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Environmental Kuznets Curve in Greece in the Period 1960-2014

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ABSTRACT

CO_2 emissions in Greece have increased significantly in recent decades. Many researches point out that Greek's economy structure is characterized by a strong interdependence of energy use and economic growth, so that any increase in national production leads to an increase in CO_2 emissions. In this sense, Greek's economy structure does not allow policies to de-escalate the level of CO_2 emissions without cost in terms of economic growth. This paper focuses on investigating the short and long term relationship between Gross National Product (GDP), CO_2 emissions and gross energy use over the period 1960-2014, using appropriate econometric tools. Additionally, the impact of the urbanization rate on CO_2 emissions is examined. The exploration of these relationships is part of the Kuznets Environmental Curve (EKC) theory that economic growth ultimately leads to a degradation of environmental degradation.

Keywords: Kuznets Environmental Curve, CO_2 Emissions, Energy Use, Granger Causality, Greece
JEL Classifications: Q01, Q40, Q50, Q56

1. INTRODUCTION

The Environmental Kuznets Curve (EKC) theory first appears in the early 1990s and examines the relationship between economic growth and environmental degradation. The relationship developed between environmental degradation and economic growth takes the form of an inverse U, confirming the theory developed by Simon Kuznets about the income inequality – economic growth nexus (Kuznets, 1955).

The EKC case has been empirically studied for many types of pollutants (Shafic and Bandyopadhyay, 1992). Most studies indicate that the EKC hypothesis is confirmed for pollutants that have local and perceived impact and low cost of treatment (Stern et al., 1996). However, the results are rather mixed when CO_2 emissions are considered as a form of environmental degradation and the EKC hypothesis is neither rejected nor confirmed adequately on an empirical basis (Dinda, 2004; Kaika and Zervas, 2013a). Many studies indicate a rather positive relationship with economic growth (Shafic and Bandyopadhyay, 1992; Grossman and Krueger, 1995), implying that the level of CO_2 emissions rises with income. An interpretation for this is that CO_2 emissions are not immediately felt locally and the cost of dealing with them is high, as it is directly linked to the productive structure of an economy (Shafic and Bandyopadhyay, 1992; Grossman and Krueger, 1995). In addition, CO_2 emissions have a global impact and even if their growth rate is reduced as a result of the decline in economic growth (mainly from the developed countries), global CO_2 emissions will continue to increase due to the rapid economic growth of developing economies (Kaika and Zervas, 2013a). Moreover, Generalised Method of Moments and ARDL has been also used to test if there is any relationship between GDP and CO_2 emissions, with the result to be EKC evidence for some countries including Greece (Acaravci and Ozturk, 2010; Jaunky, 2011).

Recent studies set in the center of consideration energy use as a crucial factor affecting the income – CO_2 emissions nexus. For this purpose, several studies attempt to examine the relationships between CO_2 emissions, income and energy use, either by using panel data techniques (Apergis and Payne, 2009; Marrero, 2010;

Pao and Tsai, 2011) or by adopting time series techniques (Acaravci and Ozturk, 2010; Ang, 2007; Halicioglu, 2009; Hatzigeorgiou et al., 2011; Jalil and Mahmud, 2009; Pao et al., 2011; Saboori and Sulaiman, 2013; Shahbaz et al., 2013). What comes up from the literature review is that the causal relationships between the variables of economic growth, energy use and CO_2 emissions are not clear-cut. The dynamic relationships among the variables in question may move into different directions depending on the time period used, the econometric methodology adopted, the assumptions implied and the country/ies examined (Kaika and Zervas, 2013b).

The case of Greece is quite peculiar, since there are several economic cycles (growth, stagnation, recession) between 1960 and 2014. After the 2nd World War and the Greek Civil War (1946-1949), the rural population moved to urban centers for the needs of industrial production. This urbanization resulted in important changes in the productive structure of the Greek economy. However, a long-run relationship between real GDP and CO_2 emissions caused by the urbanization trend has not been sufficiently studied using econometric applications.

This paper investigates the causality among Gross Domestic Product (GDP), CO_2 emissions and energy use on a per capita basis over the period 1960-2014 in Greece. This study is crucial for policy makers in Greece in order to achieve a sustainable growth pattern with respect to energy limitations and the necessity to comply with global strategies to curb CO_2 emissions. In order to achieve this, econometric methods adopting time series analysis is used. For this purpose, the paper is organized as follows: The following section analyses the economic and environmental parameters of Greece. Next, the methodology adopted and the data used are presented. The paper continues with the presentation of results. Finally, the results are discussed in section 5.

2. ANALYSIS OF ECONOMIC, CO_2 EMISSIONS AND ENERGY PARAMETERS IN GREECE

As can be seen in Figure 1, per capita GDP, per capita CO_2 emissions and per capita energy use follow an almost common trend through the years. By taking 1960 as base year, all three variables increase until the beginning of the last economic crisis started in 2008. During the 1960-2008 period, real GDP per capita has grown 4 times compared to 1960s levels, while energy use per capita and CO_2 emissions have grown respectively 9 and 7,5 times compared to 1960s levels. Therefore, the growth of energy use and CO_2 emissions per capita overcomes the growth of GDP per capita (Figure 1). However, from 2008, all three variables report declining trends indicating that the negative GDP growth leads to decreased energy use and CO_2 emissions.

The growth of urbanization rate is almost stable over the 1960-2014 period and does not seem to be affected by the 2008s economic crisis or other economic cycles in Greece (Figure 1).

CO_2 emissions and energy use in Greece seem to be coupled over the years as shown in Figure 1 and both variables seem to be determined by GDP changes over time. Hondroyiannis et al. (2002) argue that total energy consumption is an important inherent determinant of economic growth during 1960-1996. According to the authors, from the early 1960s until the Second Oil Crisis in 1979, the Greek economy is experiencing high rates of economic growth fuelled by the significant growth of energy consumption in the industrial sector. This outcome is verified concerning CO_2 emissions in Greece in Figure 2, where the growth of CO_2 emissions of the manufacturing industries and construction sector is greater than the grown of total CO_2 emissions. After the two oil crises, the slowdown in economic growth is followed by a slowdown of energy use the industrial sector (Hatzigeorgiou et al., 2011) while, according to Polemis (2007), since 1980, energy consumption of the industrial sector is growing at a lower rate compared to total energy consumption (Polemis, 2007).

In the sub-period 1980-1996, the Greek economy records low growth rates of real GDP, while growth rates of total CO_2 emissions and total

Figure 1: Trend of variables in Greece (1960=base year) 1960-2014. (WDI, 2019)

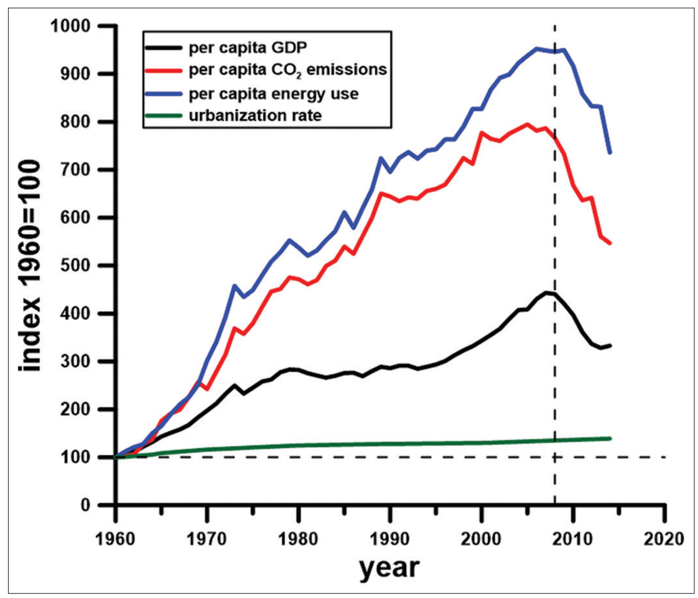
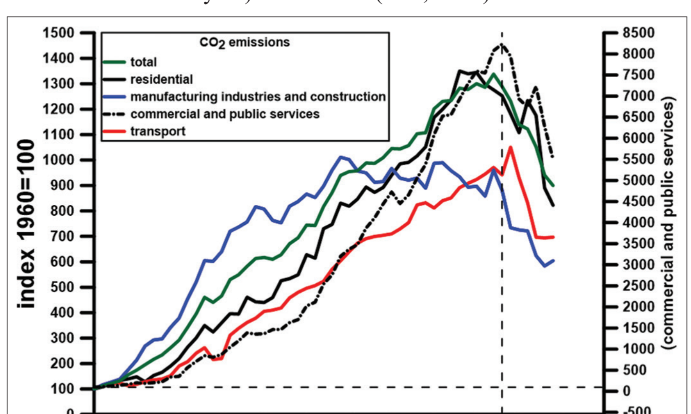


Figure 2: Sectoral approach of CO_2 emissions in Greece (1960=base year) 1960-2014. (IEA, 2016)



energy use remain higher (Figure 1). Over this period, the growth of CO_2 emissions of the manufacturing industries and construction sector fall behind the growth of total CO_2 emissions (Figure 2).

The Greek economy seems to recover during the period of 1997-2007: the growth of real GDP is higher than the growth rates of total energy consumption and total CO_2 emissions (Figure 1), while energy consumption of the industrial sector remains low (Hondroyiannis et al., 2002). Contrary to the evolution of energy consumption in the industrial sector, energy consumption of the services sector and the residential sector has increased significantly since the mid-1970s (Hondroyiannis et al., 2002). An interpretation of this statement is the improvement of living conditions in Greece (Hondroyiannis et al., 2002), resulting in increases in the use of private cars (Zervas et al., 2006), electrical appliances (Hondroyiannis et al., 2002) and/or cooling systems in the summer months (Rapanos and Polemis, 2006). In accordance, CO_2 emissions of the services sector -as allocated in commercial and public services and transport in Figure 2 - and residential sector boost the growth of total CO_2 emissions in Greece (Figure 2). Finally, from 2009 onwards, all sizes report negative growth rates (Figures 1 and 2) due to the last economic crisis in Greece.

In overall, the transition of the Greek productive structure from an economy based on industry to a service-based economy may explain the evolution of the level of CO_2 emissions in Greece for the period 1960-2014. Some researchers attempt to study the underlying relationships among GDP, energy use and CO_2 emissions in Greece. For instance, Jaunky (2011), considers only the income-CO_2 emissions nexus in Greece adopting panel data techniques over the 1980-2005 period. Hatzigeorgiou et al. (2011) add the energy intensity as an additional explanatory variable in their income-CO_2 emissions model over the 1977-2007 period using times series techniques, but do not adopt an EKC estimation model. Acaravci and Ozturk (2010) are considering energy consumption, CO_2 emissions and economic growth in Greece over the 1960-2005 period confirming an EKC-pattern.

The present study deviates from these studies in the following ways. First, the period under consideration is larger including the recent economic crisis in Greece. This allows testing whether the drop in the growth of CO_2 emissions after 2008 is due to a reduced growth of GDP or to improvements in energy use by testing short and long term causalities among the variables in question. Second, the study adopts an estimation model based on the EKC theory allowing testing whether an EKC pattern is confirmed in the period under consideration. Finally, the study considers the possible effect of urbanization rate on CO_2 emissions, following Kuznets proposal in his initial work considering the income inequality – economic growth nexus that urbanization is an affecting factor (Kuznets, 1955). Also, the effect of urbanization has not been tested in the case of Greece while is of high interest as an exogenous variable in other studies. For example, Shahbaz et al. (2014) include urbanization as an exogenous variable in their test relationship and conclude that urbanization increases CO_2 emissions in United Arab Emirates, while Liobikienė and Butkus (2019) conclude that urbanization has a "positive but not significant effect on GHG emissions" in a panel consisting of 147 countries. However, other studies that include urbanization as an exogenous variable do not support evidence in favor of an EKC-pattern (Dogan and Turkekul, 2016; Farhani and Ozturk, 2015).

3. MATERIALS AND METHODS

3.1. Econometric Methodology

The relationship among per capita CO_2 emissions (ECO2), per capita energy use (CENER) and per capita gross domestic product (CGDP) is represented by the long-term equilibrium relationship:

$$Y_t = a_0 + a_1 X_t + a_2 B_t + a_3 Z_t + urb + dum1974 + e_t \quad (1)$$

Where,
Y= CO_2 emissions per capita (ECO2),
X= GDP per capita income (CGDP),
B= GDP^2 per capita income (CGDP2),
Z= per capita use of energy (CENER),
urb = the percentage of the urban population in year t,
dum1974 = the dummy variable for the extreme value of CGDP in 1974.

In order to investigate how Y, X, B, Z variables are related, as well as to determine the dynamic direction of causality among these variables, we assume that the relationship can be approximated by a vector autoregressive models VAR at levels (Hondroyiannis et al., 2002). The VAR approach allows us to consider all series Y, X, B, Z as endogenous system variables. CGDP2 is inserted as an endogenous variable, following the EKC approach that considers the inclusion of a squared term of GDP in order to test the EKC hypothesis. In particular, the EKC hypothesis is confirmed if a_2 is negative and statistically significant. Moreover, we do not suppose that any of these variables is determined exogenously and unilaterally affect the other variables of the model. The vector auto regression model includes also annual urbanization rate (urb) as well as a dummy variable for the extreme value of per capita GDP (cgdp) in 1974 as exogenous interpretative variables. We choose to include the urbanization rate as an exogenous variable in order to test whether urbanization exerts a significant effect on CO_2 emissions between 1960 and 2014 following the proposal of other studies (Shahbaz et al., 2014; Liobikienė and Butkus, 2019). Additionally, the extreme value of per capita GDP in 1974 is likely to be due to the political change from dictatorship to democracy in Greece this year, or due to the oil crisis in 1973 or a combination of both above factors.

The representation of the relationship through a VAR gives us the advantage to investigate the underlying causality relationships between variables.

Therefore, the vector regression model (VAR) is given by the following relationship:

$$y_t = a_0 + \sum_{j=1}^{p} A_j Y_{t-j} + X_t + \varepsilon_t \quad (2)$$

Where:
Y_t = [$ECO2_t$ $CENER_t$ CGDPt $CGDP2_t$] vector of endogenous variables,
X_t = [urb_t dum1974] vector of exogenous variables,

$a_0 = [a_{ECO2}\ a_{CENER}\ a_{CGDP}\ a_{CGDP2}]$ vector of fixed terms,
A_J the matrix of VAR parameters for the delay j and,
ε_t vector of the error conditions.

The following steps are applied in this work. First, we test whether endogenous series are stationary. All endogenous series are transformed into logarithmic form allowing normalization of the series, that is, series have a linear trend (Asteriou and Hall, 2011). Then, we apply the augmented Dickey-Fuller unit root test (Dickey and Fuller, 1979; Dickey and Fuller, 1981), the Phillips-Perron test (PP statistic) (Phillips and Perron, 1988) and the KPSS test (Kwiatkowski et al., 1992).

The second step is to check for Johansen co-integration for each of the VARs. The Johansen co-integration process tests for long-run equilibrium among the variables (Johansen, 1991; Al-mulali et al., 2012). If the series are co-integrated then the series have a long-run equilibrium, even if there is imbalance in the short-run period. More specifically, the co-integration resolves the problem of non-stationary series. The Johansen co-integration test requires that all endogenous series are stationary or they are integrated at the same order (Asteriou and Hall, 2011) Otherwise, results may be spurious (Asteriou and Hall, 2011).

At this step, it is crucial to specify the optimal lag – length of the VAR that minimises the Schwarz (SC) criterion and satisfies tests for normality, autocorrelation and heteroscedasticity of the residuals (Asteriou and Hall, 2011). Next, in order to achieve the optimal specification, we adopt the Pantula principle. Johansen (1991) suggests that the joint hypothesis of both the rank order and the deterministic components need to be tested, applying the Pantula principle. The Pantula principle involves the estimation of all three plausible models in terms of economic theory and the presentation of the results from the most restrictive hypothesis to the least restrictive hypothesis. The method and the corresponding test statistic for determining the number of cointegrating relations is based on the trace statistic (Asteriou and Hall, 2011).

In case of co-integration, Granger causality analysis is applied among the variables based on the multi-variable Vector Error Correction Model (VECM) in order to check long-term direction of causality. If co-integration is rejected, a simple Granger method is applied, to check for short-term direction of causality.

3.2. Data

Data on CO_2 emissions per capita (named ECO2), real gross domestic product per capita (named CGDP), gross use of energy per capita (named CENER) and annual urbanization rate (named URB) are derived from the World Development Indicators (WDI, 2019). Per capita CO_2 emissions are per capita emissions from fossil fuel combustion and cement production and are expressed in metric tons per capita. Real GDP per capita is expressed in constant 2010 U.S. $. Per capita use of energy includes per capita gross per capita energy (before its transformation into any other form of energy) and is expressed in kg of oil equivalent per capita. The urbanization rate refers to the percentage of total population living in urban areas. All data cover the period from 1960 to 2014.

4. RESULTS

4.1. Unit Root Tests

Table 1 shows the results concerning the stationarity of series. The series contain a unit root at their logarithmic levels, but are stationary in their first logarithmic differences. Therefore, the series are integrated at the same order (I(1)).

4.2. Johansen Co-integration Test

Since series are integrated at the same order (I(1)), we use the vector autoregressive relation (Shafic and Bandyopadhyay, 1992) in order to specify the optimal number of time lags in accordance to Schwarz criterion (SC). The optimum number is set to k=1. The results of Johansen co-integration test are shown in Table 2 according to the Pantula principle, in order to specify the type of co-integration.

Table 1: Unit root tests

Unit root test results								
Panel A: Logarithmic levels								
Levels	**ADF**			**PP**			**KPSS**	
	Intercept	**Trend and intercept**	**None**	**Intercept**	**Trend and intercept**	**None**	**Intercept**	**Trend and intercept**
LCGDP	−2.7721	−1.6089	1.4312	−3.7662*	−1.7370*	1.9770	0.7684*	0.1738*
LECO2	−5.1426*	−0.4840	−0.6383	−5.1694*	−0.3205	0.7548	0.7509*	0.2470*
LCENER	−6.5254*	−1.2609	1.2910	−5.6701*	−1.2604	2.0748	0.7700*	0.2326*
Panel B: First-logarithmic differences								
First differences	**ADF**			**PP**			**KPSS**	
	Intercept	**Trend and intercept**	**None**	**Intercept**	**Trend and intercept**	**None**	**Intercept**	**Trend and intercept**
LCGDP	−3.9813*	−4.6635*	−3.6458*	−3.9960*	−4.7578*	−3.5845*	0.5182*	0.1034
LECO2	−1.1018	−8.4678*	−1.5220*	−5.5024*	−8.6005*	−4.7902*	0.8054*	0.0734*
LCENER	−3.6207*	−5.9784*	−2.0840*	−3.6876*	−6.0596*	−3.6876*	0.7776*	0.1045*

ADF and PP→H_0: Series contains a unit root
KPSS→H_0: Series is stationary
ADF: Lag length based on SIC
PP: Bandwidth using the Newey-West method, Spectral estimation method Barlett Kernel

*rejection of H_0 at 5% significance level

According to the trace statistic criterion, in three forms of specification (Asteriou and Hall, 2011), the null hypothesis for the existence of a co-integration relationship between the variables is accepted. So, the long-term co-integration function is shown in Table 3. According to the obtained results, all coefficients are significant at 5% significance level in the cointegrating equation. Per capita use of energy is positive, indicating that a rise in per capita energy use increases per capita CO_2 emissions. More specifically, a 1% increase in per capita energy use – holding all other variables stable- leads to approximately a 0.74% increase in per capita CO_2 emissions.

However, the EKC – hypothesis between per capita CO_2 emissions and per capita GDP is not confirmed over the 1960-2014 period, since the coefficient of the squared-term of per capita GDP is positive, indicating a U relationship between the variables in question rather than an inverse U pattern (Table 3). Moreover, the variable of urbanization is positive and statistically significant, indicating that a 1% rise in the growth of urbanization increases marginally per capita CO_2 emissions 0.0073% over the 1960-2014 period. Also, the dummy variable for year 1974 is negative and significant.

The error correction term (ECT) a_{ii} is significant and implies that the system needs approximately 5 years and 4 months to return to long-run equilibrium, which is a rather slow rate of convergence.

4.3. Granger's Causality Test

The results of Granger's causality test are shown in Tables 4 and 5. In particular, Table 4 depicts results concerning Granger causality in the short run, while Table 5 summarizes results in the long-run period based on the joint test including the error correction term (ECT).

According to Table 4, there is a bi-directional Granger causality between per capita GDP (LCGDP) and per capita CO_2 emissions (LECO2) in the short run. The same outcome is confirmed in the long-run period according to Table 5.

No Granger causality is confirmed between per capita GDP (LCGDP) and per capita energy use (LCENER) in the short-run (Table 4); however, per capita energy use (LCENER) Granger causes per capita GDP (LCGDP) in the long run (Table 5).

Concerning causality between per capita CO_2 emissions (LECO2) and per capita energy use (LCENER), there is a uni-directional

Table 2: Johansen cointegration test

Johansen cointegration test results							
Exogenous series: urb, dum1974							
Lag intervals (in first differences): 1-1							
		Model 2		Model 3		Model 4	
		No trend in CE, no intercept in VAR		Intercept in VAR and CE, no trend in CE and VAR		Intercept in VAR and CE, linear deterministic trend, no trend in VAR	
Country	r	Trace stat	Prob.[1]	Trace stat	Prob.[1]	Trace stat	Prob.[1]
Greece	0	84.87720	54.07904	55.59889	47.85613	74.57510	63.87610
	1	33.96274*	35.19275	19.34170	29.79707	35.47923	42.91525
	2	14.85606	20.26184	5.709113	15.49471	15.93614	25.87211

H_0: There are r numbers of cointegrating vectors, *: 1st time H_0 is not rejected, R: Number of cointegrating vectors, [1]: Critical values at 5% significance level

Table 3: Long-run co-integration function

Cointegrating equation (CE)					
LECO2	LCENER	LCGDP	LCGDP^2	c	aii
βi	0.7387	−10.8117	0.5139	50.1620	−0.187511
[t statistic]	[−3.22678]*	[3.43752]*	[−3.33020]*	[−3.28220]*	[−3.88673]*
LECO2(−1)+10.8117*LCGDP(−1)−0.5139*LCGDP(−1)^2−0.7387*LCENER(−1) −50.1620=0					
	Bi	[t statistic]			
urb	0.007331	[3.905584]*			
dum1974	−0.131058	[−2.375024]*			

*significant at 5% significance level

Table 4: Granger causality test analysis – short run

Null hypothesis	Short-run χ^2		
	χ^2	Prob. (χ^2)	Result
LCGDP, LCGDP2 do not Granger cause LECO2	9.49976	0.0087	LCGDP, LCGDP2-->LECO2
LECO2 does not Granger cause LCGDP	8.14602	0.0043	LECO2-->LCGDP
LCGDP, LCGDP2 do not Granger cause LCENER	4.86318	0.0879	LCGDP, LCGDP2--> LCENER
LCENER does not Granger cause LCGDP	1.27733	0.2584	LCENER--> LCGDP
LCENER does not Granger cause LECO2	2.95699	0.0855	LCENER-->LECO2
LECO2 does not Granger cause LCENER	11.38073	0.0007	LECO2-->LCENER
-/→no Granger cause			
→ Granger cause			

Table 5: Granger causality test analysis – long run

Null hypothesis	Joint χ^2		
	χ^2	Prob. (χ^2)	Result
LCGDP, LCGDP2 do not Granger cause LECO2	15.27221	0.0016	LCGDP, LCGDP2 --> LECO2
LECO2 does not Granger cause LCGDP	21.25712	0.0001	LECO2 --> LCGDP
LCGDP, LCGDP2 do not Granger cause LCENER	7.40460	0.0601	LCGDP, LCGDP2 -/-> LCENER
LCENER does not Granger cause LCGDP	24.20424	0.0001	LCENER--> LCGDP
LCENER does not Granger cause LECO2	26.10867	0.0001	LCENER --> LECO2
LECO2 does not Granger cause LCENER	11.39190	0.0034	LECO2 --> LCENER

-/→no Granger cause
→ Granger cause

causality running from per capita CO_2 emissions (LECO2) to per capita energy use (LCENER) in the short-run (Table 4), while there is a bi-directional causality between the variables in question in the long run (Table 5).

5. DISCUSSION AND CONCLUSION

The long-run relationship between real GDP and CO_2 emissions in Greece under the EKC-hypothesis has not been studied adequately using econometric applications under the EKC perspective. This paper investigates the short-term and long-term relationship between per capita income, per capita use of energy and per capita CO_2 emissions under the Environmental Kuznets Curve (EKC) concept in Greece over the period 1960-2014 by using appropriate econometric methods. Furthermore, the impact of the urbanization rate on CO_2 emissions per head is considered.

Econometric analysis suggests that time series of per capita CO_2 emissions, per capita GDP and per capita use of energy are stationary in their first differences and there is a co-integrated relationship. According to the results, CO_2 emissions are not declining in Greece following an EKC-pattern in the period under consideration. Rather, the relationship between per capita GDP and CO_2 emissions follow a U pattern contrary to findings of Acaravci and Ozturk (2010), who confirm an EKC- pattern in Greece in the 1960-2005 period. In addition, according to our results, urbanization rate has a significant but minor impact on per capita CO_2 emissions. Possibly, urbanization in Greece leads to increased energy use and increased energy consumption of transport, as seen in many high and middle income countries (Al-mulali et al., 2012).

Based on the results concerning Granger causality, per capita CO_2 emissions and per capita GDP are coupled over time since there is a bi-directional causality between the variables in the short and long term. This indicates that policies to reduce CO_2 emissions have cost in economic growth terms or, put differently, the growth of the Greek economy is of high carbon intensity. However, per capita energy use Granger causes per capita GDP in the long run while there is a bi-directional causality between per capita energy use and per capita CO_2 emissions in the long run. This implies that policies to reduce the carbon intensity of energy use in Greece could delink the long-run relationship between GDP growth and CO_2 emissions in Greece. In any case, there is no confirmation of an Environmental Kuznets Curve (EKC)-pattern in Greece during 1960-2014.

From these results it can be said that the adoption of policies targeting at the optimal energy use in Greece could lead to economic growth with lower CO_2 emissions. For example, a shift to the use of renewable energy sources to complement energy needs in Greece would lower carbon intensity of energy use in Greece contributing to the de-escalation of CO_2 emissions without inhibiting the economic growth process.

Furthermore, improving transport infrastructure in large urban centers, where the majority of the population is concentrated, could help rationalize the energy use and de-escalate CO_2 emissions. In addition, policies able to enhance energy efficiency may be useful, for example by increasing competition, security of supply, sustainability and transition to a low-carbon economy. All these policies have to be measured for industrial appliances, vehicles, households and the building stock.

Finally, policymakers in Greece could adopt strategies proposed in Paris Treaty for climate change for the reduction of CO_2 emissions such as funding measures for mitigating climate change.

REFERENCES

Acaravci, A., Ozturk, I. (2010), On the relationship between energy consumption, CO_2 emissions and economic growth in Europe. Energy, 35, 5412-5420.

Al-mulali, U., Che Sab, C.N.B., Fereidouni, H.G. (2012), Exploring the bi-directional long run relationship between urbanization, energy consumption and carbon dioxide emission. Energy, 46, 156-167.

Ang, J.B. (2007), CO_2 emissions, energy consumption, and output in France. Energy Policy, 35, 4772-4778.

Apergis, N., Payne, J.E. (2009), CO_2 emissions, energy usage, and output in central America. Energy Policy, 37, 3282-3286.

Asteriou, D., Hall, S.G. (2011), Applied Econometrics. 2nd ed. London, United Kingdom: Palgrave Macmillan. p512.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74, 427-431.

Dickey, D.A., Fuller, W.A. (1981), Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49, 1057-1072.

Dinda, S. (2004), Environmental Kuznets curve hypothesis: A survey. Ecological Economics, 49, 431-55.

Dogan, E., Turkekul, B. (2016), CO_2 emissions, real output, energy consumption, trade, urbanization and financial development: Testing the EKC hypothesis for the USA. Environmental Science and Pollution Research, 23, 1203-1213.

Farhani, S., Ozturk, I. (2015), Causal relationship between CO_2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia. Environmental Science and Pollution Research, 22, 15663-15676.

Grossman, G.M., Krueger, A.B. (1995), Economic-growth and the environment. Quarterly Journal of Economics, 110, 353-377.

Halicioglu, F. (2009), An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37, 1156-1164.

Hatzigeorgiou, E., Polatidis, H., Haralambopoulos, D. (2011), CO_2 emissions, GDP and energy intensity: A multivariate cointegration and causality analysis for Greece, 1977-2007. Applied Energy, 88, 1377-1385.

Hondroyiannis, G., Lolos G.S., Papapetrou E. (2002), Energy consumption and economic growth: Assessing the evidence from Greece. Energy Economics, 24, 319-336.

IEA, (2016), CO_2 Emissions from Fuel Combustion for OECD Countries Database. Available from: http://www.iea.org/statistics/topics/CO2emissions.

Jalil, A., Mahmud, S.F. (2009), Environment Kuznets curve for CO_2 emissions: A cointegration analysis for China. Energy Policy, 37, 5167-5172.

Jaunky, V.C. (2011), The CO_2 emissions-income nexus: Evidence from rich countries. Energy Policy, 39, 1228-1240.

Johansen, S. (1991), Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. Econometrica, 59, 1551-1580.

Kaika, D., Zervas, E. (2013a), The environmental Kuznets curve (EKC) theory. Part A: Concept, causes and the CO_2 emissions case. Energy Policy, 62, 1392-1402.

Kaika, D., Zervas, E. (2013b), The environmental Kuznets curve (EKC) theory. Part B: Critical issues. Energy Policy, 62, 1403-1411.

Kuznets, S. (1955), Economic growth and income inequality. The American Economic Review, 45, 1-28.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. (1992), Testing for stationarity in the components representation of a time-series. Econometric Theory, 8, 586-591.

Liobikienė, G., Butkus, M. (2019), Scale, composition, and technique effects through which the economic growth, foreign direct investment, urbanization, and trade affect greenhouse gas emissions. Renewable Energy, 132, 1310-1322.

Marrero, G.A. (2010), Greenhouse gases emissions, growth and the energy mix in Europe. Energy Economics, 32, 1356-1363.

Pao, H.T., Tsai, C.M. (2011), Multivariate granger causality between CO_2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian federation, India, and China) countries. Energy, 36, 685-693.

Pao, H.T., Yu, H.C., Yang, Y.H. (2011), Modeling the CO_2 emissions, energy use, and economic growth in Russia. Energy, 36, 5094-5100.

Phillips, P.C.B., Perron, P. (1988), Testing for a unit root in time series regression. Biometrika, 75, 335-346.

Polemis, M.L. (2007), Modeling industrial energy demand in Greece using cointegration techniques. Energy Policy, 35, 4039-4050.

Rapanos, V.T., Polemis, M.L. (2006), The structure of residential energy demand in Greece. Energy Policy, 34, 3137-3143.

Saboori, B., Sulaiman, J. (2013), CO_2 emissions, energy consumption and economic growth in association of Southeast Asian nations (ASEAN) countries: A cointegration approach. Energy, 55, 813-822.

Shafic, N., Bandyopadhyay, S. (1992), Growth and Environmental Quality. Time-series and Cross Country Evidence. Washington, DC: World Development Report 1992, The World Bank Policy Research Working Paper no 904.

Shahbaz, M., Mutascu, M., Azim, P. (2013), Environmental Kuznets curve in Romania and the role of energy consumption. Renewable and Sustainable Energy Reviews, 18, 165-173.

Shahbaz, M., Sbia, R., Hamdi, H., Ozturk, I. (2014), Economic growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emirates. Ecological Indicators, 45, 622-631.

Stern, D.I., Common, S.M., Barbier, E. (1996), Economic growth and environmental degradation: The environmental Kuznets curve and sustainable development. World Development, 24, 1151-1160.

WDI, (2019), World Bank. Available from: http://www.data.worldbank.org/data-catalog/world-development-indicators. [Last accessed on 2019 Jan 15].

Zervas, E., Poulopoulos, S., Philippopoulos, C. (2006), CO_2 emissions change from the introduction of diesel passenger cars: Case of Greece. Energy, 31, 2915-2925.