THE NEXUS BETWEEN ENERGY CONSUMPTION, ECONOMIC GROWTH, AND URBANIZATION IN LATIN AMERICAN AND CARIBBEAN COUNTRIES: AN APPROACH WITH PVAR MODEL

O NEXO ENTRE CONSUMO DE ENERGIA, CRESCIMENTO ECONÔMICO E URBANIZAÇÃO NOS PAÍSES DA AMÉRICA LATINA E DO CARIBE: UMA ABORDAGEM COM MODELO PVAR

EL NEXO ENTRE EL CONSUMO DE ENERGÍA, EL CRECIMIENTO ECONÓMICO Y LA URBANIZACIÓN EN LOS PAÍSES DE AMÉRICA LATINA Y EL CARIBE: UN ENFOQUE CON EL MODELO PVAR

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Abstract
The nexus between energy consumption, economic growth and urbanization were analyzed for a panel of twenty-one Latin American and Caribbean countries over a period from 1980-2014. The Panel Data Vector Autoregressive (PVAR) was used in order to analyze the relationship among all variables. The results indicated that there is a unidirectional relationship between urbanization and energy consumption, and a bidirectional nexus among economic growth and energy consumption in Latin America and Caribbean region.
Keywords: Energy, econometric, energy economics, economy, energy conservation, applied economics

Resumo
O nexo entre consumo de energia, crescimento econômico e urbanização foi analisado para um painel de vinte e um países da América Latina e do Caribe durante um período de 1980 a 2014. O *Panel Data Vector Autoregressive* (PVAR) foi usado para analisar a relação entre todas as variáveis. Os resultados indicaram que existe uma relação unidirecional entre a urbanização eo consumo de energia e um nexo bidirecional entre o crescimento econômico e o consumo de energia na região da América Latina e do Caribe.
Palavras-chave: Energia, econometria, economia da energia, economia, conservação de energia, economia aplicada

Resumen
El nexo entre consumo de energía, crecimiento económico y urbanización fue analizado para un panel de veintiún países de América Latina y el Caribe durante un período de 1980 a 2014. El *Panel Data Vector Autoregresive* (PVAR) fue utilizado para analizar la relación entre todas las variables. Los resultados indicaron que existe una relación unidireccional entre la urbanización y el consumo de energía y un nexo bidireccional entre el crecimiento económico y el consumo de energía en la región de América Latina y el Caribe.
Palabras clave: Energía, econometría, economía de la energía, economía, conservación de la energía, economía aplicada

INTRODUCTION

The consumption of energy in Latin America and the Caribbean have more than tripled over the past forty years. In 1971 the energy demand was 248 Million of Tonnes of Oil Equivalent (MTOE) and 848 MTOE in 2013. This growth representing 8 % of the increase in global energy demand over this period (Balza et al. 2015). This increase is due to economic growth in the region, where the average annual grew of 3.4 % of Latin America and Caribbean's GDP between 1971 to 2013, increased the primary energy use by 3.0 % and electricity consumption by 5.4% (Balza et al.2015). Beyond economic growth, the urbanization has a positive influence on energy demand in Latin America and Caribbean region. Amid 1975 to 2007 the rate of urbanization in the region increased 0.78%, and between 2007 to 2025 will growth 0.36%. This increase results in a growth of energy consumption in until 1 % (Yang et al. 2016). The aim of this article is to investigate the nexus between energy consumption, economic growth, and urbanization in Latin America and Caribbean region over a period from 1980 to 2014. For this, the Panel Data Vector Autoregressive (PVAR) methodology developed by Holtz-Eakin et al. (1988) will be applied. Moreover, the choice to use the PVAR model is based on a flexible econometric approach that allows the decomposition of the total effects of components. Indeed, this model allows that all variables be treated as endogenous and interdependent, although identifying restriction based on theoretical model (Abrigo and Love, 2015). Moreover, the PVAR model is an excellent way to model the manner in which shocks are transmitted across countries (Koop and Korobilis, 2016).

The study of the nexus between economic growth and energy consumption have been explored by several studies in the literature. For example, Koengkan (2017a) investigated the impact of globalization, economic growth on primary energy consumption in twelve Latin American countries over a period from 1991-2012. The Autoregressive Distributed Lag (ARDL) methodology was used. The empirical results pointed that the globalization and economic growth have a positive impact on primary energy consumption. Kahia et al. (2017) studied the nexus between renewable, non-renewable energy consumption and economic growth in the Middle East and North African (MENA) countries during a period of1980-2012. The results pointed to the existence of a bidirectional relationship between economic growth, renewable, and non-renewable energy consumption. Kais and Mbarek (2017) researched the dynamic relationship between CO_2 emissions, energy growth and economic growth in three North Africa countries during 1980-2012. The Vector Error Correction (VEC) model was used. The outcomes pointed to the existence of a unidirectional relationship between economic growth and energy consumption. Gaspar et al. (2017) compared a sustainable development approach, using the ISEW, with the traditional economic growth approach using economic growth, and its relationship with energy consumption in twenty European countries over a period from 1995-2014. The results indicated a conservative hypothesis for economic growth with energy consumption. Özokcua and Özdemir (2017) investigated the relationship between environmental degradation, energy consumption and economic growth in 26 Organization for Economic Co-operation and Development (OECD) countries in a period from 1980 to 2010. The panel data estimation techniques with the application of Driscoll-Kraay Standard Errors were used. The results pointed to the existence of a positive relationship between economic growth and energy consumption in the studied countries. Antonakakis et al. (2017) examined the dynamic relationship between economic growth, energy consumption and environmental degradation in 106 countries over the period 1971–2011, and the Panel Data Vector Autoregressive (PVAR) was used. The results showed the existence of a bidirectional nexus between economic growth and energy consumption. Koçak and Şarkgüneşi (2017) explored the nexus between economic growth and renewable energy consumption in nine the the Black Sea and Balkan countries in a period of 1990–2012. The panel causality estimation technique was used. Then, the results pointed that there is a long-term balance relationship between renewable energy consumption and economic growth, and also the renewable energy consumption has a positive impact on economic growth. Tang et al. (2016) studied the nexus between economic growth and energy consumption in China over a period of 1987 to 2007. The results pointed the existence of a nexus between economic growth and energy consumption. Ahmed and Azam (2016) investigated the causal nexus between energy consumption and economic growth for 119 countries in the world over last 30 years. The results suggested the existence of feedback nexus between energy consumption and economic growth. Magazzino (2016) examined the nexus among CO_2 emissions, energy consumption and economic growth in Italy over a period of 1970–2006. The author concluded to the existence of non-causality between variables. Indeed, in the literature, some authors investigated the relationship between urbanization and energy consumption. Bilgili et al. (2017) studied the nexus between urban population intensity and energy consumption in ten Asian countries in a period from 1990 to 2014 and utilized the environmental Kuznets curve (EKC) model. The results pointed that the urbanization has a positive impact on energy consumption. Fan et al. (2017) investigated the relationship between CO_2 emissions, energy consumption and urbanization in China in a period of 1996-2012. The Divisia decomposition methodology was used. The outcomes pointed that the urbanization influences the residential energy consumption in 15.4%. Yang et al. (2016) examined the influence of urbanization on renewable energy consumption in China over a period of 1990 to 2012. The Devisia decomposition method was used. The results suggested that the urbanization increases the renewable energy consumption. Shahbaz et al. (2015) explored the impact of urbanization on energy consumption in Malaysia over a period of 1970Q1-2011Q4. The Autoregressive Distributed Lag (ARDL) was used as methodology. The outcomes pointed to the existence of a unidirectional relationship between urbanization and energy consumption. Li and Lin (2015) examined the nexus between industrialization, energy consumption, urbanization and CO_2 emissions in 73 countries over a period of 1971-2010. The Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) was used as methodology. The authors reached a conclusion that the urbanization does not cause any impact on energy consumption. Ghosh and Kanilal (2014) studied the relationship between energy consumption, economic growth, and urbanization in India over a period of 1971 to 2008. The ARDL methodology was used. The outcomes evidenced that the economic growth and urbanization increase the energy consumption. Salim and Shafiei (2014) analyzed the influences of urbanization on renewable energy and non-renewable energy consumption in OECD countries in a period from 1980-2011 and the STIRPART model was used. The authors found that the urbanization has a positive impact on renewable and non-renewable energy consumption. Solarin and Shahbaz (2013) examined the relationship between energy consumption, economic growth, and urbanization in Angola over a period of 1971 to 2009. The ARDL model was used a methodology. The results pointed to existence of a bidirectional relationship between urbanization and energy consumption. Sadorsky (2013) studied the impact of industrialization and urbanization on energy consumption in 76 countries over a period of 1980 to 2010. The Ordinary Least Square (OLS) was used as methodology. The empirical results suggested that the urbanization has a positive impact on energy consumption. Al-mulali et al. (2013) analyzed the nexus between CO_2 emissions, energy consumption, and urbanization in MENA region, over a period of 1980 to 2009. The OLS model was used as methodology. The authors discovered that there is a bidirectional relationship between energy consumption, urbanization and CO_2 emissions. Al-mulali et al. (2012) researched the nexus between energy consumption, CO_2 emissions, and urbanization in seven regions in the world namely: Asia and Pacific, Central Asia, East Europe, Middle East , North Africa, Latin America and the Caribbean, South Asia, Western Europe and Sub-Sharan Africa over a period of 1980 to 2008. The Fully Modified Ordinary Least Square (FMOLS) was used as methodology. The authors found the existence of a bidirectional relationship between urbanization, energy consumption, and emissions. Shahbaz and Lean (2012) studied the relationship between energy consumption, industrialization, urbanization, financial development in Tunisia over a period of 1971 to 2008. The ARDL model was used as methodology. The results confirmed that the urbanization raises the energy consumption. Poumanyvong and Kaneko (2010) investigated the relationship between urbanization, energy consumption and CO_2 emissions over 99 countries in a period from 1975-2005. The results pointed that the urbanization reduces the energy consumption. Liu (2009) researched the impact of urbanization on energy consumption in China over a period of 1978 to 2008. The results showed the existence of a unidirectional relationship between energy consumption and urbanization.

Indeed, for studies that approach the relationship between energy consumption, economic growth, and urbanization, there are a significant polity implications. The economic growth and urbanization process are a key to the governments investigate this relationship, and help create new policies that reduce the emissions at the same time that promotes the development. Moreover, that the finding of this study not only help to advance the literature existing, but also warrant attention from policymakers. This article is organized as follows: Section 2, will present, the data, methodology and conceptual framework. Section 3, the preliminary tests results. Section 4, the results. Section 5, discussions. Finally, the conclusions and policy implications are shown in Section 6.

Data, methodology and conceptual framework

This section is divided into three parts. In the first part, the data used is presented; In the second part, the methodology is set out, and the third part the conceptual framework.

Data

To analyze the nexus between economic growth, energy consumption and urbanization, twenty-one Latin American and Caribbean countries were used, namely: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Trinidad and Tobago, Uruguay, and Venezuela in the period from 1980 to 2014. The variables used in the analysis were: (i) Gross Domestic Production (GDP) in constant local currency units (LCU), available in World Bank Data (WBD); (ii) Primary energy consumption in Billion kWh from oil, gas, coal, wind, hydro, wind, photovoltaic, wave, waste and biomass available in International Energy Administration (IEA); (iii) Urban population available in World Bank Data (WDB). Table 1 shows the variables description, source, and summary statistics.

Table 1. Variables description and summary statistics

Variables	Description	Source	Descriptive Statistics				
			Obs	Mean	Std Dev.	Min	Max
LGDP	Logarithm of Gross Domestic Production (GDP)	WBD	733	10.5893	2.7029	6.7691	16.1938
LENERGY	Logarithm of primary energy consumption	IEA	735	-17.0991	0.8838	-18.8181	-14.1570
LURBAN	Logarithm of urban population	WBD	735	15.5397	1.5252	11.5548	18.9772

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.

The use of *per capita* values let us control the disparities in population growth between the Latin American and Caribbean countries (Fuinhas et. al. 2017; Koengkan, 2017a;Koengkan, 2017b).

Moreover, all variables, except urban population were transformed in *per capita* values, and the GDP in local currency units (LCU) reduces the influence of exchange rates. To realization of econometric analyses, the Stata 14.2 and EViews 9.5 software were used.

Methodology

To analyze the relationship between all variables, the Panel Data Vector Autoregressive (PVAR) was used. Thus, the general PVAR model follows the following equation:

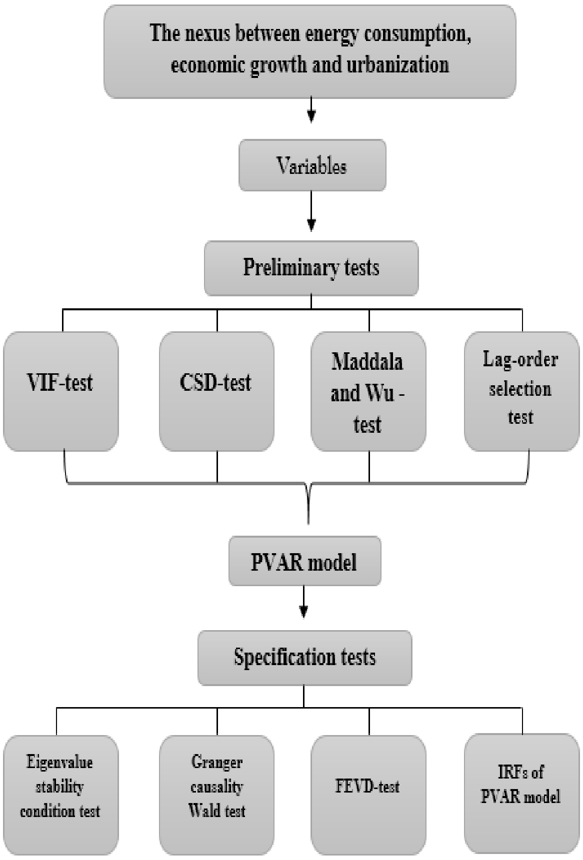
$$\mathit{\Delta}_{it} = \mathit{\Delta}_{it-1} A_1 + \mathit{\Delta}_{it-2} \mathit{\Delta}_2 + \cdots + \mathit{\Delta}_{it-p+1} A_{p-1} + \mathit{\Delta}_{it-p} A_p + X_{it} B + u_i + e_{it} \qquad (1)$$

Where $\mathit{\Delta}_{it}$ is a vector of dependent variable; X_{it} is a vector of exogenous covariates; u_i and e_{it} are a vector of dependent variable-specific panel fixed-effects and idiosyncratic errors, respectively (Koengkan et al. 2017).The matrices $A_1, A_2, \ldots, A_{p-1}, A_p$ and B are parameters to be estimated.

Conceptual framework

The main purpose of this study is to examine the nexus between energy consumption, economic growth, and urbanization in Latin American and Caribbean countries. In addition, a conceptual framework was created to highlight the methodological framework that will be used in PVAR model. Figure 1, shows the conceptual framework.

Figure 1. Conceptual framework



Notes: The conceptual framework was created by author.

Then, before performing the regression of model it is necessary to verify the proprieties of variables. For this some preliminary tests were applied namely: (i) Variance Inflation Factor (VIF) to checks the presence of multicollinearity among the variables; (ii) Cross-section Dependence (CSD-test) (Pesaran, 2004) to checks the existence of cross-section dependence in variables; (iii) Maddala and Wu (1999) to verified the existence of unit roots in variables. The null hypothesis rejection of this test is that all variables are stationary I (1); (iv) Lag-order selection statistics for PVAR (Hansen,1982).

Additionally, the best econometric practices strongly recommend to apply the following specification tests namely: (i) Eigenvalue stability condition to identification of stability in PVAR model (Abrigo and Love,2015); (ii) Granger causality Wald test to analyzes the causal relationship between variables (Abrigo and Love,2015); (iii) Forecast-error variance decomposition (FEVD) (Abrigo and Love, 2015); (iv) Impulse-response function to analyze the IRFs of PVAR model (Abrigo and Love, 2015).

Preliminary tests

To check the proprieties of the variables, the Variance Inflation Factor (VIF) test and Pesaran CD test were performed in order to verify the presence of multicollinearity and cross-section dependence. The results of both tests can be seen in Table 2.

Table 2. VIF test and Pesaran CD test

Variables	VIF	1/VIF	CD-test	p-value		Corr	Abs (corr)
LGDP	n.a	n.a	64.98	0.000	***	0.759	0.763
LENERGY	1.01	0.9890	51.74	0.000	***	0.605	0.706
LURBAN	1.01	0.9890	80.17	0.000	***	0.937	0.937
Mean VIF	1.01						
ΔGDP	n.a	n.a	24.39	0.000	***	24.39	0.289
ΔENERGY	1.00	0.9999	9.15	0.000	***	9.15	0.108
ΔURBAN	1.00	0.9999	55.24	0.000	***	55.24	0.681
Mean VIF	1.00						

Notes: *** denotes statistical significance level of 1%. The Stata command *xtcd* was used. Hereafter the prefixes (L) and (Δ), denote natural logarithms, and first differences of the variables, respectively.

The outcomes of VIF-test indicated to the existence of low-multicollinearity among the variables. The "Mean" of variables in levels (logarithms) was 1.01 and the first-differences 1.00. Thus, the VIF statistics than the benchmark of 10 % support that multicollinearity is not a great concern. Then, in the existence of cross-section dependence, it is necessary to apply the Maddala and Wu (1999) to check the presence of unit root on variables. Table 3 shows, the outcomes of unit roots test.

Table 3. Unit roots test

Variables	Maddala and Wu-test					
	Non-TREND			TREND		
	Zt-bar	p-value		Zt-bar	p-value	
LGDP	9.676	0.000	***	123.134	0.000	***
LENERGY	31.646	0.878		78.790	0.001	***
LURBAN	107.768	0.000	***	61.600	0.026	**
ΔGDP	263.461	0.000	***	226.725	0.000	***
ΔENERGY	422.757	0.000	***	330.239	0.000	***
ΔURBAN	61.220	0.028	**	78.691	0.001	***

Notes: ***,** denote statistical significance levels of 1% and 5%. The Stata command *multipurt* was used. The lag length (1) was used.

The Maddala and Wu test indicated that the variables in levels (logarithms) and the first-differences with "Non-TREND" and "TREND" are I(1), except the variable LENERGY that is I(0), in other words, it is non-stationary. Then, to calculate the lag-order selection, the overall coefficient of determination (CD), Hansen´s J statistic (J), p- value (Jp-value), MBIC, MAIC, and MQIC were computed. The used a maximum of four lag, totalizing 586 observations, 21 panels and an average of number T of 27.905. Table 4 shows the results of lag order selection on estimation.

Table 4. Lag order selection on estimation

Lags	CD	J	Jp-value	MBIC	MAIC	MQIC
1	0.9711	36.7338	0.4346	-192.7057	-35.2661	-96.6188
2	0.9684	20.9194	0.7900	-151.1602	-33.0805	-79.0950
3	0.9738	12.7645	0.8053	-101.9552	-23.2354	-53.9117
4	0.9626	8.5570	0.4791	-48.80287	-9.4429	-24.7811

Notes: The Stata the command *pvarsoc* was used.

The estimations result of the Hansen´s J statistic (J) is higher at one lag, and the MBIC, MAI, and MQIC estimations are lower at one lag.

Results

This section shows the results of PVAR model, Eigenvalue Stability Condition, Granger Causality Wald test, Forecast-Error Variance Decomposition (FEVD) and Impulse-response function. Table 5 shows the outcomes of PVAR model with one lag.

Table 5. PVAR model results

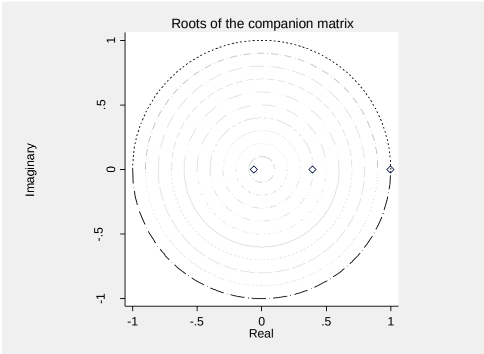
Response of	Response to					
	ΔGDP		**ΔENERGY**		**ΔURBAN**	
ΔGDP	0.3663 (7.34) 0.000	***	0.2661 (2.68) 0.007	***	0.0045 (3.34) 0.0001	***
ΔENERGY	0.0339 (2.37) 0.018	**	0.0053 (0.07) 0.942		0.0003 (0.42) 0.676	
ΔURBAN	-0.8979 (-4.38) 0.000	***	1.3168 (2.25) 0.025	**	0.9963 (106.54) 0.000	***
N obs	**670**					
N panels	**21**					

Notes: ***,** denote statistical significance levels of 1% and 5%. The Stata command *pvar*, with one lag, was used.

The PVAR model indicated that the consumption of primary energy increases the economic growth, while the urbanization reduces. The economic growth and urbanization have a positive influence on primary energy consumption. Finally, the economic growth influences the urbanization, though the primary energy consumption does not cause any impact on urbanization. Then, to check the stability condition of PVAR model, the Eigenvalue Stability Condition was applied. Table 6 display the graph of Eigenvalue Stability Condition.

Table 6. Eigenvalue stability condition

Eigenvalue			Graph
Real	**Imaginary**	**Modulus**	
0.9985	0	0.9985	
0.3952	0	0.3952	
-0.0618	0	-0.0618	



Notes: The Stata command *pvarstable* was used.

The Eigenvalue test indicated that the PVAR model is stable because all eigenvalues are inside of unity circle. The Granger Causality Wald test was used to check the presence of causalities between variables. Table 7 shows the results of Granger causality Wald test.

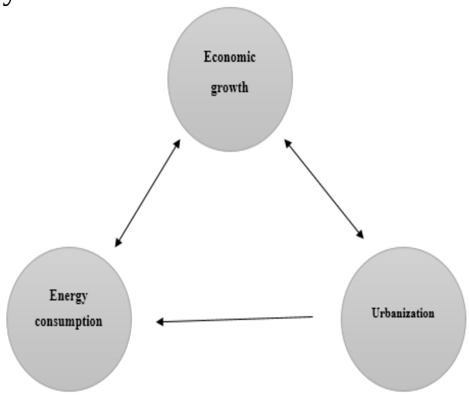
Table 7. Results of Granger causality Wald test

Equation \ Excluded		chi2	Df.	Prob > chi2	
ΔGDP	ΔENERGY	5.624	1	0.018	**
	ΔURBAN	19.200	1	0.000	***
	ALL	20.463	2	0.000	***
ΔENERGY	ΔGDP	7.208	1	0.007	***
	ΔURBAN	5.051	1	0.025	**
	ALL	8.909	2	0.012	**
ΔURBAN	ΔGDP	11.156	1	0.001	***
	ΔURBAN	0.174	1	0.676	
	ALL	11.182	2	0.004	***

Notes: ***,** denote statistical significance levels of 1% and 5%. The Stata command *pvargranger* was used.

The Granger Causality Wald test evidenced the presence of a unidirectional relationship between the variables ΔURBAN and ΔENERGY, and a bidirectional relationship between ΔGDP and ΔENERGY, and ΔURBAN and ΔGDP. Figure 2 summarizes the results of Granger Causality Wald test.

Figure 2. Granger Causality Wald test



Notes: This figure was created by the author.

Certainly, after Granger Causality Wald test estimator, the forecast error variance decomposition (FEVD) is computed. Thus, the FEVD is computed, when the exogenous variables are included in the underlying PVAR model. Table 8 shows the outputs of FEVD test.

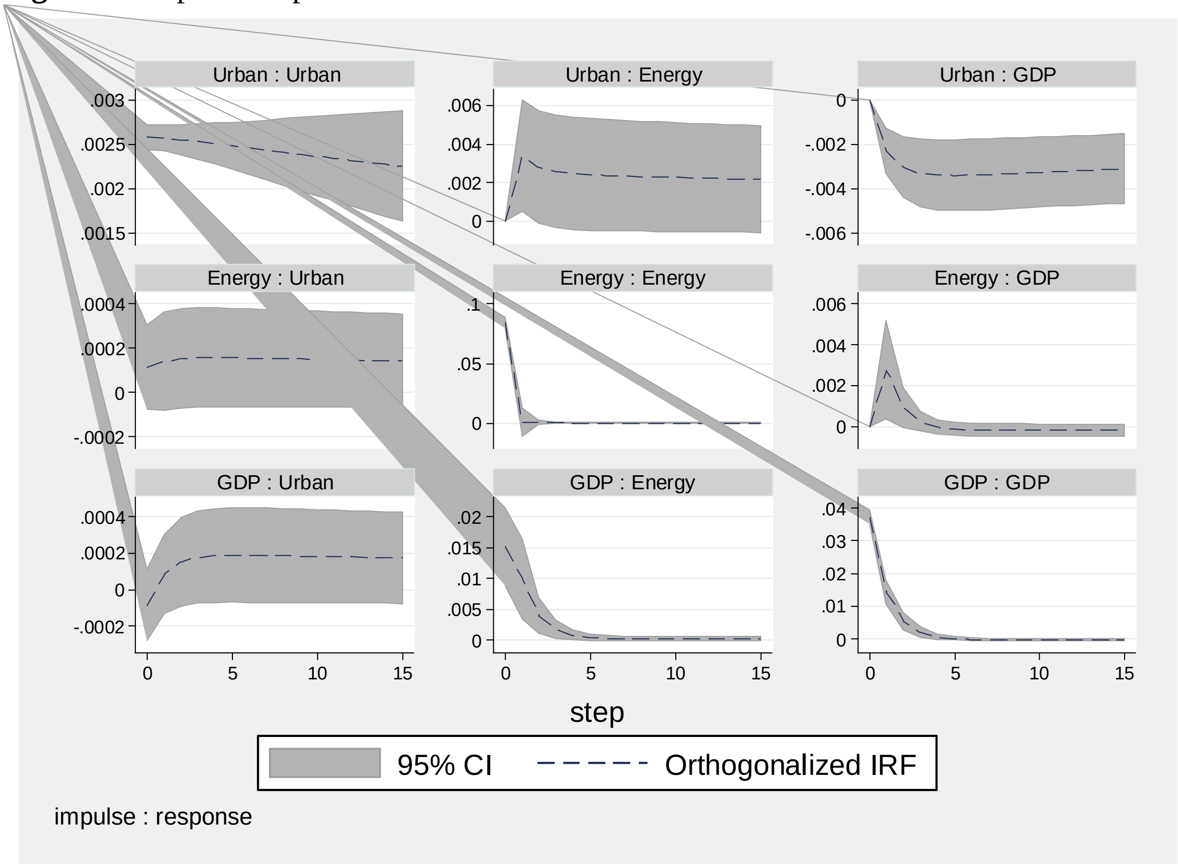
Table 8. Forecast-error variance decomposition (FEVD)

Response variable and Forecast Impulse Variable Horizon	**Impulse variable**		
	ΔGDP	**ΔENERGY**	**ΔURBAN**
ΔGDP			
0	0	0	0
1	1	0	0
5	0.9727	0.0050	0.0222
10	0.9406	0.0049	0.0543
15	0.9131	0.0049	0.0819
ΔENERGY			
0	0	0	0
1	0.0314	0.9685	0
5	0.0465	0.9491	0.0043
10	0.0464	0.9455	0.0080
15	0.0462	0.9424	0.0113
ΔURBAN			
0	0	0	0
1	0.0011	0.0019	0.9968
5	0.0031	0.0032	0.9935
10	0.0044	0.0035	0.9919
15	0.0048	0.0036	0.9914

Notes: Stata command *pvarfevd* was used.

The FEVD showed that ΔGDP explains in 0.5 % the variable ΔENERGY in five periods, and 8.18 % the variable ΔURBAN after fifteen periods. The variable ΔENERGY explains in 4.5% the variable ΔGDP after five periods, and ΔURBAN in 1.13 % after fifteen periods. The variable ΔURBAN explains in 0.48 % after fifteen periods the variable ΔGDP, and 0.36 % the variable ΔENERGY.Then, to analyze the IRFs and dynamic multipliers after the PVAR model the impulse-response was computed. Figure 3 shows the impulse-response function of variables.

Figure 3. Impulse-response function



Notes: The Stata *pvarirf* command was used.

The impulse-response function was computed following the Cholesky procedure. The procedure was repeated 1000 times to compute the 5th and the 95th percentiles of the impulse responses. The results of Impulse-response function showed that all variables converge to equilibrium after the chocks and that all variables are I(1).

Discussion

The analysis of nexus between energy consumption, economic growth, and urbanization, complements the literature. The results of preliminary tests indicate the existence of low-multicollinearity, cross-section dependence, unit roots. The PVAR model shows that the energy consumption increases the economic growth in 0.0339 %, while the urbanization reduces -0.8979 %. The economic growth has a positive influence of 0.2661 % on energy consumption and the urbanization 1.3168 %. Finally, the economic growth has a positive impact of 0.0045 % on urbanization, while the energy consumption does not cause any impact on the variable. The Eigenvalue test indicates that the PVAR model is stable because all eigenvalues are inside of unity circle. The Granger Causality Wald test shows that there is a unidirectional relationship between energy consumption and urbanization, and a bidirectional nexus between energy consumption and economic growth.

Indeed, the unidirectional nexus between energy consumption and urbanization 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 ,2013; Shahbaz and Lean ,2012). The unidirectional nexus between urbanization and energy consumption is related to a positive influence of urbanization on the popularity of household appliances and the pursuit of private transport. Thus, the increase of household appliances and private transport increase the energy demand (Fan et al. 2017). Likewise, the urbanization promotes the industrial structure, improve the energy demand structure, upgrade traditional industries, change of production mode and expand the service industry. Moreover, the urbanization, change the lifestyle is to set up the public's awareness of ecological civilization and change the unreasonable lifestyle (Yang et al. 2016). Additionally, immigration of people from rural zones to urban has a positive impact on the economy. This movement makes the economic transition from agriculture to industrialization economy and consequently positively the energy use (Shahbaz et al. 2015).

The bidirectional relationship between energy consumption and economic growth is in line with several authors that studied the Latin American countries (e.g. Rodríguez-Caballero and Ventosa-Santaulària, 2017; Koengkan, 2017a; Pablo-Romero and Jésus, 2016; Pastén et al. 2015), and others that studied the same nexus (e.g. Kahia et al.2017; Özokcua and Özdemir 2017; Antonakakis et al. 2017; Koçak and Şarkgüneşi,2017; Tang et al. 2016; Ahamed and Azam ,2016). The bidirectional nexus between economic growth and energy consumption is due to the energy used in Latin America and Caribbean region is very sensitive to changes in economic growth. Indeed, when the economy of Latin American shows a rapid growth, the energy consumption growth in an exponential way (Pablo-Romero and Jésus, 2016). Similarly, the total factor productivity caused by economic growth influence the energy demand (Koengkan, 2017).

The FEVD shows that the economic growth explains in 0.5 % the variable energy consumption in five periods, and 8.18 % the variable urbanization after fifteen periods. The variable energy consumption explains in 4.5% the variable economic growth after five periods, and urbanization in 1.13

% after fifteen periods. The variable urbanization explains in 0.48 % after fifteen periods the variable economic growth, and 0.36 % the variable energy consumption. Then, the FEVD evidence in a clear way that the economy of Latin American and Caribbean countries is dependent on energy to promote their economic growth, and that the economic growth incentive the urbanization process in Latin America and Caribbean region. The results of Impulse-response function shows that all variables converge to equilibrium after the chocks and that all variables are I (1).

Conclusions and policy implications

The nexus between energy consumption, economic growth and urbanization were analyzed in this article. The study focused on twenty-one Latin American and Caribbean countries over a period of 1980-2014. The Panel Data Vector Autoregressive (PVAR) was used as methodology. 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 and the presence of unit roots in the variables.

The results pointed that the energy consumption increases the economic growth in 0.0339 %, while the urbanization reduces -0.8979 %. The economic growth has a positive influence of 0.2661 % on energy consumption and the urbanization 1.3168 %. Finally, the economic growth has a positive impact of 0.0045 % on urbanization, while the energy consumption does not cause any impact on the variable. The Granger Causality Wald test shows that there is a unidirectional relationship between energy consumption and urbanization, and a bidirectional nexus between energy consumption and economic growth. These evidence pointed to need to create subsidy policies encouraging the consumers to purchase appliances with high energy efficiency standards, 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, develop new renewable policies to promotes economic growth and environmental sustainability, and create policies for restraining residents' behaviors like raising the gasoline prices, tiered pricing for electricity, specifying the lowest temperature of the air conditioner in summer and incentives for self-generation of renewable energies. These policies have the capacity to reduce the energy consumption and reduces the environmental degradation in long-run.

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