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THE POSITIVE INFLUENCE OF URBANIZATION ON ENERGY CONSUMPTION IN LATIN AMERICAN COUNTRIES: AN APPROACH WITH ARDL AND NARDL MODELING

ABSTRACT

The impact of urbanization on energy consumption was analyzed for a panel of eight Latin American countries in a period from 1970 to 2015. The Autoregressive Distributed Lag (ARDL) in the form of Unrestricted Error Correction Model (UECM) and Non-Linear Autoregressive Distributed Lag (NARDL) were used to decompose the total effect of urbanization on the energy consumption in its short- and long-run components. The results indicate that the economic growth and urbanization have a positive impact on energy consumption in short-and long-run.

Keywords: Energy, econometric, energy economics, energy conservation, applied economics

A INFLUÊNCIA POSITIVA DA URBANIZAÇÃO SOBRE CONSUMO DE ENERGIA EM PAÍSES LATINO-AMERICANOS: UMA ABORGAGEM COM MODELAGEM ARDL E NARDL

RESUMO

O impacto da urbanização sobre o consumo de energia foi analisado para um painel de oito países latino-americanos em um período de 1970-2015. O modelo *Autoregressive Distributed Lag* (ARDL) sobre a forma de *Unrestricted Error Correction Model* (UECM) e o modelo *Non-Linear Autoregressive Distributed Lag* (NARDL) foram utilizados para decompor o efeito total da urbanização no consumo de energia em seus componentes de curto e longo prazo. Os resultados indicam que o crescimento econômico e a urbanização têm um impacto positivo no consumo de energia em curto e longo prazo.

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Palavras-chave: Energia, econometria, economia energética, conservação de energia, economia aplicada

JEL: P18; P28; Q01.

INTRODUCTION

The rate of urbanization in Latin America region in the period from the 1920s to 1960s growth up 25 % to 48.9 %. This rapid increase is due to the introduction of new agricultural technologies, the industrialization process and the restructuring of rural economies in the most countries of the Latin America region. Then, after that in the period from 1975 to 2007 the rate of urbanization in the region increase 0.78 %, and it is projected to slow even further, to 0.36 percent between 2007 and 2025. The increase of urbanization results in the growth of energy consumption (e.g. oil, natural gas, coal and renewable energy) (Yang, et al. 2016). The aim of this study is to investigate the impact of urbanization on energy consumption in Latin American countries in the period from 1970 to 2015.

The impact of urbanization on energy consumption has been explored by several studies in the literature.These studies have used variables like Gross Domestic Product (GDP), renewable energy consumption, primary energy consumption and total energy consumption. On the other hand, other studies have used the variables like Urban population growth (annual %), urban population (% of total), urban land area (sq.km). Moreover, there are studies that used total population in the urban area (e.g Fan, et al, 2017; Yang, et al, 2016; Aunan and Wang, 2014). For an instant, Fan, et al., (2017) studied the relationship among energy consumption, urbanization and CO_2 emissions in China in a period from 1996-2012 and used the Divisia decomposition as a methodology. The empirical results pointed that the urbanization increases the residential energy consumption in 15.4%. Bilgili, et al., (2017) examined the relationship between the intensity of population in urban areas and energy intensity consumption in 10 Asian countries namely, Bangladesh, China, India, Indonesia, Malaysia, Nepal, Philippines, South Korea, Thailand, and Vietnam in a period from 1990 to 2014. The authors employed an environmental Kuznets curve (EKC) model to investigate the effects of urbanization on energy intensity consumption in Asian countries. The outcomes showed that the urbanization has a positive influence on energy intensity consumption in short-and long-run. Yang, et al., (2016) investigated the impact of urbanization on renewable energy consumption in China in a period from 1990-2012 and used as the Divisia decomposition method. The results evidenced that the urbanization increases the renewable energy consumption. Li and Lin (2015) studied the relationship between urbanization, industrialization, energy consumption and CO_2 emissions in 73 countries over the period of 1971–2010. The Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) was used. The outcomes indicated that in low-income countries the urbanization decreases the energy consumption and increase the CO_2 emissions. However, in low/middle-income and high-income countries the urbanization increase the energy consumption and emissions. Finally, in the middle-/high-income countries, the urbanization does not cause a significant impact on energy use. Shahbaz, et al., (2015) investigated the influence of urbanization on energy consumption in Malaysia. The research covers the period of 1970Q1 to 2011Q4. Then, the unit root test and Autoregressive Distributed Lag (ARDL) was used as a methodology. The results pointed to unidirectional causality between urbanization and energy consumption. Salim and Shafiei (2014) analyzed the impact of urbanization on renewable and non-renewable energy consumption in Organization for Economic Co-operation and Development (OECD) countries in a period from 1980-2011. The STIRPART model was used. The results revealed that the total population and urbanization have a positive influence on renewable and non-renewable energy consumption. Ghosh and Kanilal (2014) investigated the relationship between urbanization, energy consumption and economic activity in India, using threshold cointegration tests complemented by ARDL in a period from 1971–2008. The outcomes evidenced that the economic activity increases the urbanization and consequently has a positive influence on energy consumption. Al-mulali, et al., (2013) examined the relationship between energy consumption, urbanization, and CO_2 emissions in the Middle East and North African (MENA) region. The period studied was 1980-2009, and the ordinary least square (OLS) was used as a methodology. The authors found that there is a long-run a positive bi-directional relationship between energy consumption, CO_2 emissions, and urbanization in the region. Sadorsky (2013) investigated the impact of urbanization and industrialization on energy intensity in 76 developing countries followed over the years of 1980–2010. The ordinary least square (OLS) was used as a methodology. The author found that the urbanization has a positive impact on energy intensity. Solarin and Shahbaz (2013) examined the causal relationship between urbanization, electricity consumption and economic growth in Angola in a period from 1971-2009. The ARDL bounds test was applied as a methodology. There is a bidirectional relationship between urbanization and energy consumption in Angola. O'Neill, et al., (2012) studied the impact of urbanization on energy use in China and India in a period from 2000-2100. The integrated Population-Economy-Technology-Science (iPETS) model was used. The authors found that urbanization has a somewhat less than proportional effect on energy use. Al-mulali, et al., (2012) researched the relationship between urbanization, energy consumption and carbon dioxide emission in seven regions like Latin America and the Caribbean, Asia and Pacific, South Asia, Central Asia, East Europe, Western Europe, Sub-Sharan Africa, Middle East and North Africa in a period from 1980–2008, and for realization of this research was used the the fully modified ordinary least square (FMOLS). The results showed that the most countries studied have a positive bi-directional relationship between urbanization, energy consumption and CO_2 emissions in long-run. Shahbaz and Lean (2012) studied the relationship between financial development, energy consumption, industrialization, urbanization and financial development in Tunisia from 1971-2008. The ARDL model and Granger causality test was used as a methodology. The result confirmed the existence of long-run relationship between economic growth, financial development, urbanization, industrialization, and energy consumption in Tunisia. Poumanyvong and Kaneko (2010) investigated the relationship between energy used, urbanization and CO_2 emissions in 99 countries over the period 1975–2005. Indeed, the STIRPAT model was used. The results pointed that the urbanization decreases energy use in the low-income group, while it increases energy use in the middle- and high-income groups. Liu (2009) studied the relationship between urbanization and energy consumption in China over the period from 1978-2008, and the ARDL model was used. The results showed that there is a unidirectional relationship between urbanization and energy consumption in short-and long-run. Moreover, the urbanization has a smaller impact on energy consumption. Ewing and Rong (2008) examined the impact of urbanization on residential energy consumption in the United States in a period from 1990-2001. The OLS regression analysis was used to examine the influence of urbanization on residential energy consumption. The results suggested the urbanization has a negative impact on energy consumption. York (2007) analyzed the impact of demographic trends on energy consumption in fourteen European Union countries in a period of 1960-2000. The Prais–Winsten regression model with panel-corrected standard errors (PCSE) was used. The outcomes evidenced that the economic growth and urbanization contributes to energy consumption increase.

This article is organized as follows: Section 2, will present, the material and method. Section 3, the preliminary tests results. Section 4, the results. Section 5, discussions. Finally, the conclusions and policy implications are shown in Section 6.

2. 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.

2.1 MATERIAL

To analyze, the impact of urbanization on energy consumption, it was utilized the data from 1970 to 2015 of eight countries namely Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Mexico, and Venezuela. To realization of this analysis the following variables were used: (i) Primary energy consumption in Million tonnes oil equivalent, available in BP statistical; (ii) Gross Domestic Production (GDP) in constant local currency units (LCU), available in World Bank Data (WDB); (iii) Urban population available in World Bank Data (WDB). Table 1 shows the variables description and summary statistics.

Table 1. Variables description and summary statistics

Variables	Description	Descriptive Statistics				
		Obs	**Mean**	**Std Dev.**	**Min**	**Max**
LENERGY	Primary energy consumption in Million tonnes oil equivalent	368	3.4098	1.1539	0.2366	5.6957
LGDP	Gross Domestic Production (GDP) in constant local currency units (LCU)	367	10.6385	2.9446	7.2289	16.2150
LURBAN	Urban population	368	16.9449	0.9470	14.6847	18.9978

Notes: Obs denotes the number of observations; Std.-Dev denotes the Standard Deviation, Min. and Max. denote “Minimum” and “Maximum”, respectively. (L) denotes variables in natural logarithms.

All variables, except urban population, were transformed in *per capita* values. The use of *per capita* values let us control disparities in population growth among the Latin American countries (Fuinhas, et. al, 2017). Indeed, the GDP in local currency units (LCU) reduces the influence of exchange rates.

The first step in this study was the realization of preliminary tests namely: (a) Variance Inflation Factor (VIF) to verify the existence of multicollinearity between the variables;(b) Cross-section Dependence (CSD-test) (Pesaran, 2004) to check the existence of cross-section dependence among the variables. The null hypothesis of this test is the existence of cross-section independence;(c) Pesaran's CADF-test and 2^{sd} generation unit root test (CIPS-test) to identify the integration order of variables. The null hypothesis rejection of Pesaran's CADF-test is all series are non-stationary, and the CIPS-test is that all variables have a unit root or I (1) in the other words the variables are stationary; and (d) Hausman test (Hausman, 1978) specification test, which compares an estimator that is known to be consistent with an estimator that is efficient under the assumption being tested. This test will compare the Random Effects (RE) with Individual Fixed Effects (FE).

Thus, in the case of Random effects (RE), it applies the following specification test namely, (a) Breusch and Pagan Langrarian Multiplier test of independence (Breusch and Pagan, 1980) to measure whether the variances across individuals are correlated. Moreover, in the case of Fixed effects, it is necessary to apply (a) the Mean Group (MG) or Pooled Mean Group (PMG) estimators to check the heterogeneity of parameters both in the short and long-run. The MG it is a technique that creates regressions for each cross and computes and average coefficient to all individuals (Fuinhas, et. al, 2017). This estimator is consistent with the long-run average, but in the presence of slope homogeneity this estimator is not efficient (Pesaran et al., 1999). The PMG estimator makes restrictions among cross-sections and adjustment speed term. This estimator with the existence of homogeneity in the long-run is more efficient than the MG estimator (Fuinhas, et al. 2017); Indeed, after of heterogeneity test, it is necessary to apply the following specification tests namely (a) Friedman test (Hoyos and Sarafidis, 2006) to check the existence of contemporaneous

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correlation between cross-section; (b) Breusch and Pagan Langrarian Multiplier test of independence (Breusch and Pagan,1980) to verify whether the variances across individuals are correlated; (c) Wooldridge test (Wooldridge,2002) to check the existence of serial correlation; (d) Modified test (Greene,2002) to identified the existence of groupwise heteroscedasticity in the residuals of a fixed effect regression model; (e) Durbin-Watson statistic test, to verify the presence of the first-order autocorrelation in the disturbance when all the regressors are strictly exogenous. The null hypothesis of the test is that there is no first-order autocorrelation (Verbeek, 2008);(e) Baltagi-Wu LBI-test, to test serial correlation in the disturbance. The null hypothesis of no first-order serial correlation (Baltagi, 2008).

2.2 METHOD

The Autoregressive Distributed Lag (ARDL) in the form of Unrestricted Error Correction Model (UECM) to decompose the total effect of a variable into its short and long-run components, and Non-Linear Autoregressive Distributed Lag (NARDL) to examine the asymmetric responses of gross domestic product (GDP) *per capita* to primary energy consumption *per capita* (ENERGY) were applied to analyze the impact of urbanization on energy consumption in Latin America region. Thus, the general ARDL model follows the following equation:

$$\Delta LENERGY_{it} = \alpha_{0it} + \sum_{t=0}^{k}\phi_{2it}\Delta LGDP_{it} + \sum_{t=0}^{k}\phi_{3it}\Delta LURBAN_{it} + \gamma_{1it}LENERGY_{it} + \gamma_{2it}LGDP_{it} + \gamma_{3it}LURBAN_{it} + \mu_{1it} \quad (1)$$

Where, (ΔLENERGY and LENERGY*)* are the dependent variables in first-differences and levels, and (ΔLGDP, ΔLURBAN and LGDP, LURBAN) are the independent variables in the model in first-difference and levels. Indeed, the α_{0it} is the intercept, $\phi_{1it}...\phi_{5it}...\gamma_{1it}...\gamma_{5it}$ are the parameters of variables and μ_{1it} is the error term of the model. Indeed, introducing the short- and long-run asymmetries in the standard ARDL model leads to the following general form of the nonlinear NARDL model:

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$$\Delta LENERGY_{it} = \alpha_{0it} + \sum_{t=0}^{k} \phi_i^{+} \Delta LGDP_{t-1}^{+} + \phi_i^{-} \Delta LGDP_{t-1}^{-} + \sum_{t=0}^{k} \phi_{i}\, \Delta LURBAN_{t-1} \quad (2)$$
$$+ \gamma_{1it} LENERGY_{it} + \gamma_i^{+} LGDP_{t-1}^{+} + \gamma_i^{-} LGDP_{t-1}^{-} + \gamma_i LURBAN_{t-1} + \mu_{1it}$$

Where, (ΔLENERGY and LENERGY*)* are the dependent variables in first-differences and levels, and ($\Delta LGDP_{t-1}^{+}, \Delta LGDP_{t-1}^{-}$ and $LGDP_{t-1}^{+}, LGDP_{t-1}^{-}$) are the positive and negative asymmetries, and (ΔLURBAN and LURBAN) are the independent variables in the model in first-difference and levels. Then, the α_{0it} is the intercept, $\phi_i^{+} \ldots \phi_i^{-} \ldots \gamma_{-}^{+} \ldots \gamma_i^{-}$ are the positive and negative parameters of asymmetries, and μ_{1it} is the error term of the model.

3. PRELIMINARY TEST RESULTS

This section shows the preliminary tests on data to check the proprieties of variables. The VIF-test and CDS-test were applied to check the presence of multicollinearity and existence of cross-section dependence. The results of both tests can be seen in Table 2.

Table 2. VIF-test and CSD-test

Variables	VIF	1/VIF	CD-test	p-value		Corr	Abs (corr)
LENERGY	n.a		34.05	0.0000	***	0.951	0.951
LGDP	1.00	0.9999	20.80	0.0000	***	0.579	0.642
LURBAN	1.00	0.9999	35.75	0.0000	***	0.999	0.999
Mean VIF	1.00						
ΔLENERGY	n.a		4.88	0.0000	***	0.138	0.182
ΔLGDP	1.00	0.9987	9.44	0.0000	***	0.267	0.277
ΔLURBAN	1.00	0.9987	33.30	0.0000	***	0.941	0.941
Mean VIF	1.00						

Notes: The Stata command "*xtcd"* was used. n.a denotes (not available). *** denotes 1% of significance.

The results of VIF-test appoint to the existence of low multicollinearity, where the "Mean VIF" is 1.00 in variables in levels and first-differences. The outcomes of VIF-test bellow than the benchmark of 5 %. The CDS-test evidence the existence of cross-section in all variables in levels and first-differences. The existence of cross-section means which countries share the same characteristics. In fact, in the existence of cross-section dependence, it is

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necessary to examine the stationarity of variables. Table 3 shows the outcomes of Pesaran's CADF-test and 2nd generation unit root test.

Table 3. Unit roots tests

Variables	Pesaran's CADF-test PESCADF (Zt-bar) non-trend		trend		2nd Generation unit root tests CIPS (Zt-bar) non-trend		trend	
LENERGY	-0.987		0.151		0.170		0.615	
LGDP	-0.780		-1.516	*	0.218		0.065	*
LURBAN	0.758		-5.467	***	0.689		0.000	***
ΔLENERGY	-7.896	***	-7.917	***	0.000	***	0.000	***
ΔLGDP	-6.786	***	-5.792	***	0.000	***	0.000	***
ΔLURBAN	-4.651	***	-2.886	***	0.000	***	0.002	***

Notes: ***, * denotes statistically significant at 1% and 10 % level. The Pesaran's CADF-test has H_0: series are I (0). The CIPS test has H_0: series are I(1). To compute the CIPS test was used the Stata command "*multipurt*" and PESCADF was used "*pescadf".*

The outcomes of Pesaran's CADF-test and CIPS-test indicate that the variables in levels (LGDP and LURBAN) with "trend" are I (1). Indeed, the Pesaran's CADF-test and CIPS-test indicate that all variables in first-differences with "trend" and "non-tend" are I (1). To determine whether the panel has random or fixed effects, the Hausman test was performed (see Table 4).

Table 4. Hausman Test

Variables	(b) Fixed	(B) Random	(b-B) Difference	Sqrt(diag(V_b-V-B)) S.E.
TREND	-0.0013	0.0000	-0.0013	0.0007
ΔLGDP	0.6079	0.6190	-0.0110	0.0139
ΔLURBAN	1.9531	1.3770	0.5761	0.8943
LENERGY	-0.1156	0.0007	-0.1164	0.0214
LGDP	0.1027	-0.0010	0.1037	0.0204
LURBAN	0.1813	-0.0011	0.1825	0.0529
CONSTANT	-3.7595	0.0211	-3.7806	0.9900
Chi2 (5)	35.68 ***			

Notes: *** denote statistical significance level of 1%. To compute the Hausman Test the "*constant*" was used.

To identify the presence of Random Effects (RE) or Fixed Effects (FE) in the model, the Hausman test was applied. This test has the null hypothesis that the best model is RE. The results of Hausman test is statistically significant

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Chi2 (5)= 35.68 at 1 %. This result indicated to select the FE model. Then, after the choice of FE model, the equations (1) is converted in Equations (3) by changing μ_{1it} for $\theta_i + \beta_{it}$ representing the FE model.

$$\Delta LENERGY_{it} = \alpha_{0it} + \sum_{t=0}^{k} \phi_{2it} \Delta LGDP_{it} + \sum_{t=0}^{k} \phi_{3it} \Delta LURBAN_{it} + \gamma_{1it} LENERGY_{it} + \gamma_{2it} LGDP_{it} + \gamma_{3it} LURBAN_{it} + \theta_i + \beta_{it} \quad (3)$$

Where, (ΔLENERGY and LENERGY*)* are the dependent variables in first-differences and levels, and (ΔLGDP, ΔLURBAN and LGDP, LURBAN) are the independent variables in the model in first-difference and levels. Indeed, the α_{0it} is the intercept, $\phi_{1it}...\phi_{5it}...\gamma_{1it}...\gamma_{5it}$ are the parameters of variables and is $\theta_i + \beta_{it}$ the error term of FE model.

4. RESULTS

The heterogeneity of parameter slopes was assed testing the Mean Group (MG), and the Pooled Mean Group (PMG) against the FE estimator. The decision about the most suitable model is done by computing a Hausman test.Table 5 shows the results of the estimations for the MG, PMG and FE models, as well as the outcome of the Hausman tests.

Table 5. Heterogeneous estimators and Hausman tests

	(Dependent Variable ΔLENERGY)		
	MG	PMG	DFE
Constant	-14.0142 ***	-7.7595 ***	-3.7595 ***
TREND	-0.0085 **	-0.0012	-0.0013 *
ΔLGDP	0.6263 ***	0.5690 ***	0.6080 ***
ΔLURBAN	0.4950	2.0938	1.9532 **
ECM	-0.4211 ***	-0.3051 ***	-0.1156 ***
LGDP (-1)	1.1206 ***	0.8702 ***	0.8881 ***
LURBAN (-1)	1.7583 ***	1.1397 ***	1.5682 ***
	MG vs PMG	PMG vs DFE	MG vs DFE
Hausman tests	Chi2(6) = -3.18	Chi2(6) = 18.48***	Chi2(6) = 30.16***

Notes: ***,**,* denotes significant at 1%,5 %, and 1 % levels 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 options, alleqs) was used.

The FE estimator is appropriate, indicating that the panel is homogeneous. This result suggests that the urban population share common coefficients, and can be treated as a group. The Hausman tests support panel homogeneity, i.e. that FE is the better model. To back up the significance of FE parameters, a

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battery of specification test were implemented namely Friedman test to check the existence of contemporaneous correlation between cross-section; Breusch and Pagan Langrarian Multiplier test of independence to verify whether the variances across individuals are correlated; Wooldridge test to check the existence of serial correlation; Modified test to identified the existence of groupwise heteroscedasticity in the residuals of a fixed effect regression model; Durbin-Watson statistic test, to verify the presence of the first-order autocorrelation in the disturbance when all the regressors are strictly exogenous; Baltagi-Wu LBI-test, to test serial correlation in the disturbance. Table 6 shows the results of specification tests.

Table 6. Specification tests

	Friedman test	Breusch and Pagan LM test	Modified test	Wooldridge's test
Statistics	24.021***	n.a	chi2 (8) = 159.19***	F (1,7) =55.048***
	Durbin-Watson test	Baltagi-Wu LBI-test		
	2.2210***	2.2432***		

Notes: ***, denotes significant at 1% levels, respectively; results for H_0 of Modified Wald test: sigma(i)^2 = sigma^2 for all I; results for H_0 of Pesaran's test: residuals are not correlated; results for H_0 of Wooldridge test: no first-order autocorrelation; Friedman's: cross-sectional independence in the residuals; The Stata command "*xtregar"* was used in the Durbin-Watson statistics test and Baltagi-Wu LBI test: The null hypothesis of the Durbin-Watson statistics test is that there is no first-order autocorrelation, and Baltagi-Wu LBI test the null hypothesis of no first order serial correlation.

The specification tests (Table 6) points to the presence of cross-section dependence, the presence of the first-order autocorrelation, the presence of heteroscedasticity in the residuals and first-order correlation in the disturbance and serial correlation in the disturbance. The Breusch-Pagan LM test has the hypothesis that the residuals are correlated cannot be carried out, given that correlation matrix of residuals is singular.

Thus, in the presence of heteroskedasticity, first-order autocorrelation, contemporaneous correlation, and cross-section dependence in the context of a long-time span, the Driscoll and Kraay estimator needs to be used (Koengkan, 2017; Fuinhas, et al.,2017).The Driscoll and Kraay estimator generates robust standard errors for several phenomena found in the sample errors. The FE estimator, FE robust (to control for the heteroskedasticity) and FE Driscoll and Kraay (FE D.-K.) are shown in Table 7.

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Table 7. Estimation results

	Dependent Variable ΔLENERGY			
	FE		FE Robust	FE D.-K.
Constant	-3.7595	***	**	***
TREND	-0.0013	*		**
ΔLGDP	0.6080	***	***	***
ΔLURBAN	1.9532	**	*	*
LENERGY (-1)	-0.1156	***	***	***
LGDP (-1)	0.1027	***	**	***
LURBAN (-1)	0.1814	***	**	***
	Statistics			
N	359		359	359
R^2	0.4298		0.4298	
R^2_a	0.4084		0.4201	
F	43.3495		396.7690	78.3204

Notes: ***, **, * denote significant at 1%,5%, and 10% level, respectively; and the Stata commands "*xtreg*", and "*xtscc*" were used.

Table 8 shows the short-run (semi-elasticities) and long-run (elasticities) for the models FE, FE robust and FE Driscoll and Kraay (FE D.-K.). Indeed, in the long-run elasticities were not observed directly on the estimates. Moreover, they must be computed by dividing the coefficient of the variables by the coefficient of LENERGY, both lagged once and multiplying the ratio by -1 (Fuinhas, et al.,2017).

Table 8. Elasticities, semi-elasticities, impacts, and adjustment speed

	FE		FE Robust	FE D.-K.
Constant	-3.7595	***	**	***
TREND	-0.0013	*		**
ΔLGDP	0.6080	***	***	***
ΔLURBAN	1.9532	**	*	**
LGDP (-1)	0.8881	***	***	***
LURBAN (-1)	1.5682	***	***	***
ECM	-0.1156	***	***	***

Notes: ***, **,* denote statistically significant at 1%,5% and 10% levels, respectively. ECM denotes the coefficient of the variable LENERGY lagged once.

The results of elasticities and semi-elasticities are appropriate, given that there are dissimilar effects on the short- and long-run. Indeed, the ECM values are low, slightly above 1% (see Table 8), implying that shocks need a longer adjustment time to return to equilibrium (Fuinhas, et al., 2017).

Additionally, to examine the asymmetric responses of gross domestic product (GDP) *per capita* to primary energy consumption *per capita* (ENERGY) both the short and long-run, the Nonlinear ARDL model was used. Table 9 shows the estimation results of nonlinear ARDL model.

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Table 9. Estimation results of Nonlinear ARDL model

	FE		FE Robust	FE D.-K.
Constant	-3.6115	***	**	***
TREND	-0.0034	**		***
ΔLGDP_POS	0.5961	***	***	***
ΔLGDP_NEG	0.6144	***	***	***
ΔLURBAN	1.3079	***		
LGDP_POS	1.1844	***	***	***
LGDP_NG	0.7202	***	**	***
LURBAN	1.7413	***	**	***
ECM	-0.1205	***	***	***

Notes: ***, ** denote statistically significant at 1% and 5% level, respectively. The ECM denotes the coefficient of the variable "LENERGY" lagged once.

The nonlinear ARDL model showed that the outcomes of dynamic panel techniques are consistent and short-and long-run, and confirms that the ECM is low slightly above 1 % implying that shocks need a longer adjustment time to return to equilibrium.

5. DISCUSSION

The analysis of the influence of urbanization on energy consumption in Latin American countries extends the approach to urbanization-energy nexus. The results of the analysis are based on per capita values. Indeed, results of preliminary tests indicate the existence of low multicollinearity and existence of cross-section dependence, where the countries in the study share the same characteristics. Moreover, the specification tests (See Table 6) indicate the presence of cross-section dependence where the Friedman test is statistically significant at 1 % (24.021***). The Breusch and Pagan LM test cannot be carried out, due to the correlation matrix of residuals are singular. The Modified test points to the presence of heteroscedasticity in the residuals, where the outcome is statistically significant at 1 % (chi2 (8) = 159.19***). The Wooldridge's test evidence the presence of existence of the first-order autocorrelation, where the (F (1,7) =55.048***) is statistically significant at 1 %. Finally, the Durbin-Watson test and Baltagi-Wu LBI-test indicates the presence of first-order correlation in the disturbance and serial correlation in the disturbance due to the significance of results. The specification tests results are in line with some authors that studied the Latin American countries and applied the same tests (e.g. Koengkan, 2017; Fuinhas, et al.,2017).

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The results of ARDL model (See Table 8) indicates that the variable economic growth in short-run (semi-elasticities) increase the energy consumption in 0.6080 % and in long-run (elasticities) increase 0.8881 %. The variable urbanization short-run (semi-elasticities) increase the energy use in 1.9532 % and in long-run (elasticities) increase 1.5682 %. Moreover, the outcomes of NARDL model (See Table 9) evidence that the in short-run asymmetric responses the economic growth (positive/negative asymmetric) has a positive impact of 0.5961 % and 0.6144 % respectively, and in long-run asymmetric the variable influence positively in 1.1844 % and 0.7202 % respectively. The variable urbanization cannot be transformed in asymmetric variable due to the omission of the variable in negative asymmetric. Then, the variable urbanization in short-run (semi-elasticities) has a positive influence of 1.3079 % and in long-run (elasticities) a positive influence of 1.7413 %. In fact, the outcome of NARDL model is more significant than ARDL model.

Thus, the positive influence of economic growth on energy consumption is in line with several authors that studied the Latin American countries (e.g. Rodríguez-Caballero and Ventosa-Santaulària, 2017; Koengkan, 2017; Pablo-Romero and Jésus, 2016; Pastén et al.,2015).Certainly, according to Pablo-Romero and Jésus (2016) the positive impact of economic growth on energy used in Latin America region, it is due to the energy consumption is very sensitive to changes in economic growth in these countries, where this tends to show a rapidly growth trend as their economies growth showing an exponential energy consumption growth. Thus, the Latin American countries show economic growth, they are demanding an even greater increase in energy use. Indeed, Koengkan (2017), complements that the total factor productivity caused by economic growth that influences the energy demand. Then, these results suggest a positive relationship between economic growth and energy consumption in short-and long-run.

The positive impact of urbanization on energy consumption is in line with (e.g.Al-mulali, et al.,2012) that studied the Latin American countries and others several authors that studied this relationship (e.g. Fan, et al.,2017; Bilgili, et al., 2017; Yang, et al., 2016; Shahbaz, et al., 2015; Salim and Shafiei ,2014; Ghosh and Kanilal,2014;Al-mulali, et al., 2013; Sadorsky,2013; Solarin and Shahbaz

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,2013; Shahbaz and Lean ,2012; York ,2007).Indeed, according to Fan, et al. (2017) the positive impact of urbanization on energy consumption it is related with a positive influence of urbanization on the popularity of household appliances and the pursuit of private transport, where the increase of household appliances and private transport increase consequently the energy consumption. To Yang, et al., (2016) the urbanization has different stages of impact on renewable energy consumption. Firstly, the urbanization process, promote the industrial structure, improve the energy demand structure, c, upgrade traditional industries, change of production mode and expand the service industry. Secondly, the urbanization, change the life style is to set up the public's awareness of ecological civilization and change the unreasonable life style. Finally, Shahbaz, et al. (2015) complements that the movement of people from rural to urban has a positive impact on the economy, where this movement makes the economic transition from agriculture to industrialization economy and consequently increase the energy demand.

Lastly,this research also shows that the ECM parameter of ARDL model and NARDL are statistically significant at 1 % and negative (See Table 8 and 9). Then, this result is in line with some authors that studied the Latin American countries and that used the ARDL methodology (e.g, Fuinhas, et al.,2017, and Koengkan, 2017). Thus, when an ECM parameter is statistically significant, it is identical the realization of Granger causality test (Fuinhas, et al.,2017). Furthermore, the error correction version of Granger Causality and Cointegration can ensure that both the magnitude of the effects and causality are revealed by elasticities of themselves.

6. CONCLUSIONS AND POLICY IMPLICATIONS

The impact of urbanization on energy consumption was analyzed in this article. The study focused in eight Latin American countries from 1970 to 2015, using Autoregressive Distributed Lag (ARDL) in the form of Unrestricted Error Correction Model (UECM) and Non-Linear Autoregressive Distributed Lag (NARDL). The initial tests proved the existence of low multicollinearity and existence of cross-section dependence, where the countries in the study share the same characteristics.

The battery of model specification tests pointed the presence of cross-section dependence, the presence of the first-order autocorrelation, the presence of heteroscedasticity in the residuals and first-order correlation in the disturbance and serial correlation in the disturbance. The results showed that in the ARDL model the economic growth in short-and long-run increase the energy consumption and the variable urbanization in short-and long-run has a positive impact on energy used. Moreover, the outcomes of NARDL model showed that in short-and long-run asymmetric responses the economic growth (positive/negative asymmetric) has a positive impact on energy. Thus, the variable urbanization cannot be transformed in asymmetric variable due to the omission of the variable in negative asymmetric. Then, the variable urbanization in short-and long-run has a positive on energy consumption. In fact, the outcome of NARDL model is more significant than ARDL model.

These evidences point to the necessity to create conservation policies oriented to reduce the energy intensity level, with the introduction of new technologies that reduce the energy consumption in the industries and houses, change the current energy matrix to a more sustainable, due to some countries in Latin America are dependents of fossil fuels like Argentina, Brazil, Colombia, Ecuador, Mexico, Peru, Venezuela and Chile, as well as for the need to develop new renewable policies to promotes economic growth and environmental sustainability and also create subsidy policies encouraging consumers to purchase an appliance with high energy efficiency standards to reduce the energy consumption. Finally, the create some policies for restraining residents' behaviors are needed such as raising the gasoline prices, tiered pricing for electricity, specifying the lowest temperature of air conditioner in summer and incentives for self-generation of renewable energies.

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