REVISTA BRASILEIRA DE ENERGIAS RENOVÁVEIS

THE IMPACT OF RENEWABLE ENERGY CONSUMPTION ON CARBON DIOXIDE EMISSIONS - THE CASE OF SOUTH AMERICAN COUNTRIES[1]

MATHEUS DA COSTA KOENGKAN[2], JOSÉ ALBERTO FUINHAS[3]

[1] Apresentado no Congresso de Energias Renováveis da UFSCar: 23 a 26 de maio de 2017 – Sorocaba-SP, Brasil

[2] University of Beira Interior, Management and Economics Department, Covilhã-Portugal.
E-mail: matheuskoen@hotmail.com.br
[3] NECE-UBI and University of Beira Interior, Covilhã-Portugal.
E-mail: fuinhas@ubi.pt

ABSTRACT

The impact of renewable energy consumption on the carbon dioxide emissions was analyzed for a panel of ten South American countries in a period from 1980 to 2012. The Autoregressive Distributed Lag Methodology was used in order to decompose the total effect of renewable energy consumption on the carbon dioxide emissions in its short- and long-run components. The results indicate that the consumption of renewable energy reduce the carbon dioxide emissions in -0.0420 % when the consumption of alternative sources increases in 1% in short-run. The empirical evidence shows that the renewable consumption plays an important role in reducing CO_2 emissions and that the economic growth and energy consumption in the South American countries are still based on fossil fuels.

Keywords: Environmental, Energy economics, Econometric.

O IMPACTO DO CONSUMO DE ENERGIAS RENOVÁVEIS NAS EMISSÕES DE DIÓXIDO DE CARBONO - O CASO DOS PAÍSES DA AMÉRICA DO SUL

RESUMO

O impacto do consumo de energias renováveis sobre as emissões de dióxido de carbono foi analisado em um painel de dez países da América do Sul, durante o período compreendido entre 1980 e 2012. Neste sentido, foi utilizada a metodologia Autoregressive Distributed Lag Panel de forma a decompor o efeito total do consumo de energias alternativas sobre as emissões em seus componentes de curto e longo prazo. Os resultados indicam que o consumo de energia renovável reduz as emissões de dióxido de carbono em -0,0420% quando o consumo de fontes alternativas aumenta em 1% no curto prazo. A evidência empírica mostra que o consumo de energias renováveis desempenha um papel importante na redução das emissões de CO_2, e que o crescimento econômico e o consumo de energia nos países sul-americanos ainda são baseados em combustíveis fósseis.

Palavras-chave: Meio-ambiente, Economia da energia, Econometria.

INTRODUCTION

The consequent increase in the level of carbon dioxide emissions (CO_2) caused by fossil fuels consumption has set off an alarm signal worldwide. Additionally, almost all greenhouse gas emissions in the world come from coal 44 %, oil 36 % and 20 % natural gas (IRENA, 2014). The Latin America region according to Vergara et al. (2013) saw the CO_2 emissions more than doubling in last three decades, where the region contributes 11% of global CO_2 emissions. Indeed, the region is a small contributor to the world (SCHIPPER et al., 2011). Additionally, an intuitively appealing way to address the challenge of increase of CO_2 emissions is to expand the use of either renewable energy sources (RES) from the wind, solar, geothermal, biomass, and hydro to reduce reliance on fossil fuels, and hence the level of CO_2 emissions.

The aim of this study is to answer the following question: Does the renewable energy consumption upsetting the carbon dioxide emissions? To this question be answered, renewable energy impact will be analyzed the impact of RES consumption on the CO_2 emissions in ten

South American countries from 1980 to 2012, using Auto-Regressive Distributed Lag (ARDL). In the literature, the impact of RES consumption on the CO_2 emissions has been scarcely researched. For instance, Bilgili (2016) analyzed the existence of Inverted-U shaped relationship between environmental quality, *per capita* income, and RES consumption for 17 Organization for Economic Co-operation and Development (OECD) countries in the period from 1977-2010. The results of the analysis, suggest that the RES consumption yields have a negative impact on CO_2 emissions. Aliprandi et al. (2016) studied the RES consumption impact on CO_2 emissions in Italy. The authors found that the reduction of CO_2 emissions is lower than expected considering the amount of energy produced from RES, and it is related to the level of RES penetration. Other authors have pointed to the capacity of RES to reduces the emissions (e.g. JAFORULLAH; KING, 2015; ROBALINO-LÓPEZ et al., 2015; WESSEH; LIN, 2016). However, the second line of researchers have to points that the RES does not cause an impact on CO_2 emissions (e.g. APERGIS et al., 2010; MENYAH; WOLDE-RUFAEL, 2010). Based on the results of these studies the article has two hypotheses: (H_1) The RES consumption has the capacity to reduction the CO_2 emissions, and (H_2) The RES consumption does not capacity to reduction the emissions.

The study of this theme is important the following reasons: The real RES impact on CO_2 emissions is necessary to understand, as well as, in the literature, there are few studies which have investigated the impact of RES on CO_2 emissions in South American countries. Additionally, the choice of South American countries is justified due to the region has a rapid growth in RES consumption. This article is organized as follows: Section 2, the material and method used. Section 3, the results and discussions. Finally, the conclusions are shown in Section 4.

MATERIAL AND METHOD

This section is divided into two parts. In the first one, it will be presented the material used in this research. The second section contains the method.

Material

To analyze the impact of renewable energy consumption on the CO_2 emissions, it was utilized the data, from 1980 to 2012, of ten South America countries namely: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Paraguay, Venezuela, and Uruguay. For analysis of impact of RES consumption on CO_2, the following variables (Table 1) were used.

Table 1: Variables in the model.

Variables	Description	Source
LCO2	Carbon Dioxide Emissions (CO_2), from the consumption of fossil fuels energy in million metric tons.	Energy Information Administration (EIA).
LRE	Renewable Energy Consumption in Billion Kilowatt-hours, from the wind, geothermal, solar, biomass and waste.	Energy Information Administration (EIA
LY	Gross Domestic Product (GDP) in constant local currency units (LCU).	The World Bank Data (WBD).
LP	Petroleum consumption in quadrillion Btu.	Energy Information Administration (EIA)

The countries are chosen by the following criteria: (i) they have been RES consumption for a long period; and (ii) they have data available for the entire period for CO_2 emissions, GDP, and petroleum consumption. The total population was used to transform all variables in *per capita*. The variables in *per capita* help us control the disparities in population growth among the countries. The GDP in local currency units (LCU) reduces the influence of exchange rates. The econometric analysis was performed using EViews 9.5, and Stata 14.0 software.

The best econometric practices strongly recommend testing for the presence of heterogeneity that could arise when long time span is used. The long-time spans exacerbate the potential occurrence of a panel with parameter slope heterogeneity and presence of cross-section dependence (CSD). In South American countries, it is expected that share a common characteristic that could result in the presence of CSD. Furthermore, according to Eberhardt and Presbitero (2013), when the CSD is not controlled it can produce both biased estimates and a severe identification problem. Table 2 reveals both the descriptive statistics and the cross-section dependence of variables.

Table 2: Descriptive statistics and cross-section dependence test.

	Descriptive statistics	Cross-section dependence (CSD)

	Obs	Mean	Std.Dev	Min.	Max.	CD test		Corr.	Abs(Corr)
LCO2	330	-13.2598	0.6694	-14.8064	-11.9527	17.43	***	0.452	0.485
LRE	330	2.8335	1.4397	-0.3930	6.1292	30.60	***	0.794	0.794
LY	330	10.839	3.1129	7.2290	16.1225	28.97	***	0.752	0.752
LP	330	-1.1399	1.3553	-3.9932	1.7905	32.42	***	0.841	0.841
DLCO2	320	0.0116	0.0777	-0.2776	0.2650	3.58	***	0.094	0.181
DLRE	320	0.0503	0.1860	-0.6120	1.5046	1.99	**	0.052	0.188
DLY	320	0.0131	0.0449	-0.1531	0.1504	15.70	***	0.414	0.414
DLP	320	0.0250	0.0715	-0.2553	0.2868	4.26	***	0.112	0.195

Notes: Pesaran (2004) CD test has N (0,1) distribution, under the H_0: cross-section independence. ***, **, * denote statistically significant at 1%, 5% and 10% level, respectively. The Stata command *xtcd* was used to achieve the results for CSD.

The presence of cross-section dependence in the variables both in levels and in first-differences was confirmed by CDS-test. The presence of CSD evidences interdependence between the cross-sections that the countries share common shocks.

Method

The UECM form of the ARDL model was used to analyze the impact of RES consumption on CO_2 emissions. The ARDL model decomposes the total effects of a variable in short-and long-run components, as well as, generating consistent, efficient parameter estimation and inference of parameters based on a standard test (KOENGKAN, 2017; SRINIVASAN et al., 2012). The general UECM form of the ARDL model used in this empirical analysis follows the specification of the Equation. (1):

$$LCO2_{it} = \alpha_{0i} + \delta_{1i}TREND_t + \sum_{j=1}^{k}\beta_{11ij}LRE_{it-j} + \sum_{j=0}^{k}\beta_{12ij}LY_{it-j} + \sum_{j=0}^{k}\beta_{13ij}LP_{it-j} + \varepsilon_{1it} \quad (1)$$

where α_{0i} denotes the intercept, δ_{1it} is trend and $\beta_{11ij,}\beta_{12ij\ldots}$ are the estimated parameters, and ε_{1it} is the error term.

The Equation (1) can be transformed in an equivalent dynamic specification, Equation (2), that allows to capture the short- and the long-run effects of independent variables on the dependent one.

$$DLCO2_{it} = \alpha_{0i} + \delta_{21i}TREND_t + \sum_{j=1}^{k}\beta_{22ij}DLRE_{it-j} + \sum_{j-1}^{k}\beta_{23ij}DLY_{it-j} + \sum_{j=1}^{k}\beta_{24ij}DLP_{it-j} + \\ \gamma_{21i}LCO2_{it-1} + \gamma_{22i}LRE_{it-1} + \gamma_{23i}LY_{it-1} + \gamma_{24i}LP_{it-1} + \varepsilon_{2it} \quad (2)$$

where α_{0i} denotes the intercept, δ_{2it} is trend and $\beta_{21ij,}\beta_{22ij\ldots}\gamma_{21i,}\gamma_{22i\ldots}$ are the estimated parameters, and ε_{2it} is the error term.

The variance inflation factor (VIF), according to O'Brien, (2007) provides an indication the impact of multi-collinearity on the accuracy of estimated regression coefficients. The VIF-test and correlation test was used to checks the presence of multicollinearity, and correlation coefficients between variables (see Table 3).

Table 3: Matrices of correlations and VIF statistics.

	LCO2	LRE	LY	LP
LCO2	1.0000			
LRE	0.3396 ***	1.0000		
LY	-0.2729 ***	0.1024	1.0000	
LP	0.6780 ***	0.7427 ***	-0.2780 ***	1.0000
VIF		2.90	1.41	3.11
Mean VIF		2.47		
	DLCO2	**DLRE**	**DLY**	**DLP**
DLCO2	1.0000			
DLRE	-0.2264 ***	1.0000		
DLY	0.3664 ***	0.0091	1.0000	
DLP	0.6637 ***	-0.1898 ***	0.4037 ***	1.0000
VIF		1.05	1.21	1.25
Mean VIF		1.17		

Notes: *** denote statically significant at 1%.

The results of VIF-test points that the mean VIF of (2.47) to long-run and (1.17) to short-run are low. The low VIF-test statistics support that the multicollinearity is not a great concern in the model. Moreover, the first and second-generation unit root test were used to assess the order of integration of the variables. The first-generation unit root tests of LLC (LEVIN; LIN; CHU, 2002), ADF-Fisher (MADDALA; WU, 1999), and ADF-Choi (CHOI, 2001), were used. The null hypothesis rejection of the LLC, ADF-Fisher and ADF-Choi tests means unit root (common unit root process). The second-generation unit root test CIPS of Pesaran (2007) was used. The null hypothesis rejection of CIPS-test has H0: Series are I (1). Table 4 shows, the results of unit root tests.

Table 4: Unit roots tests.

	1st Generation test						2nd Generation unit root test CIPS (Zt-bar)			
	LLC		ADF-Fisher		ADF-Choi					
	Individual intercept and trend						Without trend		With trend	
LCO2	-1.2109		29.8091	*	-0.9332		-0.802		-0.812	
LRE	-3.3297	***	42.4013	***	-2.9146	***	-1.600	**	-3.354	***
LY	-2.5527	***	30.6570	**	-0.9030		-0.237		-0.627	
LP	-2.3364	***	19.6462		-0.5193		-0.417		1.173	
DLCO2	-8.4104	***	109.419	***	-8.0681	***	-8.817	***	-8.499	***
DLRE	-8.8996	***	109.200	***	-8.2202	***	-9.505	***	-7.997	***
DLPY	-6.2199	***	73.6748	***	-5.8164	***	-6.130	***	-5.318	***
DLP	-7.2684	***	90.9046	***	-6.8320	***	-8.153	***	-7.465	***

Notes: ***, **, * denote statistically significant at 1%, 5% and 10% level, respectively. The null hypotheses are as follow: the LLC test the unit root (common unit root process), this unit root test controls for individuals effects, individual linear trends, has a lag length 1, and Newey-West automatic bandwidth selection and Bartlett kernel were used; the ADF-FISHER and ADF-Choi test the unit root (individual unit root process), this unit root test controls for individual effects, individual linear trends, has a lag length 1, the first generation test follows the option "individual intercept and trend", which was decided after a visual inspection of the series. The Eveiws 9.5 was used in the calculus of the first-generation tests. The CIPS test (Pesaran, 2007) has H_0: series are I(1). The Stata command *multipurt* was used to compute CIPS test.

The results of first and second generation unit root test indicates that the first-difference of variables and the variable LRE in logarithm are I (1).

The macro panel structure according to Baltagi (2008) has a long-time span, where it has the advantage of allowing panel unit root test that has a standard asymptotic distribution, which it is important when checking for cointegration. The presence of individual effects must be tested against random effects (RE) in the model. The RE model, the error term assumes the following form: $\mu_i + \omega_{it}$, where, the μ_i denotes N-1 country specific effects, and ω_{it} is the independent and identically distributed errors. The Equation (2) converted in Equation (3) by changing ε_{2it} for $\mu_i + \omega_{it}$:

$$\begin{aligned} DLCO2_{it} = {} & \alpha_{0i} + \delta_{21i}TREND_t + \sum_{j=1}^{k}\beta_{22ij}DLRE_{it-j} + \sum_{j-1}^{k}\beta_{23ij}DLY_{it-j} + \sum_{j=1}^{k}\beta_{24ij}DLP_{it-j} + \\ & \gamma_{21i}LCO2_{it-1} + \gamma_{22i}LRE_{it-1} + \gamma_{23i}LY_{it-1} + \gamma_{24i}LP_{it-1} + \mu_i + \omega_{it.} \end{aligned} \quad (3)$$

The Hausman test of the Random Effects (RE) against Fixed Effects (FE) specification was applied to identify the presence of RE or FE in the model. This test has the null hypothesis that the best model is RE. The results of this test point to the selection of (FE) model, where the result is significant $\chi_8^2 = 38.63$. The (FE) model evidence a greater suitability for analyzing the influence of variables over time.Additionally, this allows a great evaluation of the net effect of the explanatory variables.The presence of long time spans and many cross-sections in macro panels make testing for the slope heterogeneity of parameters highly advisable. This testing could be of two types: (i) heterogeneity of parameters in the short- and long-run; and (ii) heterogeneity of parameters only in the short-run. To deal with heterogeneity, the Mean Group (MG) or Pooled Mean Group (PMG) estimators could be applied. The MG is a flexible technique, where creates regressions for each individual, and then computes for all individuals an average coefficient. (PESARAN et al., 1999). Indeed, this estimator is consistent in long-run average, while in presence of slope homogeneity the model is not efficient (PESARAN et al., 1999). The PMG is an estimator that in long-run parameters make restrictions among cross-sections, but not in short-run and in adjustment speed term. Moreover, the PMG estimator it is more efficient and consistent in the existence of homogeneity in long-run if compared with MG estimator (FUINHAS et al., 2015).

RESULTS AND DISCUSSION

The MG and PMG estimations were tested against the dynamic fixed effects (DFE). Additionally, in the presence of heteroskedasticity contemporaneous, first order autocorrelation and cross-section dependence in the context of a long-time span, the Driscoll and Kraay (1998) estimator need to be apply because this estimator generates robust standard errors for several phenomena found in the sample errors (FUINHAS et al., 2015; FUINHAS et al., 2017). The DFE estimator, DFE robust standard errors and DFE Driscoll and Kraay (DFE D.-K) were computed. The battery of specification tests were used like the modified Wald test for groupwise heteroscedasticity, the Pesaran for cross-section independence, the Breusch-Pagan Langrarian Multiplier test for cross-section independence, and the Wooldridge test for autocorrelation in panel data. Table 5, evidences the estimations of the MG, PMG, DFE models, outcomes of the Hausman test, the short-and long-run elasticities for the models DFE, DFE robust and DFE D.-K, and also the specification tests.

Table 5: Estimations results.

(Dependent Variable DLCO2)									
	Heterogeneous estimator				**Fixed effects**				
	MG (I)		**PMG (II)**		**Coefficients**		**FE (III)**	**FE Robust (IV)**	**FE D.-K. (V)**
Constant	-10.7926	***	-7.2669	***	-4.3155	***	***	***	***
Trend	-0.0015		-0.0032	***	-0.0023	***	***	*	***
	Short-run (semi-elasticities)								
DLRE	-0.1343	***	-0.1252	***	-0.0420	**	***		**
DLY	0.3741	***	0.3877	***	0.2792	***	***	***	***
DLP	0.5228	***	0.5641	***	0.6371	***	***	***	***
(Dependent Variable LCO2)									
	Long-run (elasticities)								
LRE (-1)	-0.0976		-0.0412		-0.0263				
LY (-1)	0.3014		0.5022	***	0.5025	***	**	**	**
LP (-1)	0.4374	***	0.5497	***	0.6196	***	***	***	***

	Speed of adjustment				
ECM	-0.6713 ***	-0.4093 ***	-0.2427 ***	*** ***	***
	Hausman test		**Specification test**		
	MG vs PMG	**PMG vs DFE**	**Modified Wald test**	**Pesaran test**	**Wooldridge test**
	$\chi^2_9 =$ -0.43	$\chi^2_9 =$ 0.00***	$\chi^2_{10} =$574.85***	1.348	F (1,9) = 82.006***

Notes: ***, **,* denote statistically significant at 1% ,5% and 10% level, respectively; Hausman results for H_0: Difference in coefficients not systematic; ECM denotes error correction mechanism; the long-run parameters are computed elasticities; the Stata commands *xtpmg*, and Hausman (with the sigmamore option) were used;In the fixed effects were used the *xtreg*, and *xtscc* Stata commands; For H_0 of Modified Wald test: sigma(i)^2 = sigma^2 for all I; results for H_0 of Pesaran test: residuals are not correlated; results for H_0 of Wooldridge test: no first-order autocorrelation.

The Hausman-test points that the DFE is the appropriate estimator, i.e there is evidence that the panel is homogeneous. The estimations result of DFE, DFE robust, and DFE Driscoll and Kraay points to the presence of long memory of the variables, and the ECM term is statically significant at 1% level and it has a negative signal, where this result confirms the presence of Granger causality. The semi-elasticities were calculated by adding the coefficients of variables in the first differences. The elasticities are calculated by dividing the coefficient of lagged independent variable by the coefficient of the lagged independent variable, multiplier by (-1). The results showed that in the short-run elasticities the RES consumption has the capacity to reduction CO_2 emissions in -0.0420 %, when the RES consumption increase in 1%, and in the long-run the RES consumption, it is not capable of decreasing the emissions. The negative impact of renewable energy consumption on CO_2 emissions, it is in line with several authors that studied the Latin American countries (e.g. FUINHAS et al., 2017; ROBALINO-LÓPEZ et al., 2015; SHEINBAUM et al., 2011).Certainly, the decrease of CO_2 emissions by renewable energy consumption in short-run is due to the investments in renewable energy sources that are the result of the availability of enormous biodiversity and the abundance of renewable sources (e.g. hydropower, wind, solar, geothermal, and biomass) in most Latin American countries (FUINHAS et al., 2017).

Moreover, the GDP has a positive impact in short-run of 0.2792 %, and in long-run of 0.5025 %, and petroleum consumption has a positive effect of 0.5641 % in short-run and 0.6196 % in long-run. These results are in line with several authors that studied the Latin America region (e.g. FUINHAS et al, 2017; PABLO-ROMERO; JESÚS, 2016; ROBALINO-LÓPEZ et al., 2015; SAID; HAMMAMI, 2015).

The battery of specification tests to back up the parameters statistical significance of the DFE model were applied. The modified Wald-test points to the presence of heteroscedasticity. The Pesaran test of cross-section independence, indicate to the non-existence of a correlation between the crosses. The Wooldridge-test points to the presence of the first-order autocorrelation, and the Breusch-Pagan LM-test can not be applied due to correlation matrix of residuals are singular.

CONCLUSIONS

The impact of RES consumption on CO_2 emissions was analyzed in the article. The study focused in ten South American countries from 1980-2012 using auto-regressive distributed lag (ARDL) methodology. The initial tests prove the existence of cross-sectional dependence, where confirm that these countries share spatial patterns, the phenomena of heteroscedasticity, contemporaneous correlation, first order autocorrelation, cross-sectional dependence, and the existence of Granger causality. The results pointed that in the short-run elasticities the RES consumption has the capacity to reduction the CO_2 emissions in -0.0420 %, when the RES consumption increase in 1%, confirming the hypothesis that the RES consumption has the capacity to reduction the emissions. The empirical evidence shows that RES consumption plays an important role in reducing CO_2 emissions. Consequently, to achieve steady and sustainable growth in RES use, governments should design and implement effective support policies to promote investment in RES technologies. In addition, the increase of 1% in GDP has a positive impact in short-run of 0.2792 %, and in long-run of 0.5025 %, and petroleum consumption has a positive effect of 0.5641 % in short-run and 0.6196 % in long-run. These results indicate that the economic growth and energy consumption in the South American countries are still based on fossil fuels.

ACKNOWLEDGMENTS

The financial support of the NECE - Research Unit in Business Science and Economics, sponsored by the FCT - Portuguese Foundation for the Development of Science and Technology, Ministry of Education and Science, project UID/GES/04630/2013, is acknowledged.

REFERENCES

ALIPRANDI, F.; STOPPATO, A.; MIRANDOLA, A. Estimating CO_2 emissions reduction from renewable energy use in Italy. **Renewable Energy**, v.96, part. A, p.220-231, 2016. doi. 10.1016/j.renene.2016.04.022.

APERGIS, N.; PAYNE, J.E.; MENYAH, K.; WOLDE-RUFAEL, Y. On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. **Ecological Economics,** v.69, n.11, p.2255–2260, 2010. doi. 10.1016/j.ecolecon.2010.06.014.

BALTAGI, B.H. **Econometric analysis of panel data.** Fourth Edition, Chichester, UK: *John* Wiley &Sons, 2008.

BILGILI, F.; KOÇAK, E.; BULUT, U. The dynamic impact of renewable energy consumption on CO_2 emissions: A revisited Environmental Kuznets Curve approach. **Renewable and Sustainable Energy Reviews**, v.54, p.838-845, 2016. doi.10.1016/j.rser.2015.10.080.

CHOI, I. Unit root test for panel data. **Journal of International Money and Finance**, v.20, n.2, p.249-272, 2001. doi. 10.1016/S0261-5606(00)00048-6.

DRISCOLL, J.; KRAAY, A.C**.** Consistent covariance matrix estimation with spatially dependent data. **Review of Economics and Statistics**, v.80, n.4, p.549-560, 1998. doi: 10.1162/003465398557825.

EBERHARDT, M.; PRESBITERO, A.F. **This time they are different:** Heterogeneity and nonlinearity in the relationship between debt and growth. IMF, Working Paper 13/248, 2013.

FUINHAS, J.A.; MARQUES, A.C.; COUTO, A.P. Oil rents economic growth in oil producing countries: Evidence from a macro panel. **Economic Change and Restructuring**, v.48, n.3, p.257-279, 2015. doi. 10.1007/s10644-015-9170-x.

FUINHAS, J.A.; MARQUES, A.C.; KOENGKAN, M. Are renewable energy policies upsetting carbon dioxide emissions? The case of Latin America countries. **Environmental Science and Pollution Research**, v.24, n.17, p.15044-15054, 2017. doi: 10.1007/s11356-017-9109-z.

IRENA. U.S. REMAP 2030. **Mitigating Climate Change Thought Renewables:** How Doubling the Renewable Energy Share Can Keep Global Temperatures in Check,2014. Available in:< https://www.irena.org/remap/REmap-FactSheet-8-Climate%20Change.pdf>. Access in 05 Nov. 2016.

JAFORULLAH, M.; KING, A. Does the use of renewable energy sources mitigate CO_2 emissions? A reassessment of the US evidence. **Energy Economics**, v.49, p.711-717, 2015. doi. 10.1016/j.eneco.2015.04.006.

KOENGKAN, M. Is globalization influencing primary energy consumption? The case of Latin American and Caribbean countries. **Cadernos UniFOA**, v.12, n.33, p.1-11. e-ISSN: 1982-1816.

LEVIN, A.; LIN, C-F.; CHU, C-S.J. Unit root test in panel dada: Asymptotic and finite-sample properties. **Journal of Econometrics**, v.108, n.1, p.1-24, 2002. doi. 10.1016/S0304-4076(01)00098-7.

MADDALA, G.S.; WU, S. A comparative study of unit rood test with panel data a new simple test. **Oxford Bulletin of Economics and Statistics**, v.61, n.1, p.631-652, 1999. doi. 10.1111/1468-0084.0610s1631.

MENYAH, K.; WOLDE-RUFAEL, Y. CO_2 emissions, nuclear energy, renewable energy and economic growth in the US. **Energy Policy**, v.38, n.6, p.2911–2915, 2010. doi. 10.1016/j.enpol.2010.01.024.

O'BRIEN, R.M. A caution regarding rules of thumb for variance inflation factors. **Quality & Quantity**, v.41, n.5, p.673- 690, 2007. doi. 10.1007/s11135-006-9018-6.

PABLO-ROMERO, M.D.P.; JESÚS, J.D. Economic growth and energy consumption: The Energy-Environmental Kuznets Curve for Latin America and the Caribbean. **Renewable and Sustainable Energy Reviews**, v.60, p.1343-1350, 2016. doi: 10.1016/j.rser.2016.03.029.

PESARAN, M.H. General Diagnostic Tests for Cross Section Dependence in Panels. **Department of Applied Economics**, 2004. doi: 10.17863/CAM.5113.

PESARAN, M.H. A simple panel unit root test in the presence of cross-section dependence. **Journal of Applied Econometrics**, v.22, n.2, p.256-312, 2007. doi.: 10.1002/jae.951.

PESARAN, M.H.; SHIN, Y.; SMITH, R.P. Pooled mean group estimation of dynamic heterogeneous panels. **Journal of American Statistical Association**, v.94, n.446, p.621-634, 1999.

ROBALINO-LÓPEZ, A.; MENA-NIETO, A.; GARCÍA-RAMOS, J.E.; GOLPE, A.A. Studying the relationship between economic growth, CO2 emissions, and the environmental Kuznets curve in Venezuela (1980–2025). **Renewable Sustainable Energy Reviews**, v.41, p.602-614, 2015. doi. 10.1016/j.rser.2014.08.081.

SAIDI,K.;HAMMAMI,S. The impact of CO2 emissions and economic growth on energy consumption in 58 countries. **Energy Reports**, v.1, p. 62–70, 2015. doi: 10.1016/j.egyr.2015.01.003.

SRINIVASAN, P.K; SANTHOSH, P.K.; GANESH, L. Tourism and economic growth in Sri Lanka: An ARDL bounds testing approach. **Environment and Urbanization Asia Journal**, v.3, n.2, p.397-405, 2012. doi. 10.1177/0975425312473234.

SCHIPPER, L.; DEAKIN, E.; McANDREW, C. Carbon dioxide emissions from urban road transport in Latin America: CO_2 reduction as a co-Benefit of transport strategies. **Economics and Policy**, p.111-127, 2011. doi. 10.1007/978-1-4419-7643-7_8.

SHEINBAUM, C.; RUÍZ, B.J.; OZAWA, L. Energy consumption and related CO2 emissions in five Latin American countries: Changes from 1990 to 2006 and perspectives. **Energy**, v.36, n.6 , p.3629-3638, 2011. doi: 10.1016/j.energy.2010.07.023.

VERGARA, W.; RIO, R.R.; GALINDO, L.M. **The climate and development challenge for Latin America and the Caribbean:** Options for climate-resilient, low-carbon development. *Inter-American Development Bank*, ISBN 978-1-59782-165-0, 2013. Available in:< http://www.imf.org/external/np/seminars/eng/2013/caribbean/pdf/challenge.pdf>. Access in 05 Nov. 2016.

WESSEH, P.H.; LIN, B. Can African countries efficiently build their economies on renewable energy?. **Renewable Sustainable Energy Reviews**, v.54, p.161-173, 2016. doi. 10.1016/j.rser.2015.09.082.

ZOUNDI, Z. CO_2 emissions, renewable energy, and the Environmental Kuznets Curve, a panel cointegration approach. **Renewable and Sustainable Energy Reviews**, 2016. doi. 10.1016/j.rser.2016.10.018.