shown explains this relationship in different economies explaining that the environmental pollution increases with the rise of industrial process and income in a country (Apergis and Ozturk, 2015). However, in the industrial economies, when the income reaches a certain point, the relationship turns opposite and with an increase in income per capita and as the economy moves towards post-industrial phase, there is a decline on economic degradation.

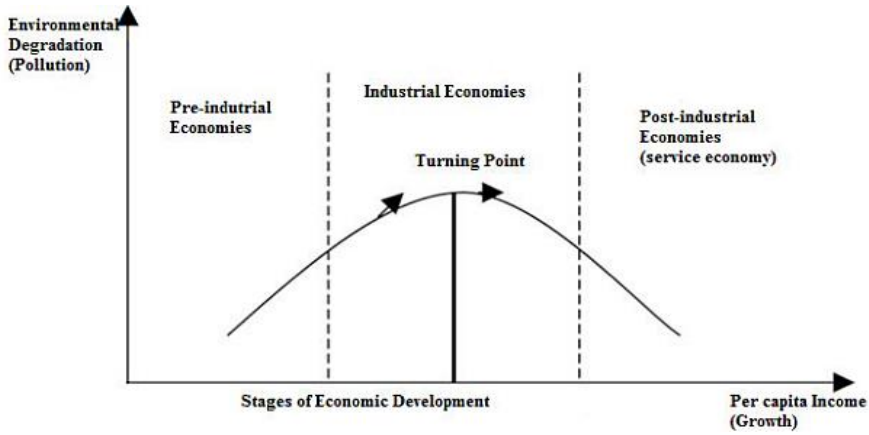

Figure 2: Environmental Kuznets Curve (Bozkurt & Yusuf, 2014)

4. Research Methodology

Two major types of research methods are used by researchers to execute the research, qualitative, and quantitative research methods. Qualitative researches are based upon textual information and are used to shed light on opinions, emotions, and feelings of an individual or group (Castellan, 2010). On the other hand, quantitative research methods include making use of numbers and statistics to address an issue, develop a hypothesis, or verify it (Barnham, 2015). The current research has used quantitative research method as the impact of the factors on CO_2 emissions can be measured using financial information and statistics of energy consumption and CO_2 emissions which can be measured quantifiably. This research is based on secondary data as it requires previously collected statistics spanning over decades to establish a relation between the variables (Clark, 2013).

This research has collected data of 28 years from 1990 to 2018 about energy consumption, economic growth, financial development, and CO_2 emissions in Greece using government-collected statistics and records. This information and data

will then be analysed using Unit Root Testing through ADF, Vector Autoregression, and Granger Causality to evaluate the effects of independent variables that are the energy consumption, economic growth, and financial development to the dependent variable, CO_2 emissions.

5. Results and Discussion

The following research paper is aimed at evaluation the effects of energy consumption, economic growth, and financial development on CO2 emissions in Greece. The previous sections have shed light upon introduction, literature, conceptual and theoretical framework and research methodology. The data is collected from the time period of 1990 to 2018 equalling to 29 years. The data has been collected for variables of energy consumption, economic growth, financial development and CO2 emissions from World Bank and government websites of Greece. The results are generated on the basis of descriptive statistics, unit root, VECM and Granger Causality test. The results are presented as below;

5.1. Descriptive Statistics

Descriptive statistics are statistical techniques that are used to illustrate the characteristics of data. It is the most commonly used technique to describe the data. The measures that are used include mean, standard deviation, minimum and maximum values.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO2Emissions	29	.3604992	.1118223	.1874813	.5482337
Domesticcr~o	29	69.98264	32.61118	19.36571	117.8832
Economicgr~P	29	.7004302	3.60787	-8.99795	5.542361
Renewablee~n	29	10.48871	4.551432	6.81373	22.0603
Fossilfuel~n	29	91.25253	4.553855	79.26285	94.59119

The above table 1 illustrates the descriptive characteristics of the variable taken into consideration for this study. Firstly, the observation column shows that overall, there are 29 observations for all variables which is the time period taken for the study. For this purpose, the mean for CO2 emission is 0.36 metric tons. This means that on an average over the last 29 years, 0.36 metric ton CO2 has been emitted by Greece. With regards to standard deviation, the value is 0.11 which is lower indicating that values were close to mean. The minimum value is 0.18 while max value is 0.54. The second variable domestic credit represented financial development is found to have a mean of 69.9 explained as a percentage of GDP. Hence, on average, the domestic credit to private sector is 69.9% of GDP. The standard deviation is 32.61% showing low variation in data. The minimum value is 19.36 while maximum value is 117.88. The third variable is economic growth having mean of 0.7 which shows that Greek economy on average has grown 0.7% over the selected time period. The standard deviation is 3.6 which shows highly unstable economy as the deviation is greater than average. The minimum value is -8% while maximum is 5%. The next

variable is energy consumption where, percentage consumed is taken. The mean for renewable energy is 10.4% while for fossil fuel consumption is 91.25%. The standard deviation is 4.5% respectively for each. The trend shows that recently, Greece has lessened its dependability on fossil fuel and moved towards renewable energy.

5.2. Augmented Dickey Fuller (ADF)

The augmented dickey fuller, shortened to ADF, is a unit root test for determining whether the dataset under consideration is stationary or not. A stationary series show similar patterns in time and hence, estimating them is not required since they do not change over time. For empirical analysis, it is necessary that variables should not be stationary and should have a unit root. The results are presented as follows:

Table 2: Unit Root Test

Augmented Dickey-Fuller test statistic	t-Statistic	Prob.*
CO2 Emissions	-6.553	0.000
DomesticCreditToPrivateSector	-3.111	0.025
EconomicGrowthGDP	-5.007	0.000
RenewableEnergyConsumption	-3.331	0.013
FossilFuelEnergyConsumption	-3.364	0.012

As stated above that for the data to be valid for further empirical testing, there must be a unit root. The null hypothesis states that there is no unit root in the data set. From the table illustrated above, it is evident that all the variables are non-stationary and have a unit root since all the probability values lie below the 5% range or in order words are less than 0.05. This indicates that there is a unit root and data does not exhibit a trend or pattern. The T-statistics represent the same because all the values are outside the range of +1.96 to -1.96 hence, the threshold has been met.

5.3. Vector Error Correction Model

The VECM model is used to test the long-run and short-run association of CO2 emissions with regards to energy consumption, financial development and economic growth. In other words, the error refers to the fact that deviation from long-run impacts the short-run dynamics and therefore, VECM is a restricted VAR to test both short and long-run relationship. The tables presented below indicate the results.

Table 3: Vector Error Correction Equations

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_CO2Emissions	7	.012505	0.6165	32.15233	0.000
D_ Domesticcredit	7	5.64692	0.4693	17.68444	0.013
D_Economicgrowth	7	2.53282	0.2244	5.786993	0.564
D_Renewableenergy	7	.61735	0.7494	59.80722	0.000
D_Fossilfuelenergy	7	.620802	0.7592	63.06842	0.000

The above table 3 illustrates the relationship between variables with respect to their equations individually. It is noted that there exists a significant relationship of

variables with regards to CO2 emission equation since the p-value is less than 0.05 and the relationship is significant at 1% threshold. Similarly, for domestic credit, the value is 0.01 less than 0.05 indicating that significant relationship exists between variables of this equation. Economic growth shows no significant relationship because the p-value is above the threshold. Significant relationship of variables with equation of energy consumption both renewable and fossil is observed. The below results indicate the equations and the association of variables in the long-run.

Table 4: Vector Error Correction (CO2 Emission)

	Coef.	Std. Err.	z	P>|z|
CO2				
CO2				
L1.	-.4303102	.2217487	-1.94	0.052
DMC				
L1.	.0011036**	.0005305	2.08	0.037
ECN				
L1.	-.0010074	.0011426	-0.88	0.378
RENEW				
L1.	-.0075361	.0048845	-1.54	0.123
FFUEL				
L1.	.0009909	.0034164	0.29	0.772
_cons	-.0162798***	.0041429	-3.93	0.000

The above table depicts VECM with regards to CO2. It can be observed that only domestic credit is observed to have a significant effect on CO2 emission [B=0.0011, P=0.037].

Table 5: Vector Error Correction (Domestic Credit)

	Coef.	**Std. Err.**	**z**	**P>|z|**
CO2				
CO2				
L1.	-42.24403	100.1318	-0.42	0.673
DMC				
L1.	.004708	.2395623	0.02	0.984
ECN				
L1.	-.424158	.5159692	-0.82	0.115
RENEW				
L1.	3.478638	2.205641	1.58	0.807
FFUEL				
L1.	.377169	1.542677	0.24	0.807
_cons	.2396894	1.870765	0.13	0.898

From the above table, it is observed that there is no association between the selected variables and domestic credit.

Table 6: Vector Error Correction (Economic Growth)

	Coef.	**Std. Err.**	**z**	**P>|z|**
CO2				
CO2				

L1.	48.40122	44.91226	1.08	0.281
DMC				
L1.	-.123551	.1074513	-1.15	0.250
ECN				
L1.	.036201	.2314285	0.16	0.876
RENEW				
L1.	.996611	.9892997	1.01	0.314
FFUEL				
L1.	.4189105	.6919392	0.61	0.545
_cons	.7362437	8390971	0.88	0.380

The above table illustrates that there is no significant impact of economic growth and financial development on the CO2 emissions particularly in the wrong run.

Table 7: Vector Error Correction (Renewable Energy Consumption)

	Coef.	**Std. Err.**	***z***	**P>|*z*|**
CO2				
CO2				
L1.	24.29516**	10.94692	2.22	0.026
DMC				
L1.	-.058291**	.0261902	-2.23	0.026
ECN				
L1.	-.1354897**	.0564084	-2.40	0.016
RENEW				
L1.	.1316923	.2411321	0.55	0.585
FFUEL				
L1.	-.0560254	.1686534	-0.33	0.740
_cons	.9331817***	.2045216	4.56	0.000

The above table shows significant effect of CO2 emissions on renewable energy consumption [B=24.29, P=0.02] since the threshold is less than 0.05. Similarly, the effect of domestic credit [B=-0.05, P=0.02] and economic growth [B=-0.13, P=0.016] on renewable energy consumption is significant.

Table 8: Vector Error Correction (Fossil Fuel Energy Consumption)

	Coef.	**Std. Err.**	***z***	**P>|*z*|**
CO2				
CO2				
L1.	-3.163282	11.00813	-0.29	0.774
DMC				
L1.	.0201294	.0263366	0.76	0.445
ECN				
L1.	-.0089548	.0567238	-0.16	0.875
RENEW				
L1.	.3980789	.2424803	1.64	0.101
FFUEL				
L1.	-.0768278	.1695964	-0.45	0.651
_cons	-.9186265***	.2056652	-4.47	0.000

The above table shows that there is no significant effect of any variable with regards to equation of fossil fuel consumption.

5.4. Granger Causality Test

Granger causality is an econometric technique used to assess whether a time series is useful in forecasting another time series or not in the short-run. The test is applied with respect to each variable and results are presented as follows:

Table 9: Granger Causality Test

Equation	Excluded	chi2	df	Prob > Chi2
CO2				
CO2	DMC	2.2939	1	0.130
CO2	ECN	4.1128**	1	0.043
CO2	RENEW	.3077	1	0.579
CO2	FFUEL	.54899	1	0.459
CO2	ALL	5.1673	4	0.271
DMC				
DMC	CO2	23.973***	1	0.000
DMC	ECN	17.176***	1	0.000
DMC	RENEW	.72959	1	0.393
DMC	FFUEL	2.6163	1	0.106
DMC	ALL	100.48***	4	0.000
ECN				
ECN	CO2	3.9025**	1	0.048
ECN	DMC	1.8414	1	0.175
ECN	RENEW	.56052	1	0.454
ECN	FFUEL	.02973	1	0.863
ECN	ALL	12.164**	4	0.016
RENEW				
RENEW	CO2	.05739	1	0.811
RENEW	DMC	.48329	1	0.487
RENEW	ECN	22.436***	1	0.000
RENEW	FFUEL	13.891***	1	0.000
RENEW	ALL	78.462***	4	0.000
FFUEL				
FFUEL	CO2	8.1989***	1	0.004
FFUEL	DMC	1.4696	1	0.225
FFUEL	ECN	1.0488	1	0.306
FFUEL	RENEW	47.851***	1	0.000
FFUEL	ALL	90.983***	4	0.000

From the Granger causality test, the short-term relationship between the variables of study is identified. From the table above, it can be observed that economic growth and carbon emissions have a significant relationship as the p-value is less than 0.05. Secondly, carbon emission and economic growth have a short-run relationship with domestic credit to private sector. Moreover, overall, all the variables are linked to domestic credit to private sector or financial development in the short-run as all have a significant effect over financial development. With regards to

renewable energy, economic growth, fossil fuel consumption and overall, all variables have a significant short-run association with renewable energy consumption at 1% significance level as observed in the table above. Lastly, CO2 emissions, renewable energy consumption and overall model has a short-run effect on fossil fuel consumption which is all evident through the p-values being less than 0.05. This shows that short-run relationship is explained by economic growth, financial development and energy consumption on CO2 emissions.

Table 10: Hypothesis Assessment Summary

Hypotheses	Proposition	Results
H_1	There is a significant influence of economic growth on carbon emission.	Accepted
H_2	There is a significant influence of financial development on carbon emission.	Accepted
H_3	There is a significant influence of renewable energy consumption on carbon emissions.	Rejected
H_4	There is a significant influence of fossil fuel consumption on carbon emissions.	Rejected

The table above depicts the hypothesis assessment summary where the influence of financial development on carbon emission in long-run is empirically proven; hence, the hypothesis has been accepted. Moreover, the influence of economic growth on carbon emission in short-run is determined through the Granger causality test and has been accepted. The rest of the hypotheses have been rejected.

The results have depicted a long-run relationship between financial development and CO2 emissions during a short-run relationship between economic growth and CO2 emissions. The findings of this study are identical to the findings of Jiang and Ma (2019), who stated that a relationship exists between financial development and CO2 emissions. However, the findings are partially identical to the study of Khan et al. (2020), who found that energy consumption and economic growth significantly impact CO2 emissions, but this study has only found the significant impact of economic growth in the short-run. Another study conducted by Aye and Edoja (2017) showed that there is a positive relationship between economic growth and CO2 emission, which is similar to the findings of this study.

6. Conclusion and Recommendation

The CO2 emissions are harming the climate, which has become one of the prime concerns of world leaders today. Therefore, the factors that are leading to higher CO2 emissions are focused on relentlessly by the authorities. Among these, energy consumption and economic growth rank the highest, increasing CO2 emissions. This study has tested these variables in the Greek economy, and results have revealed that there is a long-run relationship between financial development and CO2 emissions, whereas a short-run relationship exists between economic development and CO2 emissions. The Greek economy is provided with the following recommendations. a) To reduce CO2 emissions, Greek authorities are advised to lessen the domestic credit to the private sector and revise the policies

regarding energy consumption so that a sustainable future can be achieved. b) Although CO2 emissions foster economic growth because more energy is consumed, it is vital for Greece to move towards renewable energies so that economic growth can be achieved with sustainable sources.

The results only apply to Greece since the data was taken specifically from Greece. Future researchers can consider other emerging countries having the same problem. Secondly, the researcher has considered only one country. In future, more than one country can be used to compare results and present a comprehensive analysis.

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