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Testing the Environmental Kuznets Curve Hypothesis in Portugal

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ABSTRACT

This paper provides empirical evidence of an environmental Kuznets curve (EKC) hypothesis for Portugal by applying autoregressive distributed lag bounds testing approach from 1971 to 2008. In order to capture Portugal's historical experience, demographic changes and international trade on carbon emissions, we augment the traditional income-emissions model with variables such as energy consumption, urbanization, and trade openness in time series framework. Empirical results confirm the evidence of EKC hypothesis in both the short-run and long-run. All variables carry the expected signs except trade openness. Despite the success of Portugal in containing CO_2 emissions so far, it is important to note that in recent years, carbon emissions have risen. In order to comply with the 1992 Kyoto Protocol on CO_2 emissions, there is need for policies that focus on the sectors responsible for CO_2 emissions.

Keywords: Carbon Dioxide Emissions, Energy Consumption, Environmental Kuznets Curve
JEL Classifications: C32, O52, Q43, Q5

1. INTRODUCTION

The existing empirical literature on the relationship between energy consumption and economic growth, as well as economic growth and environmental pollution are not conclusive to suggest policy recommendation that can be applied across countries. Because the existing literature suggests that most studies focus either on the nexus of growth-energy or growth-environmental pollutants where little effort has been made to test these two links under the same framework (Acaravci and Ozturk, 2010). Thus, the aim of this paper is to use these linkages by testing environmental Kuznets curve (EKC) hypothesis. Empirical evidence on the EKC hypothesis varies from country to country. Economists model the relationship between environmental quality and economic growth in a variety of emissions-income equations. The EKC hypothesis suggests that - environmental degradation increases at initial level of economic growth and then starts to decrease at a higher level of economic growth. This relationship between measure of environmental degradation, for example CO_2 emissions, and measures of economic growth, for example per capita gross domestic product (GDP), is the inverted U-shaped curve.

This paper contributes to the debate on environmental degradation by estimating an EKC for CO_2 emissions for Portugal. The rational for selecting Portugal for our analysis is that it has implemented a variety of programs and policy initiatives that encompass all of the augmented variables stated above, given that it faces challenges on the environmental front. Portugal has made great strides in terms of economic growth since its accession to the EU in 1986. The linkages of energy consumption, trade, urbanization, and economic growth to CO_2 emissions has been aided to a greater extent by desire the 2012 CO_2 emissions targets specified under the Kyoto Protocol. As a result, Portuguese policy makers have focused on reducing greenhouse gas emissions, especially CO_2 emissions in the following five sectors: extraction of crude petroleum, manufacture of refined products, electricity distribution, construction, land transport and transport via pipeline services and whole and retail trade. Portugal's EKC appears to be a result of this focus on CO_2 emissions.

Portuguese economy experienced with 0.90% economic growth rate in 2008. However, growth has been associated with structural changes such as the decline in agriculture, rapid urbanization of coastal areas, and environmental degradation. Despite this impressive growth, the Portuguese economy faces the challenges in achieving balanced environmental development. Therefore, the appropriate utilization of resources is important for the environmental protection. Given this background, Portuguese policymakers have made significant investments and achieved positive results regarding environmental quality along with the economic growth. These developments motivate the researchers to investigate the relationship between economic growth and environmental quality as environmental concerns are making their way into main public policy agenda.

Major contributions of this paper in testing the EKC hypothesis are three-fold. First, we investigate the issue based on time series data for Portugal. Second, the paper employs the autoregressive distributed lag (ARDL) method which is amenable for short time series data as in this paper. Third, we provide empirical evidence of the EKC by augmenting the standard GDP variable by trade relationship, demographic factors, and energy consumption (Stern et al., 1996). Most of the existing literature has employed pooled panel data of a group of countries on the emissions-growth nexus, energy-growth nexus, and emissions-urbanization nexus. However, these studies still provide mixed results which have contributed in keeping the problem unresolved.

The objective of present article is to investigate the EKC for the Portuguese economy over the period of 1971-2008. In addition to GDP variable, we also include energy consumption, trade and the urbanization. The rest of paper is organized as follows. Section 2 reviews a selected literature encompassing the EKC and the variables listed above. Section 3 has the theoretical and the econometric model including the ARDL estimation strategy. The empirical results are reported in Section 4 followed by the conclusion and policy implications.

2. LITERATURE REVIEW

An interesting debate prevails over the relationship between environmental degradation and economic growth in the relevant literature. Most of studies document the existence of an inverted-U shaped relationship between economic growth and environmental degradation. This is especially so when other measures of environmental degradation is used. However, when CO_2 emissions are the dependent variable, various tests of the hypothesis have produced mixed results. The growth-environmental performance nexus has been tested by various researchers after following work by Grossman and Krueger (1991, 1993) and Douglas and Selden (1995). Their work offers empirical evidence that environmental degradation increases at initial level of economic growth and then starts to decline at a higher level of economic growth (Suri and Chapman, 1998; Friedl and Getzner, 2003; Stern, 2004; Dinda and Coondoo, 2006; and Coondoo and Dinda, 2008).

It is worth mentioning here the different studies tested the EKC hypothesis for different indicators of environmental degradation, such as deforestation, carbon emissions and municipal waste. However, sulfur dioxide has been among the most commonly used environmental degradation indicators and EKC hypothesis has been shown to hold mostly for sulfur dioxide emissions in the literature (Jalil and Mahmud, 2009). Generally, it is difficult to find an inverted-U form relation for the CO_2 emission. A number of studies working on CO_2 emissions find an ever-increasing positive correlation between CO_2 and economic growth for example Chang (2010) for China, Ozturk and Acaravci (2010) for Turkey and Pao and Tsai (2010) for Russia. However, Martínez-Zarzoso and Morancho (2004), Cole (2003), Vollebergh et al. (2005), Galeotti et al. (2006) and Apergis and Payne (2010), who employ panel data methods, report an inverted U-shaped function for CO_2 emissions.

Furthermore, the role of energy consumption in CO_2 emissions should not be neglected while discussing the environmental performance and economic growth nexus. A substantial volume of research has been devoted towards analyzing the energy consumption and economic growth nexus (See a detailed literature survey on the energy-growth nexus in the study of Ozturk [2010]). Therefore, researchers think that it will be more fitting if economic growth and energy consumption is analyzed simultaneously in a single multivariate model. This approach is utilized by Ang (2007), Soytas et al. (2007), Halicioglu (2009), and Jalil and Mahmud (2009), Narayan and Narayan (2010), Apergis and Payne (2010) and Shahbaz et al. (2010) to test the both nexus in a single framework.

The next strand in investigating the emission dynamics is to test the relationship between the dynamics of demographic factors and environmental performance. Shi (2003) and Cole and Neumayer (2004) found a positive link between CO_2 emissions and a set of other explanatory variables including population, urbanization and energy intensity. In addition, few studies have discussed population density as an additional explanatory variable in the EKC framework (Cole et al. 1997; Panayotou 1993, 1995). More recently, Dhakal (2009) examines the relationship between urbanization and CO_2 emissions in China. Dhakal (2009) indicates that around 40% contribution in CO_2 emissions is due to an 18% increase in population. Shahbaz et al. (2010) investigate the relationship between CO_2 emissions, energy consumption, economic growth and trade openness for Pakistan. Their results support the EKC hypothesis when energy consumption and trade openness variables are added to the standard GDP variable. Leitao (2015) examined the relationship between energy consumption and foreign direct investment (FDI) in Portugal for the period 1990-2011. The empirical results illustrate that the income per capita and political globalization present a positive impact on energy consumption. The selected components of globalization (cultural, social and political) show that these variables promote Portuguese FDI. The variables of income per capita and the squared income per capita validate the EKC assumptions.

3. THEORETICAL AND MODELING FRAMEWORK

The paper follows the framework in Ang (2007, 2008), Soytas et al. (2007), Halicioglu (2009), Jalil and Mehmud (2009) and Shahbaz et al. (2010) in estimating an environmental degradation equation. These studies estimated the emissions-growth nexus and energy-growth nexus in a single equation model. In addition, we include urbanization as variable to proxy for demographic changes reflecting the rapid movements of young people from rural and small farms into large cities and coastal areas in search of jobs. We also include trade openness as a controlling variable. In Equation 1, we suggest that CO_2 emission (CO_2) in Portugal depend on energy consumption (ENC), GDP, square of GDP (GDP^2), trade openness (TR), and urbanization (URB).

$$CO_2 = f(ENC, GDP, GDP^2, TR, URB) \quad (1)$$

We convert linear specification of model into log-linear specification. It is noted that log-linear specification provides more appropriate and efficient results as compared to simple linear functional form of model (Cameron, 1994; Ehrlich 1975, 1996). Furthermore, logarithmic form of variables gives direct elasticities for interpretations. Therefore, we specify estimable equation in log linear form:

$$LCO_2 = \beta_1 + \beta_{ENC} LENC + \beta_{GDP} LGDP + \beta_{GDP^2} LGDP^2 + \beta_{TR} LTR + \beta_{URB} LURB + \mu_t \quad (2)$$

Where μ is stand for residual or error term. We hypothesize that economic activity is positively stimulated by an increase in energy use resulting in an increase in environmental pollutants or carbon emissions. This leads us to expect $\beta_{ENC}>0$. The EKC hypothesis suggest that $\beta_{GDP}>0$ and $\beta_{GDP^2}<0$. The sign of $\beta_{TR}<0$ if production of pollutant intensive items is reduced due to environment protection laws and imports such items from the other countries where environmental laws are flexible. The expected sign of trade openness is negative, $\beta_{TR}<0$. Frankel and Rose (2005) posit that foreign investors come with advanced technology and innovative managerial skills from their parent country for the advantage of host countries. This tends to lead the use energy efficient approaches which increase welfare. Moreover, trade openness increases in the demand of environmental quality and cleaner product as trade openness offers a set of available varieties to consumers (Eskeland and Harrison, 2002). In contrary, Grossman and Krueger (1995) and Halicioglu (2009) argued that sign of β_{TR} is positive if dirty industries of developing economies are busy to produce heavy share of CO_2 emissions with production. Finally, URB indicates urbanization proxies by urban population as share of total population. Urbanisation is a variable indicates demographic growth on environment. A rise in population tends people to urban areas for better education and job opportunities. This rise in urban population leads to enhance energy demand which creates more atmospheric pollution. Therefore, we expect $\beta_{URB}>0$.

The data on all variables comes from World Development Indicators (WDI CD-ROM, 2009). CO_2 emissions is proxied by CO_2 emissions (carbon dioxide metric tons per capita), and ENC is for energy use (kg of oil equivalent per capita). Real GDP per capita (GDP) is used to capture the impact of economic growth on CO_2 emissions. TR is for trade openness is proxied by the ratio of exports plus imports to GDP while URB is the urbanisation population as share of total population.

4. ESTIMATION STRATEGY

This paper applies the ARDL bounds testing approach to cointegration developed by Pesaran and Pesaran (1997), Pesaran et al. (2000, 2001) to examine long run relationship between CO_2 emissions, energy consumption, economic growth, international trade and urbanisation. The ARDL model can be applied without investigating the order of integration. Haug (2002) has argued that an ARDL approach to cointegration provides better results for small sample data set such as in our case, compared to traditional approaches to cointegration, that is, Engle and Granger (1987), Johansen and Juselius (1990) and Phillips and Hansen (1990). Laurenceson and Chai (2003) state that another advantage of ARDL bounds testing is that the unrestricted model of error correction model (ECM) has sufficient flexibility to accommodate lags that captures the data generating process in a general-to-specific framework of specification. In addition, Pesaran and Shin (1999) state that, "appropriate modification of the orders of ARDL model is sufficient to simultaneously correct for residual serial correlation and problem of endogenous variables." The unrestricted model is stated as follows:

$$\begin{aligned}\Delta \ln CO_2 = {} & \alpha_1 + \alpha_{ENC} \ln ENC_{t-1} + \alpha_{GDP} \ln GDP_{t-1} + \alpha_{GDP^2} \ln GDP^2_{t-1} \\ & + \alpha_{TR} \ln TR_{t-1} + \alpha_{URB} \ln URB_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta \ln CO_{2t-i} \\ & + \sum_{j=0}^{q} \alpha_j \Delta \ln ENC_{t-j} + \sum_{k=0}^{m} \alpha_k \Delta \ln GDP_{t-k} + \sum_{l=0}^{n} \alpha_l \Delta \ln GDP^2_{t-l} \\ & + \sum_{l=0}^{o} \alpha_m \Delta \ln TR_{t-m} + \sum_{l=0}^{r} \alpha_n \Delta \ln URB_{t-n} + \mu_t \end{aligned} \quad (3)$$

The ARDL bounds testing approach to cointegration depends upon the tabulated critical values by Pesaran et al. (2001) to make a decision about cointegration among the variables. The null hypothesis of no cointegration in the model is $\alpha_{ENC} = \alpha_{GDP} = \alpha_{GDP^2} = \alpha_{TR} = \alpha_{URB} = 0$. The alternative hypothesis of cointegration among variables is $\alpha_{ENC} \neq \alpha_{GDP} \neq \alpha_{GDP^2} \neq \alpha_{TR} \neq \alpha_{URB} \neq 0$. Next step is to compare the calculated F-statistics with lower critical bound and upper critical bound values from Pesaran and Pesaran (1997) or Pesaran et al. (2001). For small samples, Turner (2006) has assembled critical values for F-statistics that are suitable for the short data series employed in this paper. There is cointegration among variables if calculated value of F-statistics is more than upper critical bound. If the lower critical bound is more than computed F-statistics then there is no cointegration. Finally, if the calculated F-statistics is between lower and upper critical bounds then decision about cointegration is inconclusive. In such situation, we rely on the significance of the lagged error correction term (ECT) for cointegration to investigate the long run relationship. If there exists a long run relationship among variables, the short run behavior of variables is investigated by the following vector ECM model:

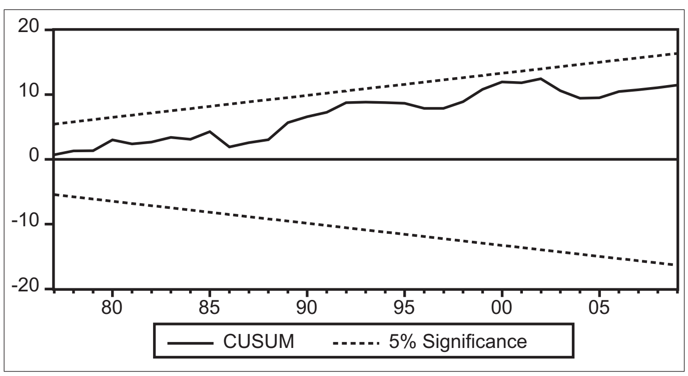
$$\begin{aligned}\Delta \ln CO_2 = {} & \delta_1 + \sum_{j=0}^{p} \delta_2 \Delta \ln ENC + \sum_{k=0}^{q} \delta_3 \Delta \ln GDP_{t-k} + \sum_{l=0}^{o} \delta_4 \Delta \ln GDP^2_{t-l} \\ & + \sum_{r=0}^{m} \delta_5 \Delta \ln TR_{t-r} + \sum_{s=0}^{n} \delta_6 \Delta \ln URB_{t-s} + \eta ECM_{t-1} + \varepsilon_t \end{aligned} \quad (4)$$

The existence of an ECT implies the changes in dependant variable. These changes are a function of both the levels of disequilibrium in the cointegration relationship and the changes in the other explanatory variables. This indicates the deviation in dependant variable from short span of time to long-run equilibrium path (Masih and Masih, 1997). The goodness of fit for ARDL model is checked through stability tests such as cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ).

The stability tests were used to investigate the stability of long run and short run parameters. In doing so, cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests have been employed (Figures 1 and 2). Pesaran et al. (2000, 2001) suggest that CUSUM and CUSUMSQ tests are adequate in testing for stability of coefficients in such models. The graph of CUSUM is significant at 5% significance levels indicating the stability of parameters.

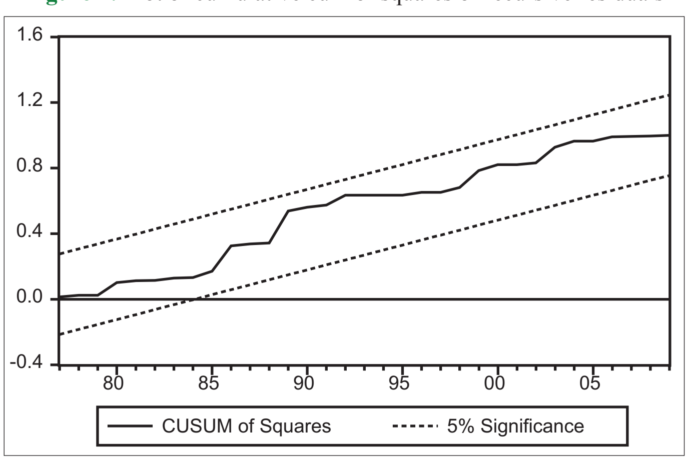
The diagnostic tests such as the LM test for serial correlation, normality of the residual term and White heteroscedisticity test in the short-run model have also been conducted. The relevant statistics show that the short-run model passes all diagnostic tests. The evidence indicates no serial correlation and the residual term are normally distributed. There is no evidence of autoregressive conditional heteroscedisticity and same holds is for White heteroscedisticity. Model specification is well constructed.

Figure 1: Plot of cumulative sum of recursive residuals



Note: The straight lines represent critical bounds at 5% significance level

Figure 2: Plot of cumulative cum of squares of recursive residuals



Note: The straight lines represent critical bounds at 5% significance level

5. EMPIRICAL RESULTS

Ouattara (2004) states that if any variable is integrated at I(2) then the computation of F-statistics for cointegration becomes inconclusive as Pesaran et al. (2001) critical bounds are based on the assumption that such variables should be stationary at I(0) or I(1). Thus, we apply unit root tests to ensure that no variable is integrated at I(2) or beyond. We use the ADF unit root test to check for stationarity. The results in Table 1 indicate that all variables are non-stationary at their level form and stationary at their first differences.

The two step procedure in ARDL bound testing by Pesaran et al (2001) requires adequate lag length in variables to remove any serial correlation. The order of lag length has been selected by estimating first difference of the conditional error correction version of ARDL. The selection of lag order is based on minimum value of Akaike information criteria. There is evidence that the calculation of ARDL F-statistic is sensitive to the selection of lag order in the model. Table 2 shows a maximal of lag 2 in the data. The appropriate selection of lag order is necessary for unbiased and reliable results.

The next step is to calculate F-statistic by ARDL bound test using unrestricted OLS following Equation 3. The results presented in Table 3 indicate a high calculated value of an F-statistic which is greater than the upper critical bound of 6.198 from Turner (2006)

Table 1: Unit root test

Variable	T-Statistics	*P* value*
ADF test at level with intercept and trend		
In CO_{2t}	−0.2961	0.9871
In ENC_t	−2.3993	0.3741
In GDP_t	0.4353	0.9987
In GDP_t^2	−0.1559	0.8918
In TR_t	−0.9626	0.9365
In URB_t	−2.2018	0.4715
ADF test at first difference with intercept and trend		
Δ In CO_{2t}	−6.8985	0.0000
Δ In ENC_t	−6.7119	0.0000
Δ In GDP_t	−6.8691	0.0009
Δ In GDP_t^2	−6.7551	0.0000
Δ In TR_t	−5.7913	0.0002
Δ In URB_t	−3.3051	0.0825

*MacKinnon (1996) one-sided *P* values

Table 2: Lag length selection criteria

VAR lag order selection criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	140.581	NA	7.31e-09	−7.382	−7.209	−7.321
1	339.1163	343.4125	3.82e-13	−17.25	−16.379	−16.943
2	375.646	55.290*	1.30e-13*	−18.359*	−16.791*	−17.807*

*Lag order selected by the criterion. LR: Sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion at 5% significance. We have used Turner (2006) critical values instead of Pesaran et al., (2001) and Narayan (2005). We conclude that CO_2 is cointegrated with ENC, GDP, GDP^2, TR and URB when CO_2 emissions are dependent variable.

The long run estimates are reported in Table 4. The results reveal that an increase in energy consumption increases in CO_2 emissions. For example, a 1% increase in energy consumption raises CO_2 emissions by 0.87%. Both linear and non-linear terms of GDP per capita show the existence of inverted-U relationship between economic growth and CO_2 emissions. The coefficients of linear and non-linear terms are 10.25 and −0.57 respectively and are highly significant.

The results indicate that a 1% rise in per capita income will increase carbon emissions by 10.25% while the negative sign of squared term corroborates the delinking of carbon emissions and real GDP per capita at high level of income per capita in the country. The evidence confirms that CO_2 emissions increase in the initial stage of economic growth, and eventually decline after a threshold of GDP. These findings are consistent with various studies that examine the relationship between GDP growth and CO_2 emissions, such as He (2008), Song et al. (2008), Halicioglu (2009), Jalil and Mehmud (2009), and Fodha and Zaghdoud, (2010).

The coefficient on trade openness (TR) shows a positive impact on CO_2 emissions. The coefficient of TR on CO_2 is positive, very small and statistically insignificant. It indicates that a 1% increase in international trade results in a 0.002% increase in emissions. Fossil energy resources are not much available in Portugal and Portugal imports most of the energy consumed such as oil products due its consumption structure. Furthermore, considering domestic demand, both exports and imports are imputed with CO_2 emissions (Cruz, 2004). Finally, the impact of urbanization on CO_2 emissions is positive and significant. Urbanization increases energy consumption and hence high carbon emissions, resulting in high CO_2. On the basis of empirical evidence, a 1% increase in urban population results in a 0.60% increase in CO_2 emissions.

All variables are I(1), therefore Granger-Causality test can be used to examine the direction of causality between GDP and carbon emissions. The results indicate that GDP leads to cause CO_2 emissions in the long run (Table 5). The results also confirm the existence of EKC. The evidence is in line with the findings of Zhang and Cheng (2009) and Jalil and Mahmud (2009) for China, Ghosh (2010) for India, and Shahbaz et al. (2010) for Pakistan.

The short run dynamics results are reported in Table 6. Evidence indicates that an increase in energy consumption in the short run

Table 3: Cointegration tests results

Bounds testing to cointegration	
Estimated equation	$CO_2=f(ENC, GDP, GDP^2, TR, URB)$
Optimal lag structure	2
F-statistics	7.3827**
Diagnostic check	
R^2	0.9436
Adjusted-R^2	0.8085
F-statistics (*P*)	6.9817
J-B Normality test	0.5802
Breusch-Godfrey LM test [2]	0.2588
ARCH LM test [2]	1.3766
Ramsey RESET	1.1583
CUSUM	Stable
CUSUMSQ	Stable

**The significant at 1% level. The optimal lag structure is determined by AIC.
AIC: Akaike information criterion

Table 4: Long run estimates

Dependent variable=In CO_{2t}			
Variable	**Coefficient**	**Standard error**	**T-statistic**
Constant	−50.9189	9.6869	−5.2564*
In GDP_t	10.2513	2.1511	4.7655*
In GDP_t^2	−0.5736	0.1169	−4.9059*
In ENC_t	0.8754	0.1379	6.3438*
In URB_t	0.6020	0.1380	4.3615*
In TR_t	0.0024	0.0642	0.0380
Diagnostic checks			
R-squared	0.9948		
Akaike info criterion	−3.7678		
Schwarz criterion	−3.5030		
F-statistic	1154.062		
Durbin–Watson	1.8136		
Serial correlation LM	0.3202		
ARCH test	0.3661		
Normality test	1.0471		
Heteroscedisticity test	1.0063		
Ramsey RESET test	2.6249		

*1% level of significance

Table 5: Granger causality test results

Null hypothesis	F-statistic	*P* value
In GDP_t does not Granger Cause In CO_{2t}	5.06828	0.03075
In CO_{2t} does not Granger Cause In GDP_t	0.19584	0.66082
In GDP_t^2 does not Granger Cause In CO_{2t}	4.48858	0.04129
In CO_{2t} does not Granger Cause In GDP_t^2	0.18862	0.66673

Table 6: Short run estimates

Dependent variable=Δ In CO_{2t}			
Variable	**Coefficient**	**Standard error**	**T-statistic**
Constant	−0.007970	0.017272	−0.461450
Δ In GDP_t	11.32968	5.986932	1.892402***
Δ In GDP_t^2	−0.636843	0.344594	−1.848099***
Δ In ENC_t	0.859039	0.134972	6.364573*
Δ In URB_t	0.120681	0.055179	2.187077**
Δ In TR_t	0.070053	0.060762	1.152896
ECM_{t-1}	−0.108312	0.023200	−4.668681*
Diagnostic checks			
R^2	0.8123		
Akaike info criterion	−4.0230		
Schwarz criterion	−3.7183		
F-statistic	21.6410		
Durbin–Watson	1.9832		
Serial correlation LM	0.2401		
ARCH test	0.3234		
Normality test	2.2756		
Heteroscedisticity test	0.5759		
Ramsey RESET test	0.2774		

*, **, *** 1%, 5%, 10% level of significance

leads to increases in CO_2 emissions. For example, a 1% rise in energy consumption increases CO_2 emissions by 0.85%. The signs of coefficients of GDP and GDP^2 support the EKC hypothesis and are significant at 10% level of significance respectively. The impact of a rise in urban population is positive and statistically significant at 5% level of significance. It implies that a 1% increase in urban population will raise CO_2 emissions by 0.12%. The short run effect of international trade on CO_2 emissions is positive but statistically insignificant.

The sign of coefficient of lagged ECM term is negative and significant at 1% level of significance. This corroborates the established long run relationship among the variables. Furthermore, the value of lagged ECM term is significant and shows that deviations in CO_2 emissions away from equilibrium are corrected by 10.83% within a year.

6. CONCLUSION AND POLICY IMPLICATIONS

In this paper, we investigated the relationship among energy consumption, economic growth, trade, urbanization and carbon emissions for Portugal over the period of 1971-2008. The EKC hypothesis has been tested by applying ARDL model. The results suggest that there exists a long run relation among energy consumption, economic growth, international trade, urbanization and carbon emissions. The existence of an EKC in Portugal included additional variables that capture demographics (URB), international trade (TR), and energy consumption (ENC). We found a positive and significant impact of energy consumption and urbanization on CO_2 emissions. Trade openness has positive and significant impact on CO_2 emissions in the long run.

Since the EKC hypothesis holds in Portugal, we heed Stern et al. (1996) warning not to conclude that economic growth is the means to environmental improvement. Instead, one looks at the trade-offs among three objectives that have been central in Portugal's energy policy since its accession to the EU in 1986; economic growth, environmental protection and energy security. Portugal has made great strides in terms of economic growth since its accession to the EU. There is a need for further policies that address CO_2 emissions from the top five sectors responsible for about 55% of CO_2 emissions.

However, the 2010 forest fires might have undermined Portugal's ability to meet 2012 goals. De Queiroz (2010), reports that The Quercus National Association for Nature Conservation (ANCN) says that the fires released 1.1 million tones of CO_2 this year which they argue reduces "the capacity of forested areas to absorb carbon, and is a stain on Portugal's performance under the Kyoto Protocol." Similar concerns have been raised about 2010 forest fires by Off7 (a private firm that certifies emissions). They suggest that a "3% loss of absorptive capacity by forests is equivalent to 100,000 tonnes of CO_2 emissions that the forests were unable to prevent." If one considers the fact that in 2008, Portugal's forest areas absorbed 4.42 million tones of CO_2; the concerns of ANCN and Off7 are significant.

Portuguese policy makers need a forestry policy that has as its major components zoning, maintenance, management, and regulation of pulp-making companies. Overall, Portugal's EKC reflects structural changes of an economy that increasingly will have information-based industries and services and with adequate technologies should experience a decline in CO_2 emissions. However, Portugal must have clear policies on clean technologies, forestry management and increasing rates of urbanization.

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