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Article

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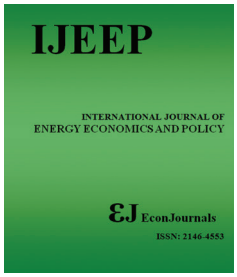

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The Impact of Renewable and Non-renewable Energy on Carbon Dioxide Emission: An Empirical Analysis for Euro Mediterranean Countries

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ABSTRACT

Given that carbon dioxide emissions is the main reason of environmental pollution and global warming, this paper attempts to investigate the impact of gross domestic product (GDP) per capita, electricity production from different sources (including renewable and non-renewable energy) and industrial sector share in GDP on Carbon dioxide emissions (CO_2) for a Euro Mediterranean panel of 25 countries using dynamic panel data model for the period 2002-2016. The paper uses the Hausman test and panel unit root test in order to verify the stationary of the variables series employed. Generalized least square estimator is used for building Panel regression model. The results indicate a significant positive impact of economic growth and electricity output from coal on CO_2 emissions In contrast, renewable resources have a negative impact on CO_2 emission.

Keywords: Caron Dioxide Emissions, Renewable Energy, Euro Mediterranean
JEL Classifications: C23, O13, P18, P28, P48, Q42

1. INTRODUCTION

Since the industrial revolution, human activities have contributed substantially to climate change by adding carbon dioxide (CO_2) and other heat trapping gases to the atmosphere. The emissions of these greenhouse gases (GHG) have increased the greenhouse effect and caused Earth's surface temperature to rise (EPA, 2017). Therefore, growing industrialization has damaged the ecological environment and stimulated global warming. CO_2 is considered main source of greenhouse gases and is one of the most important causes of increasing global warming and climate change (IPCC, 2014).

Thus United Nations Framework Convention on Climate Change in the Rio Earth Summit 1992 was considered the first and most important international agreement aiming to control environmental pollution (United Nations, 1992). A few years later, in 1997, the Kyoto Protocol was signed to legally a bind emission reduction targets for developed countries (United Nations, 1998).

Moreover, in the Euro Mediterranean Conference held in Barcelona in 1995, energy cooperation has been numbered among the key themes of the Euro Mediterranean Partnership (Ruggiero, 2014). In 1997 The European Commission adopted the Communication "Energy for the Future: Renewable Sources of Energy" a White Paper for a Community Strategy and Action Plan to contribute, by promoting renewable energy sources, to the achievement of the energy policy objectives: Security of supply, environment and competitiveness and sustainable development (Commission of the European communities, 2001).

On June 8, 1998 the Council adopted a Resolution on renewable sources of energy by agreeing that there is a need to promote the sustainable use of renewable energy sources. The council welcomed the general thrust of the White Paper as a basis for actions at the Community and national levels (Council, 1998).

The Euro-Mediterranean Energy Forum was launched as a follow-up to the conclusions of the Euro- Mediterranean

Conference in Trieste, June 1996. The Forum prepared an Action Plan (1998-2002) with two main axes: Co-operation at political and administrative level, co-operation at the industrial level aiming to adapt energy companies to developments in demand, to increase energy efficiency in industry, and to facilitate co-operation among businesses across the Mediterranean (European Commission, 2005).

Following this action plan and according to Barcelona Process, energy projects were launched (MEDA Regional Energy Projects) involving the legal and institutional framework, reform of the energy sector, applications of thermal solar energy, and a training network in energy policy (European Commission, 2000).

One of these projects is The Mediterranean electric ring launched in February 2001(received a grant of EUR 2.1 million as European Union contribution) and aimed to build connections between national networks in the Mediterranean area and between the Mediterranean area and the EU (Commission of the European communities, 2001), (European Commission, 2002).

In 2001, funding for a project on energy and the urban environment was approved. The project concerns energy management and energy planning and conservation with a total cost of EUR 3.25 million and a Community contribution of EUR 1.9 million (European Commission, 2002).

Mediterranean cooperation was necessary to implement the objectives of the Barcelona Declaration. In terms of environment, cooperation was coordinated by the European Commission and focused on integrated management of water, soil and coastal areas; management of waste; preventing and combating air pollution and pollution in the Mediterranean sea (Barcelona Declaration, 1995).

In the Mediterranean, environmental protection is an obvious area. SMAP (short and medium-term priority action programme for the environment) is the environmental component of the Barcelona process which provides a framework for policy orientations and funding both at regional level and at national level. The programme was approved in 1997, at the first Euro-Mediterranean Ministerial Conference on the Environment (Scoullos and Ferragina, 2010).

So, it may be clear from the above discussions that reducing greenhouse gas emissions mainly carbon dioxide emissions is the main target for most countries in general and the Euro Mediterranean countries in specific (Islam et al., 2018). This can be achieved by shifting to renewable energy sources which are the least expensive options in reducing carbon dioxide emissions worldwide (United Nation, 2018). Hence, this paper aims to investigate the relationship between environmental pollution proxied by carbon dioxide emissions and renewable energy in the Euro Mediterranean countries, specifically the countries that signed Barcelona Process in the year 2001. Although several studies investigated the relationship between renewable energy resources and environmental degradation, our present study adds to strand of literature review by examining this relationship in the Euro Mediterranean countries where there is a lack of investigating it.

The study conducts panel data analysis for the period of 2002-2016 to investigate the relationships between carbon dioxide emissions, renewable electricity output, industrial value added, gross domestic product (GDP) per capita, electricity production from nuclear resources and from coal resources.

The rest of the paper is organized as follows. Section two briefly presents literature review. In section three, model specification, data and methodology are explained, Section four is concerned with empirical results and discussions. And finally in section five we conclude the paper and suggest policy implications.

2. LITERATURE REVIEW

Numerous researchers have investigated the relationship between environmental degradation and renewable energy resources. In this part we try to summarize the most relevant literature related to environmental pollution, (mainly CO_2 emissions), and renewable and nonrenewable energy resources. Economic growth is closely related to CO_2 emissions as growth is assumed to be positively correlated with energy consumption, leading to more pollution. Thus, developed countries targeted using renewable sources of energy to reduce CO_2 emissions (Balogh and Jámbor, 2017).

Many studies have examined the relationship between the use of renewable energy sources and CO_2 emissions, and found a negative significant. Abolhosseini et al. (2014) investigated the impact of renewable energy development on carbon emission reduction based on a panel data estimation using the EU-15 countries data observed from 1995 to 2010. A model was estimated to evaluate the effectiveness of renewable energy development, technological innovation, and market regulations in carbon emission reduction. In order to evaluate the effectiveness of each parameter, the elasticities of CO_2 emissions are estimated. The findings show that the effects of a negative climate change could be mitigated by governance-related parameters instead of economic development.

Qi et al. (2014) found that current renewable electricity targets in china result in significant additional renewable energy installation and a reduction in cumulative CO_2 emissions of 1.8% relative to a No Policy baseline. Bilgili et al. (2016) launched panel FMOLS and panel DOLS estimations using a panel data set of 17 OECD countries over the period 1977-2010. The findings indicated that GDP per capita and GDP per capita squared have the impacts on CO_2 emissions positively and negatively, respectively, and that renewable energy consumption has a negative impact on CO_2 emissions.

Also, Li and Su (2017) examined the dynamic effect of renewable energy consumption and on carbon dioxide emissions over the period 1990-2015 in United States. The results indicated that the use of primary energy has a positive and notable influence on CO_2 emissions. The impulse response function (IRF) results showed that the use of renewable energy would remarkably reduce carbon emissions, despite leading to an increase in emissions in the early stages. Moreover, natural gas consumption will have a negative impact on CO_2 emissions in the beginning, but will have only a modest impact on carbon emission reductions in the long run.

Koengken and Fuinhas (2018) analyzed the impact of renewable energy consumption on the carbon dioxide emissions for a panel of ten South American countries in a period 1980-2012. The results indicate that the consumption of renewable energy reduce the carbon dioxide emissions by 0.0420% when the consumption of alternative sources increases in 1% in short-run. The empirical evidence of the study shows that the renewable consumption plays an important role in reducing CO_2 emissions.

Also, Sasana and Putri (2018) aimed to analyze the effect of fossil energy consumption, population growth, and consumption of renewable energy on carbon dioxide emission in Indonesia, using multiple linear regression analysis and time series in the period of 1990-2014. The result showed that the consumption renewable energy has a negative effect on the level of carbon dioxide emissions produced. Saudi et al. (2018) investigated the role of renewable energy, non-renewable energy and technology innovation on environmental degradation in Malaysia during (1980-2017). The empirical results indicated that renewable energy consumption and technology innovation have significant and negative impact on carbon dioxide emission whereas, the non-renewable energy consumption and economic growth have a significant and positive impact on carbon dioxide emission.

Karasoy and Akçay (2019) examined the impacts of (non-renewable and renewable) energy consumption and trade on environmental pollution in Turkey for the period (1965-2016). To investigate the interrelationships among the variables, the autoregressive distributed lag and the vector error correction methodologies are employed. The results showed that the increase in trade and non-renewable energy consumption rise carbon emissions in long run, while renewable energy consumption reduces it in both short- and long-run. Cheng et al. (2019) employed a panel quantile regression method to study the impacts of economic growth, renewable energy, and development of patents on carbon emissions. Economic growth had significant and positive impact on carbon emissions. The impact of renewable energy on carbon emission showed an inverted U-shaped trend at different quantile levels.

In contrast to the previous studies, several studies did not support the negative effect of using renewable energy sources on CO_2 emissions. Twumasi (2017) investigated the relationship between carbon dioxide (CO_2) emissions and renewable energy production in the United States of America. The data analysis revealed there was a significant positive correlation between population and CO_2 emissions, while GDP also showed positive correlation with CO_2 emissions. However, there was no specific pattern between renewable energy and CO_2 emissions; meaning that producing more renewable energy does not necessarily reduce CO_2 emissions. The empirical study of Azlina and Taib (2019) examined the relationship between environmental quality, economic development, renewable and non-renewable energy consumption in 13 developing countries in Asia over the period 1980-2014. The results indicated that conventional energy consumption and economic growth decrease the environmental quality. However, the renewable energy consumption is insignificant in reducing CO_2 emissions.

Another strand of literature focuses on energy consumption and its relation to environmental pollution (mainly CO_2 emissions). Bento (2014) examined the major determinants of CO_2 emissions in Italy over the period 1960-2012, he found short and long run relationships between emissions, trade openness and energy consumption, hence recommending the use of environmentally friendly and renewable energy sources. Vidyarthi (2014) examined the relationship between energy consumption, carbon emissions and economic growth for a panel of five South Asian economies (India, Pakistan, Bangladesh, Sri Lanka and Nepal) over the period 1972-2009. The study used Pedroni cointegration and Granger causality test based on panel vector error correction model. Cointegration result indicated the long-run equilibrium relationship between economic growth, energy consumption and carbon emissions for panel. Causality results suggest that bidirectional causality exist between energy consumption-GDP, and unidirectional causality from carbon emissions to GDP and energy consumption in long run. However, energy consumption causes carbon emissions in short run. Similarly, Alshehry and Belloumi (2015) found a long term relationship between energy consumption, energy price, carbon dioxide emissions, and economic growth. Mardani (2018) concluded using prediction models by real data to predict CO_2 emissions based on energy consumption and economic growth, using an adaptive neuro-fuzzy inference system (ANFIS) model during period 1962 to 2016 on the G-20 countries to find an interrelationship between the variables. Also Banday and Aneja (2019) examined the relationship between energy consumption, economic growth and CO_2 emissions for the G7 countries over the period 1971-2014. The findings showed the absence of causality from economic growth to renewable energy and the acceptance of neutrality hypothesis. Causal relationship from renewable energy to CO_2 emission is significant for France, Italy, Japan and UK, whereas no causal relationship for Canada, Germany and USA.

Moreover, other studies are concerned with the relationship between nuclear, hydropower energy resources and coal energy resources and environmental degradation. For example, Iwata et al. (2010) found uni-directional causal relationship running from nuclear energy to CO_2 emissions which provides evidence of the role of nuclear power in reducing CO_2 emissions. However the results were limited to some countries. Alam (2013) aimed to study the relationship between economic growth, nuclear energy consumption and carbon dioxide (CO_2) emissions for a panel of 25 countries over a period of 1993-2010. Separate panels are created for developing and developed economies. For the developed countries, short-run causality running from CO_2 emissions to economic growth was estimated, whereas strong form of causality indicated the dependence of CO_2 emissions on economic growth and nuclear energy consumption was seen to impact CO_2 emissions. For the developing countries, both the short-run and strong-form causality estimates indicate that economic growth causes CO_2 emissions.

Katircioglu (2015) examined the long-term equilibrium relationship between carbon dioxide (CO_2) emissions and total

biomass consumption (BC) in Turkey using annual data over the period 1980-2010 and conditional error correction models under the autoregressive distributed lag approach. Results suggest that CO_2 emissions are in a long-term equilibrium relationship with total BC in Turkey. BC has a negative effect on CO_2 emissions; 1% increase in total BC would lead to 0.029 % reduction in CO_2 emissions. Long-term coefficient of fossil fuel consumption for CO_2 emissions is positive and elastic, 1.247. Conditional error correction model showed that CO_2 emission in Turkey converges to its economic long-term equilibrium very quickly by 93.7 % speed of adjustment through the channel of BC and fossil fuel consumption. Balogh and Jámbor (2017) conducted a panel data set including 168 countries for a time series of 24 years, found that there is a significant role of nuclear energy and renewable energy production in reducing CO_2 emissions, while energy from coal increased environmental pollution.

Additionally, Sinaga et al. (2018) examined the relationship between hydropower energy consumption and carbon dioxide emissions in Malaysia by using the annual time series data over the period 1978-2016. The results confirmed that hydropower energy consumption and square of economic growth have significant and negative impact on carbon dioxide emission. Grijalva and Martínez (2019) evaluated the positive environmental effects in terms of CO_2 emissions that would be produced by the replacement of conventional urban transport bus fleets by electric buses. The simulation of an electric urban bus conceptual model is presented as a case study. The results shows that by gradually replacing the current fleet of buses by electric buses over 10 years (2020-2030), CO_2 emissions would be reduced by up to 92.6% compared to 2018 levels.

3. ECONOMETRIC SPECIFICATION AND METHODOLOGY

In order to investigate the relationships between environmental pollution caused by carbon dioxide emissions and GDP per capita, industrial sector value added to GDP, percentage of renewable electricity output, percentage of nuclear electricity output, and percentage of coal electricity output, Panel regression model was built. As the use of panel data technique give more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency. Also, panel data are better suited to study the dynamics of change (Gujarati, 2003) Generalized least square estimator (GLS) was used to estimate the model.

3.1. Data

Annual data that covers 25 countries was collected from World Bank Development Indicators (WDI), during the period from 2002 to 2016 (Table 1).

Countries were chosen from the Euro- Mediterranean area, namely countries that signed the Euromed Partnership Agreement, with the aims of establishing a common area of peace, stability, and shared prosperity in the Euro-Mediterranean region. It worth mentioning in this context that Palestine and Syria were excluded for data limitation.

Table 1: Countries in the model

Algeria	Austria	Belgium	Cyprus	Denmark
Egypt	Finland	France	Germany	Greece
Ireland	Israel	Italy	Jordan	Lebanon
Libya	Luxembourg	Morocco	Netherlands	Portugal
Spain	Sweden	Tunisia	Turkey	United Kingdom

The variables of the study are CO_2 emissions (is an indicator) for global warming measured in metric tonnes per capita, GDP per Capita (constant 2010 US$), industrial sector (including construction) value added as a percentage of GDP, electricity production from renewables as a percentage of total electricity output, electricity production from nuclear sources as a percentage of total output, and electricity production from coal sources as a percentage of total output.

3.2. Model

A standard panel fixed effects regression model can be written as follows:

$$\text{Log}\,(X_{it}) = \alpha + B_1\,(R_{it}) + B_2\,(D_{it}) + B_3\,(Y_{it}) + B_4\,(N_{it}) + B_5(C_{it})\,eu_{it}$$

Where,

X_{it} indicates the carbon dioxide emission for country (i)

R_{it} represent renewable electricity output (% of total electricity output)

D_{it} measures the industry (including construction), value added (% of GDP)

Y_{it} represent GDP per capita (constant 2010 US$)

N_{it} represent electricity production from nuclear sources (% of total)

C_{it} represent electricity production from coal sources (% of total)

B's are parameters of the model.

Carbon dioxide emission is the dependent variable. Renewable electricity output, electricity production from coal sources (% of total), GDP per capita, electricity production from nuclear sources (% of total) and the industry (including construction) value added (% of GDP) are the independent variables.

4. EMPIRICAL RESULTS

In order to verify the stationary of the variables series employed, this paper employs panel unit root test the LLC's (Levin, Lin, and Chu) test (Levin et al., 2002). The results of the test are reported in Table 2 indicating that the autoregressive parameters are common across cross sections, where the test uses the null hypothesis of a unit root showing that the residuals are stationary (Gujarati and Porter, 2003), (Kwiatkowski et al., 1992).

There are two main approaches in panel data models. When choosing between fixed effects models and random effects models in a panel data analysis, we need to take into consideration the correlation of unit effects to independent variables. If unit effects are correlated to independent variables, then the fixed effects model is selected; if not, the random effects model is used. The appropriate model may also be selected by the help of the Hausman (1978) test (Wooldridge, 2012).

Table 2: Panel root test results

Xt unit root llc residuals		
Levin – Lin – Chu – unit - root test for residuals		
H_0: Panel contains unit root	Number of panels=25	
H_a: Panels are stationary	Number of periods=14	
AR parameter: Common	Asymptotics: N\T-≥0	
Panel means: Included		
Time trend: Not included		
ADF regressions: 1 Lag		
LR variance: Bartlett Kernel, 7.00 lags average (chosen by LLC)		
	Static	**P-value**
Unadjusted t	−7.2332	0.0001
Adjusted t*	−3.7017	

Table 3: Panel fixed effect estimation

Variables and constants	Coefficient (Std. error)
Log_electricity_coal	0.2237743***
	(0.0289114)
Log_electricity_nuclear	0.0535346
	(0.0753946)
Log_ renewable	−0.0168738**
	(0.007807)
Log_industry	0.1510519**
	(0.0712161)
Log_gdppercapita	0.6360833***
	(0.061375)
_Cons.	−2.218819***
	(0.6217161)

*** and **indicate 1% and 5% level of significance respectively

The Hausman test stated that the fixed effects model is the appropriate one, interpretation of the results will focus on the fixed effects model.

The results of the analysis are displayed in Table 3.

The results of the model are consistent with the theoretical expectations; there is significant relationship between all independent variables and the dependent variable except for electricity production from nuclear and this can be shown in Table 3.

The findings portray that the GDP per capita, industrial sector share and electricity production from coal have a vital role in the CO_2 emissions growth, where a 1% increase in each of these variables, will lead to increase in the CO_2 emission by 0.64%, 0.15% and 0.22% respectively. While 1% increase in renewable electricity output will lead to a decrease in CO_2 emissions by 0.02%.

5. CONCLUSION AND POLICY IMPLICATIONS

The study aims at examining some variables as determinants of carbon dioxide emissions including GDP per capita, electricity production from different sources and industrial sector share in GDP using a panel data for 25 of Euro Mediterranean countries.

The empirical results of this study showed that the GDP per capita, industrial sector share and electricity production from coal have a positive impact on CO_2 emissions. While renewable electricity output has a negative impact on CO_2 emissions as it leads to a decrease in CO_2 emissions. The empirical results provide policymakers a better understanding of energy consumption, economic growth and industrial sector growth and energy as determinants of CO_2 emissions, in order to formulate energy and climate policies in these countries.

The findings of this study have important policy implications as the policymakers should then take into consideration the degree of economic growth, the efficient use of different energy resources.

Shifting towards increasing the consumption of renewable energy resources instead of the non-renewable one in order to decrease carbon dioxide emissions according to the negative relationships that have been proven the panel regression models is considered a vital step. Policy makers in Euro Mediterranean countries can promote the consumption of renewable energy resources through some methods include subsidies in order to increase the supply, investments in renewable energy resources and expenditure on research and development concerning renewable energy.

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