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Climate Change and Kuznets Curve: Portuguese Experience

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Climate Change and Kuznets Curve: Portuguese Experience

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Summary

Climate change has inspired the interest of the academic community in the most diverse areas of knowledge. This study tests and revisits the environmental Kuznets curve assumptions for Portugal. The econometric strategy used in this research is time series (ARIMA model, OLS estimator, ARCH regression, VAR model, and Granger causality) for the time period 1980-2013.The econometric results show that the income per capita and squared income per capita are according to the expected signs, i.e. a positive impact of income per capita on carbon dioxide emissions, and a negative effect of squared income per capita on carbon dioxide emissions. The empirical study also demonstrates that Portugal presents a dependence on energy consumption. The openness trade and foreign direct investment are negatively correlated with carbon dioxide emissions.

Keywords: Environmental Kuznets Curve, Climate Change, Time Series and Openness Trade

JEL Classification: C50, Q43, Q53

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CLIMATE CHANGE AND KUZNETS CURVE: PORTUGUESE EXPERIENCE

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ABSTRACT

The climate change has inspired the interest of the academic community in the most diverse areas of knowledge. This study tests and revisited the environmental Kuznets curve assumptions for Portugal. The econometric strategy used in this research is time series (ARIMA model, OLS estimator, ARCH regression, VAR model, and Granger causality) for the time period 1980-2013.The econometric results show that the income per capita and squared income per capita are according to the expected signs, i.e. a positive impact of income per capita on carbon dioxide emissions, and a negative effect of squared income per capita on carbon dioxide emissions. The empirical study also demonstrates that Portugal presents a dependence on energy consumption. The openness trade and foreign direct investment are negatively correlated with carbon dioxide emissions.

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1. INTRODUCTION

This paper evaluates the relationship between climate change and the economic growth of the Portuguese economy. Indeed, the environmental Kuznets curve has some theoretical characteristics of monopolistic competition, when the researchers decided to introduce as the explanatory variables international trade and foreign direct investment, these permit to explain the economic growth using the assumptions of monopolistic competition.

The correlation of environmental pollutants and Kuznets curve have been the object of study since the 1990s (e.g. Shafik and Bandvopadhyay 1992, and

Grossman and Krueger 1995). As we will see in the literature review, the econometric strategies used in this type of studies has been time series (unit roots, autoregressive models, ARDL models, ARMA, and cointegration) and panel data (fixed effects, random effects, and System-GMM). The empirical studies have tested an inverted U Shaped. According to the hypotheses, we expected a positive association between income per capita and the environmental pollutants and a negative correlation between squared income per capita and environmental pollutants.

The empirical study of Esteve and Tamarit (2012) evaluates the environmental Kuznets curve in Spain for the period 1857-2007 using cointegration methodology. The results of this study validate an inverted -U shape. In this context, Baek (2015) analyses the Arctic countries for the period 1960-2010. The author uses the cointegration methodology and ARDL model, and the results also show that Norway and U.S present an inverted-U shaped.

This paper pretends to contribute to the existing empirical literature. At first, we evaluate the relationship between income per capita, squared income per capita and carbon dioxide emissions, considering the assumptions of environmental Kuznets curve (EKC). The association between foreign direct investment, the international trade, and environmental pollutants was also investigated.

In terms of methodology, we use the time series to evaluate the relationship between the climate change and the environmental Kuznets curve.

This research is organized as follows: in section 2, we present the literature review, where we present the importance of climate change and its association with economic growth, considering the recent empirical studies about the determinants of environmental pollutants and the growth. The methodology is presented in section 3. The econometric models and its interpretation are presented in section 4. In the final, we suggest some conclusions of this research.

2. LITERATURE REVIEW

The empirical studies have used different econometric techniques to evaluate the environmental Kuznets. Usually, the empirical studies utilize as independent variables, the income per capita, squared income per capita, openness trade, energy consumption, globalization, foreign direct investment to explain the determinants of environmental Kuznets curve. The researchers had utilized such as dependent variable environment pollutants.

The urban econometric model considered by Kim et al. (2016) applied by 15 cities and provinces in Korea for the 2000-2012 tested environmental Kuznets curve using different air pollutant. The authors use a static (fixed effects, and random effects) and dynamic panel data (GMM-System). The assumptions of environmental Kuznets curve have support in the literature, when the authors used as dependent variable Nitrogen Oxide (NOx). The econometric results with random effects (Kim et al.2016: 339) showed that income per capita and squared income per capita presents a positive and a negative impact on air pollutant (NOx). The similar conclusion is presented with a dynamic panel. However, the other

explanatory variables introduced in the regression as the share of manufacturing, population density, and the metropolitan city (dummy variable) are not statistically significant (Kim et al.2016: 344).

According to theoretical hypotheses, there is a positive association between the economic growth and the pollutants. However, when the economies or countries are at a higher stage of development, the empirical studies refer that there is a negative correlation between pollutants and economic growth.

Indeed, there is a vast quantity of empirical studies about this issue. In this research, we analyses the Portuguese economy, in this context, we present some studies that considered the Portuguese case. However, it is important to refer, other studies as in Özokcu and Özdemir (2017), Alshehry and Belloumi (2017), and Och (2017) such as complementarity and with the objective to have an international perspective.

These studies demonstrate that the Kuznets environmental curve has gained quite a few adherents in the academic community, since the studies of Grossman and Krueger (1991,1993) and Douglas and Selden (1995). Thus, the changes in carbon dioxide emissions and environmental degradation have been studied in a variety of areas: economics, ecology, engineering and the international relations.

Portuguese carbon dioxide emissions and economic growth were investigated by Shahbaz and Leitão (2013). Considering OLS estimator and ARMA model, the authors concluded that there is a positive impact of income per capita on carbon

dioxide emissions (CO_2). The squared income per capita has a negative effect on CO_2. These results are according to the hypotheses of environmental Kuznets curve. The variables of energy consumption and openness trade present a positive impact on CO_2. Other empirical study, Shahbaz et al. (2015) analyzed the environmental Kuznets curve assumptions applied by Portugal. The authors consider the period 1971-2008, using time series (unit root test, Granger causality, and ARDL model). The econometric results show that the coefficients of energy consumption, urbanization, and income per capita are positively correlated with carbon dioxide emissions (Shahbaz et al. 2015: 479, table 4 and table 5). The squared income per capita is negatively correlated with CO_2.

The empirical study of Leitão and Shahbaz (2013) applied a dynamic panel data (GMM-System) to investigate environmental Kuznets curve. This empirical research shows that the variables of globalization, income per capita, and energy consumption have a positive effect on CO_2. The squared income per capita reveals a negative effect on CO_2, this result is according to previous studies (Halicioglu, 2009; Fodha and Zaghdoud, 2010; Lean and Smyth, 2010).

Carbon dioxide emissions and foreign direct investment were considered by Leitão (2015: 144). The author utilized as econometric methodology, the fixed effects estimator, and GMM-System. The income per capita and squared income per capita present an inverted U-shape, validating the assumptions of Kuznets curve.

Özokcu and Özdemir (2017) tested the environmental Kuznets curve using panel data (fixed effects and random effects) for the period 1980-2010. The authors formulated two econometric models, considering income per capita, squared income per capita, cubic income per capita, and energy such as explanatory variables. The economic results prove an inverted U Shape. In this context, Alshehry and Belloumi (2017) consider the Saudi Arabia case for the period 1971-2011, using time series (unit root test, and ARDL model). This study doesn´t find an inverted U between CO2 and economic growth.

The nitrous oxide emissions and environmental Kuznets curve were analyzed by Och (2017). The Granger causality shows that pollutant variable (nitrous oxide emissions), income, exports, urbanization present causality between economic growth.

The environmental Kuznets curve was investigated by Romero et al. (2017). The authors used cointegration panel such as econometric strategy (Romero et al. 2017: 262, table 2). The variables of the absolute value of transport energy and income per capita are cointegrated with economic growth. The results also demonstrate that productive transport of energy (absolute value and per capita) are positively correlated with economic growth.

The empirical study of Youssef et al. (2016: 271, table 5) utilize the simultaneous equation GMM-estimation, and the authors showed that linear income per capita

and squared income per capita are positively and negatively correlated with environmental pollution to different stages of economies. The variable of foreign trade presents a positive impact on low -income economies and middle-income countries. In this context, Apergis (2016: 269, table 5) used a panel data, and the author demonstrated that there is an inverted U shaped between pollutant variable and income and squared income per capita.

Considering the following countries: Brazil, China, Egypt, Japan, South Korea, Mexico, Nigeria, and South Africa, Onafowora, Owove (2014:54, table 3) applied an ARDL model, and the researchers conclude that the assumptions of environmental Kuznets curve are according to these pair on countries.

The link between regional productivity growth and climate change was investigated by Xin Cui et al. (2017). The authors use the methodology the CGE (Computable General Equilibrium) model. This research concluded that the assumptions of environmental Kuznets curve depend on the regional growth level.

A spatial econometric model applied by of environmental Kuznets curve was studied by Rupasingha et al. (2004). The author's utilized as econometric methodology Tobit model and Bayesian Spatial model. In general, the study validates the hypotheses of environmental Kuznets curve.

The empirical study of Balogh and Jambor (2017) tested the environmental Kuznets curve considering a dynamic panel data for 168 countries. In this article, the authors formulated six regressions (Balogh and Jambor 2017: 224). Considering the model [6], presented by these authors, we can observe that nuclear energy, renewable energy, and foreign direct investment have a negative effect on CO_2. The variable of tourism arrivals presents a positive impact on CO_2. The variables of income per capita and squared income per capita validate the assumptions of Kuznets curve.

The Indonesia experience, was investigated by Diputra and Baek (2018) considered as methodology the cointegration to explain the environmental Kuznets curve. According to the econometric results the authors found a positive correlation between income per capita and carbon dioxide emissions. This study also found a negative impact of squared income per capita, and urban population on CO_2. These results have support in the assumptions EKC. The energy consumption presents a positive effect on CO_2.

The Canadian experience applied to territorial level was investigated by Olale et al. (2018). The econometric results presented by Olale et al. (2018: 864) showed that there is a negative association between squared income per capita and CO_2. The same study demonstrates that there is the same tendency between openness trade and CO_2. However, the correlation between income per capita and CO_2 present a positive association between theses variables.

3. ECONOMETRIC STRATEGY AND DATA

In figure 1, we can observe Kernel density distribution for carbon dioxide emissions, income per capita, and squared income per capita.

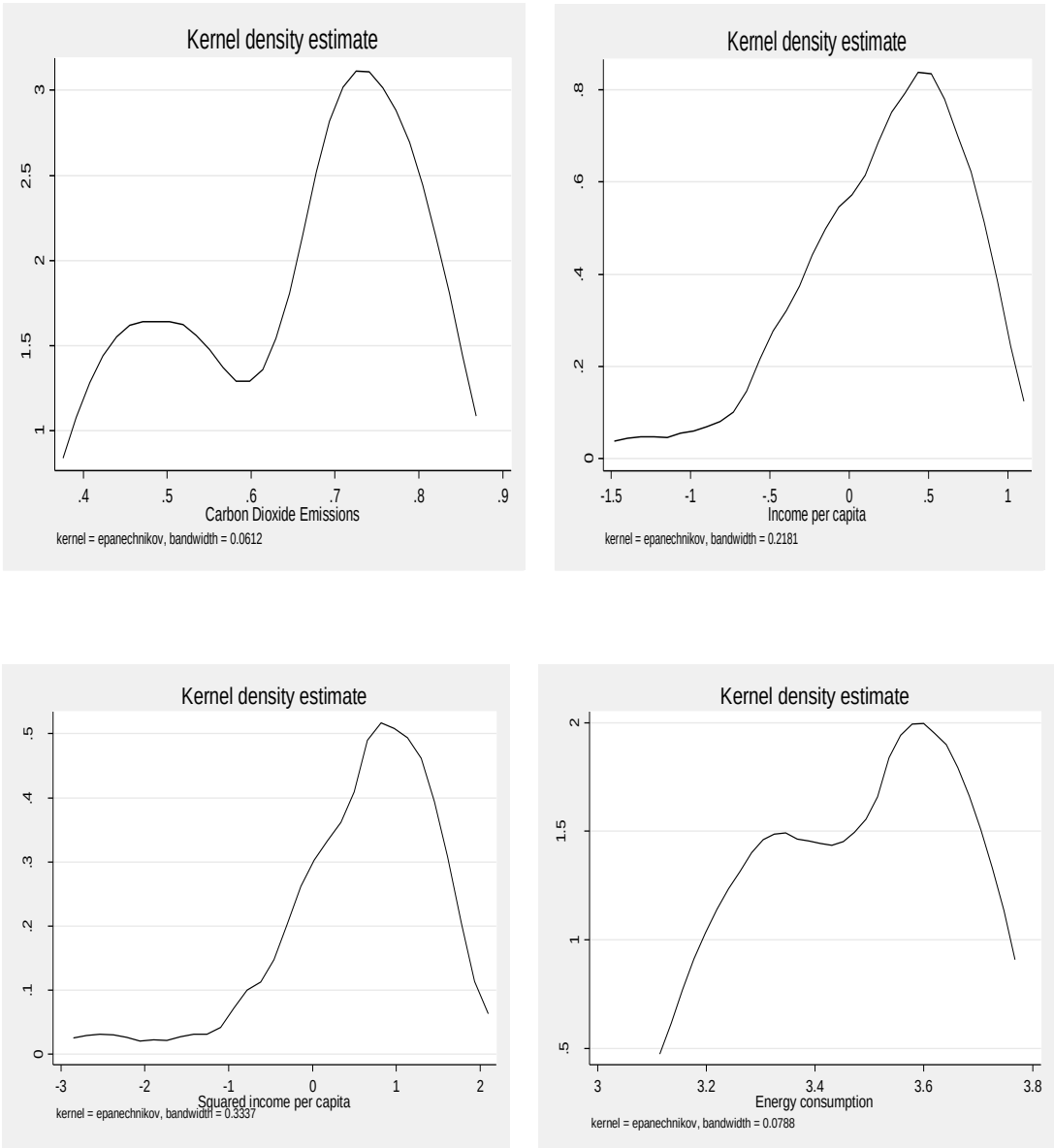

Figure 1- Kernel Density Distribution.

The correlation between climate change and environmental Kuznets curve is considered in this empirical study. We consider, the Portuguese experience for the period 1980-2013, using time series (unit root test, ARIMA model, ARCH regression, VAR model).

In this research, we use as dependent variable carbon dioxide emissions per capita (CO_2). The data were collected from the World Bank. The independent variables introduced in the regressions are income per capita (*GDP*), squared income per capita (GDP^2), energy consumption (*EC)*, openness trade (*TRADE)*, and foreign direct investment (*FDI*). We consider that environmental pollutant (CO_2) is directly correlated with this function:

$$CO_2 = f\,(GDP,\ GDP^2,\ EC,\ TRADE,\ FDI) \qquad (1)$$

In this section, we formulate the follow equation, based on equation 1. All variables are presented in logarithm form:

$$LogCO_2 = \alpha_0 + \alpha_1 LogGDP + \alpha_2 LnGDP^2 + \alpha_3 LogEC + \alpha_4 LogTRADE + \alpha_5 LogFDI + ut_{it} \qquad (2)$$

According to the literature, we expected a positive effect of income per capita (*GDP*) on carbon dioxide emissions. The empirical studies of Shahbaz and Leitão (2013), Shahbaz et al. (2015), and Leitão and Shahbaz (2013) found a positive association between these variables.

For the second explanatory variable squared income per capita (GDP^2), we expected a negative sign. This effect shows that developed economies have concerns about environmental issues, demonstrating that there is a decrease in pollutant emissions. Romero et al. (2017), Youssef et al. (2016), Apergis (2016) found a negative correlation between squared income per capita (GDP^2) and carbon dioxide emissions.

The previous studies of Shahbaz et al. (2015), Leitão and Shahbaz (2013), and Leitão (2015) found a positive association between energy consumption and carbon dioxide emissions.

GDP- is gross domestic product by population, and GDP^2- squared gross domestic product. The data were collected by World Bank (national accounts data, and OECD national accounts).

EC- the variable represents the energy of consumption per capita by World Bank. There are positive association between energy consumption and CO_2.

The variables of openness trade (*TRADE*), and foreign direct investment *(FDI*) was been introduced in environmental Kuznets empirical studies e.g. Grossman and Krueger (1995), Shahbaz et al. (2015), and Leitão and Shahbaz (2013). The literature demonstrates that there are two different perspectives. The dominant paradigm considers that there is a positive relationship between trade and foreign direct investment and carbon dioxide emissions. However, some studies argue that there are a negative association between these variables and carbon dioxide

emissions, referring that developed economies are less polluting, requiring less energy intensive use.

TRADE-is exports plus imports by GDP. The source used are World Bank.

FDI- foreign direct investment, net inflows (% GDP). The data were collected by IMF, and international financial statistics and balance of payment.

4. EMPIRICAL RESULTS

The empirical results are discussed in this section. We use STATA software to estimate the following the econometric results. The summary and descriptive statistics is presented in table 1. The variables of foreign direct investment (FDI), energy consumption (EC), and openness trade (TRADE) present the higher values by means, and the same is verified by minimums values, and maximus values.

Table 1 Summary and descriptive statistics

	$LogCO_2$	LogGDP	$LogGDP^2$	LogEC	LogTRADE	LogFDI
Mean	0.65	0.22	0.57	3.47	1.80	9.22
Std. Dev.	0.13	0.48	0.90	0.17	0.04	0.62
Min	0.43	-1.26	-2.52	3.19	1.74	8.16
Max	0.81	0.88	1.76	3.69	1.90	10.13
Observations	29	32	32	30	32	32

Table 2 exbibits the correlation between the variables used in this research.

Table 2 Summary and descriptive statistics

	$LogCO_2$	LogGDP	$LogGDP^2$	LogEC	LogTRADE	LogFDI
$LogCO_2$	1.00					
LogGDP	-0.17	1.00				
$LogGDP^2$	-0.20	0.95	1.00			
LogEC	0.95	-0.32	-0.33	1.00		
LogTRADE	0.54	-0.02	-0.03	0.65	1.00	
LogFDI	0.86	-0.15	-0.17	0.90	0.68	1.00

Table 3 shows the unit root for each variable used in this empirical study, considering the Augmented Dickey-Fuller. The results demonstrate that all variables are stationary in ADF at level and First differences.

Table 3 Unit root rest: ADF (Augmented Dickey-Fuller)

Augmented Dickey-Fuller test	ADF at Level		ADF at First differences	
Variables	Statistic	P-value	Statistic	P-value
$LogCO_2$	-1.57	0.06	-1.63	0.05
LogGDP	-2.16	0.01	-1.55	0.07
$LogGDP^2$	-2.46	0.01	1.53	0.07
LogEC	-2.04	0.02	-2.26	0.01
LogTRADE	-1.50	0.07	-2.11	0.02
LogFDI	-1.96	0.03	-1.59	0.06

Table 4 reports the econometric results with ARIMA model. The explanatory variables are income per capita (GDP), squared income per capita (GDP^2), energy consumption (EC), openness trade (TRADE), and foreign direct investment (FDI). The variables of income per capita (GDP), and squared income per capita (GDP^2) are statistically significant at 5% and 10% level. The income per capita presents a positive effect on carbon dioxide emissions (CO_2), and squared income per capita shows a negative effect on (CO_2). These results are according to previous studies (e.g. Shahbaz and Leitão 2013; Leitão and Shahbaz 2013, and Shahbaz et al. 2015).

The coefficient of energy consumption has a positive sign, as expected by the literature (Leitão 2015, and Leitão and Shahbaz 2013). The foreign direct investment (LogFDI) is statistically significant at 10% level, and shows a negative correlation with CO_2.

Table 4 Portuguese environment Kuznets curve with ARIMA model

Dependent variable: $LogCO_2$			
Variables	Coef	T-student	P-value
LogGDP	0.04**	2.37	0.018
$LogGDP^2$	-0.02*	-1.99	0.047
LogEC	2.20***	5.52	0.000
LogTRADE	-0.11	-0.67	0.502
LogFDI	-0.03*	-1.88	0.060
C	-0.02	-3.60	0.000
Observations	27		
Prob > chi2	0.000		
Log likelihood	73.414		
Wald chi2(6)	51.30		
Statistically significant at the 1% (***); statistically significant at the 5% (**); statistically significant at the 10% (*).			

Table 5 shows the econometric results using ARCH model. The variables are statistically significant at 1% level (LogGDP; $LogGDP^2$; Log EC, and LogTRADE). The coefficient of foreign direct investment is statistically significant at 10% level. The empirical studies of Shahbaz et al. (2015), Grossman and Krueger (1995) and Halicioglu (2009) found a negative impact between FDI and TRADE on CO_2. Our results have support in these studies.

Table 5 Portuguese environment Kuznets curve with ARCH regression

Dependent variable: $LogCO_2$			
Variables	Coef	T-student	P-value
LogGDP	0.13***	8.90	0.00
$LogGDP^2$	-0.03***	-4.40	0.00
LogEC	0.95***	25.15	0.00
LogTRADE	-0.53***	-4.93	0.00
LogFDI	-0.18*	-1.83	0.06
C	-1.58	-8.38	0.00
Observations	27		
Prob > chi2	0.00		
Log likelihood	65.96		
Wald chi2(5)	3537.9		
Statistically significant at the 1% (***); statistically significant at the 10% (*).			

Table 6 presents the results with VAR model. The equation of carbon dioxide emissions has support on the environmental Kuznets assumptions.

Table 6 Portuguese environment Kuznets curve with VAR model

Variables	$LogCO_2$	LogGDP	$LogGDP^2$	LogEC	LogTRADE	LogFDI
$LogCO_2$ (-1)	0.88*** (0.00)	3.01 (0.23)	5.94 (0.25)	0.07 (0.15)	-0.13 (0.33)	-0.08 (0.95)
LogGDP(-1)	0.05* (0.06)	0.62 (0.22)	-0.511 (0.63)	-0.07 (0.53)	0.07** (0.02)	0.32 (0.21)
$LogGDP^2$(-1)	-0.04** (0.01)	0.46* (0.06)	0.40 (0.44)	0.03 (0.48)	-0.03** (0.02)	0.06 (0.64)
LogEC (-1)	-0.08 (0.57)	-4.07 (0.11)	-8.97 (-0.09)	0.90*** (0.00)	0.24* (0.08)	3.37*** (0.00)
LogTRADE (-1)	-0.12 (0.58)	-1.62 (0.67)	-0.36 (0.96)	0.09 (0.28)	0.44** (0.04)	1.53 (0.43)
LogFDI (-1)	0.04** (0.01)	0.40 (0.24)	0.87 (0.29)	0.002 (0.75)	-0.03 (0.16)	-0.07 (0.67)
C	0.15 (0.66)	11.62* (0.05)	20.38* (0.09)	0.13 (0.32)	0.49 (0.12)	-4.70 (0.10)
Adj. R^2	0.97	0.35	0.27	0.95	0.88	0.58
P>chi2	0.00	0.02	0.13	0.00	0.00	0.00
Log likelihood	250.92					
AIC	-15.48					
HQIC	-14.88					
SBIC	-13.46					
	Statistically significant at 1%(***), 5% (**), and 10% (*).					

The lagged variable of carbon dioxide emissions [$LogCO_2$ (-1)] is statistically significant at 1% level. The variables squared income per capita and foreign direct investment are statistically significance at 5% level. However, the income per capita is statistically significant at 10% level.

When, we observe the vector of openness trade (LogTRADE), we can conclude that the coefficients of income per capita, energy consumption and the lagged variable of trade are statistically significant

5. CONCLUSIONS AND POLICY RECOMMENDATIONS

In this paper, we consider the environmental Kuznets curve and the climate change applied to Portuguese economy for the period 1980-2013. We revisited the literature review, considering the recent empirical studies realized about this issue. The environmental Kuznets curve is associated with the concept of sustainable development. This has been discussed during ministerial conferences and environmental protocols (e.g. Rio Conference, 1992, Kyoto Protocol 1997). The climate change and pollutants have been the subject of study the biology, the ecology, and the economics, that they use the scientific method to test the hypotheses. We also observe some directions, when we consider the concept of sustainable development with special incidence in social sciences, namely the international relations and political science, as well sociology and human ecology.

The results of this investigation prove that the hypothesis by environmental Kuznets curve is valid to Portuguese case. The income per capita is positively correlated with carbon dioxide emissions, and the squared income per capita presents a negative impact on carbon dioxide emissions. These results are according to previous studies (e.g. Shahbaz and Leitão 2013, Shahbaz et al. 2015). Our investigation shows that Portuguese economy presents a dependence on energy consumption, i.e., we observe a positive correlation between energy consumption and carbon dioxide emissions. In terms of economic policy, we can refer that Portuguese economy should use more renewable energy. The econometric results also demonstrate that the variables of openness trade, and foreign direct investment present ambiguous signs, when we apply ARCH and

ARIMA models. Using the ARCH model, the Portuguese economy is at a stage of development, since the openness trade and foreign direct investment are negatively correlated with carbon dioxide emissions. However, the ARIMA model does not allow infer the same conclusion.

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