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Article

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Measuring the effect of trade liberalisation on the consumption of non-renewable energy sources in Latin America and the Caribbean Countries

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Abstract

This article investigates the impact of trade openness on the consumption of fossil fuels for a panel of fourteen LAC countries over the period from 1990 to 2014. To this end, a PARDL model in unrestricted error-correction form is estimated. The results of the regression indicate that the impact of economic growth and the elasticity of trade openness are positive and statistically significant at 1%. Both contribute to increase the consumption of fossil fuels in the LAC countries. However, the impact and elasticity of the consumption of renewable energy are negative and statistically significant at 1% and 5% levels, thus contributing to decrease the consumption of fossil fuels.

Keywords: Energy economics; Econometrics; Fossil fuels; Latin America and the Caribbean; Macroeconomics; Trade openness
JEL Classification Codes: E6, F1, Q40, Q43

1. Introduction

The consumption of energy has more than doubled in Latin America and the Caribbean (LAC) countries in the last 40 years. However, this growth has not been constant. It proliferated in the 1970s, as economic activity and trade openness greatly increased in the region (Koengkan et al., 2020).

From the 1980s to the 1990s, the debt crisis lead to a decline in economic activity and Latin American countries exoerienced a deep recession, followed by a slow recovery (Koengkan et al., 2019a). It was also in this period that, according to Tissot (2012), the consumption of energy from non-renewable sources rapidly expanded.

The prominence of non-renewable energy sources in the energy matrix of LAC countries derives from the fact that some of them are ranked among the most significant oil producers in

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the world, i.e., Argentina, Brazil, Colombia, Mexico, Venezuela (RB), Ecuador, and others are significant importers, i.e., Brazil, Chile, Dominican Republic, Uruguay, and Paraguay (Fuinhas et al., 2017). These countries are benefiting from plunging oil prices because they will have to pay less for their oil imports, and also because in some cases, the generation of energy depends on oil products (Koengkan et al., 2020). According to Jurado (2018), although Brazil is the second major oil producer in the region, the country is also the biggest net importer as it is the top oil consumer in the LAC region.Venezuela (RB), Brazil, Colombia, Argentina, and Ecuador are responsible for 85% of total oil production in the region (IEA, 2018).

Non-renewable energy sources accounted for 46% of the primary energy supply in the LAC region in 2013, while averaging 31% worldwide (Koengkan et al., 2020). According to IRENA (2016), natural gas represents 23% of the primary energy consumed. Despite this, the region has one of the most significant shares of renewable sources in the energy mix (Koengkan and Sousa, 2019d).The renewable energy market in the LAC region is also experienced rapid growth in both investment in and consumption of this kind of energy sources (Fuinhas et al., 2017). This trend has been enhanced by, inter alia, the abundance of natural resources, the rapid increase in energy demand, the significant dependence on fossil fuels, high energy prices and energy security concerns (Koengkan, 2018b). The consumption of energy from this kind of sources represented 20% of total energy consumption in 2009 (Santos, 2015).

The first sustained experience with trade liberalisation in the LAC region happened in Chile, in the 1970s, when the country's economy became one of the most open in the world. In the 1980s, other countries such as Costa Rica in 1993, and Bolivia and Mexico in 1995 followed this trend and gradually opened their markets. In the early 1990s, more countries, including Argentina, Brazil, Colombia, Peru and Venezuela (RB), joined this movement (Agosin and French-Davis, 1993).

These events motivated the central question of this investigation: What is the impact of trade openness on the consumption of non-renewable energy in the LAC countries?

The interactions of fossil energy, renewable energy, Gross Domestic Product (GDP), and trade openness have been debated in the literature, mostly in the framework of the extended energy consumption – economic growth nexus (e.g., Chen et al. 2021; Zeren and Akkuş, 2020; Destek and Sinha, 2020; Mohamed et al., 2019; Halicioglu and Ketenci, 2018). Other authors, for example, Chen et al. (2019), have also approached this topic, including foreign trade in their study of relationships between CO2 emissions, GDP and energy production in China. Trade has not been considered by authors examining links between consumption of energy (from renewable and non-renewable sources) and economic growth, or between emissions and economic growth. In what concerns the geographic focus of such analyses, attention is often directed to countries such as the US, Turkey (e.g., Bölük and Mert, 2015; Menyah and Wolde-Rufael, 2010, respectively), others situated in Europe (Ntanos et al., 2018; Mert et al., 2019), Africa (Cherni and Jouini, 2017; Da Silva et al., 2018) or Asia (Chen et al., 2019; Toumi and Toumi, 2019). This investigation is innovative and contributes to the literature, because it focus in the LAC countries to explore the effect of trade liberalisation on the consumption of non-renewable energy sources, using the PARDL model to such end.

2. Methods

The PARDL model in the form of UECM is used as our central model estimation. In the 80s (Granger, 1981; Engle and Granger, 1987) introduced cointegration techniques that allow the identification of a long-run relationship between non-stationary series. These techniques were later improved by Johansen and Juselius (1990). Pesaran and Shin (1999) and Pesaran et al. (2001) developed the Autoregressive Distributed Lag (ARDL) cointegration technique. The ARDL approach is also known as the bounds test, and it is a parametrisation into an error correction model (UECM) (Nkoro and Uko, 2016). The PARDL model in the form of UECM is an extension of the time series ARDL model to longitudinal data. This model allows the decomposition of the total effects of variables into their short- and long-run components (Koengkan et al., 2019). A feature of (P)ARDL models is the ability to work with stationary variables, integrated of order one variables or a mixture of both. The general PARDL model in the form of UECM follows the specification of Equation (1):

$$DLogFOSSIL_{it} = \alpha_{it} + \beta_{1i1} DLogGDP\_PC_{it-1} + \gamma_{1i1} + DLogREN_{it-1} + \gamma_{3i1} + DLogTROPEN_{it-1} + \gamma_{4i1} + LogFOSSIL_{it-1} + \gamma_{1i2} LogGDP\_PC_{it-1} + \gamma_{1i3} LogREN_{it-1} + \gamma_{1i4} LogTROPEN_{it-1} + \varepsilon_{1it}. \quad (1)$$

Where α_i represents the intercept, β_{ik} an γ_{ik}, with k = 1, …, 3, denote the estimated parameters, and ε_{it} is the error term.

3. Data

The empirical analysis is developed using annual data, collected from 1990 to 2014, for fourteen countries from the LAC region, i.e., Argentina, Bolivia, Brazil, Chile, Colombia, Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Panama, Peru, and Venezuela (RB). The considered variables are:

Table 1. Description of variables, sources and summary statistics.

Description of variables			Summary statistics				
Variable	**Definition**	**Source**	**Obs**	**Mean**	**Std Dev**	**Min**	**Max**
LogFOSSIL	Fossil fuel consumption from oil, gas and coal sources in kWh (per capita)	World Bank Open Data (2019)	350	10.576	0.9261	7.4260	12.4303
LogGDP_PC	GDP in constant 2010 US$ (per capita)	World Bank Open Data (2020)	350	8.4631	0.6886	6.9659	9.5943
LogREN	Renewable energy consumption from biomass, hydropower, solar, photovoltaic, wind, wave and waste in kWh (per capita)	World Bank Open Data (2020)	350	12.0473	4.8717	8.2764	30.9759
LogTROPEN	Trade (% of GDP): trade is the sum of exports and imports of goods and services measured as a share of GDP.	World Bank Open Data (2020)	350	3.9433	0.4822	2.6212	5.1161

Notes: "Log" denotes variables in natural logarithms; Obs. denotes the number of observations in the model; Std.-Dev. denotes the Standard Deviation; Min. and Max. denote Minimum and Maximum values, respectively.

The variables FOSSIL, GDP_PC, and REN are transformed into per capita values with the total population of each cross. Per capita values allow the control of disparities in population growth over time and within countries (e.g., Koengkan et al., 2018a; Koengkan, 2018b; Koengkan, 2018c).

4. Results

As previously mentioned, results are presented and discussed in this section. The preliminary tests of this study indicated that the variables of interest display characteristics such as low-multicollinearity, cross-sectional dependence (in the variables in logarithms and in first-differences, with almost all cases are I(0) or I(1)), and existence of fixed effects. Additionally, the specification tests indicated the presence of heteroscedasticity and first-order autocorrelation, as well as the absence of correlation and dependence in the residuals. The results of these tests are essential to identify the characteristics of the data for countries under analysis, as well as the possible methodologies to be used in the empirical assessment.

Dummy and shift-dummy variables were introduced to account for shocks (peaks and breaks of significant magnitude) in some countries in the LAC region. The outcomes from the short-run impacts, the long-run elasticities, the speed of adjustment of the model with the FE, FE robust standard errors (FE Robust), and FE Driscoll and Kraay (FE D.-K.) estimators and shocks are displayed in Table 2.

The estimated PARDL model (including the dummies and shift-dummies) suggests that the impact and elasticity of GDP_PC on the consumption of non-renewable energy are positive (and equal to 0.6255 and 2.0488, respectively). The impact and elasticity of the variable TROPEN (trade openness) are also positive: 0.2235 and 0.5912, respectively. However, as expected, the impact and elasticity of REN are negative: -0.4731 and -0.3508, respectively. This indicates that the consumption of energy from renewable sources reduces the consumption of fossil fuels. Figure 1 below, summarises these impacts.

The ECM term is negative and statistically significant at the 1% level. The statistical significance at the 1% level of the dummy and shift-dummy variables support the decision of including them in the model.

Figure 1. Impacts of independent variables on the dependent variable.

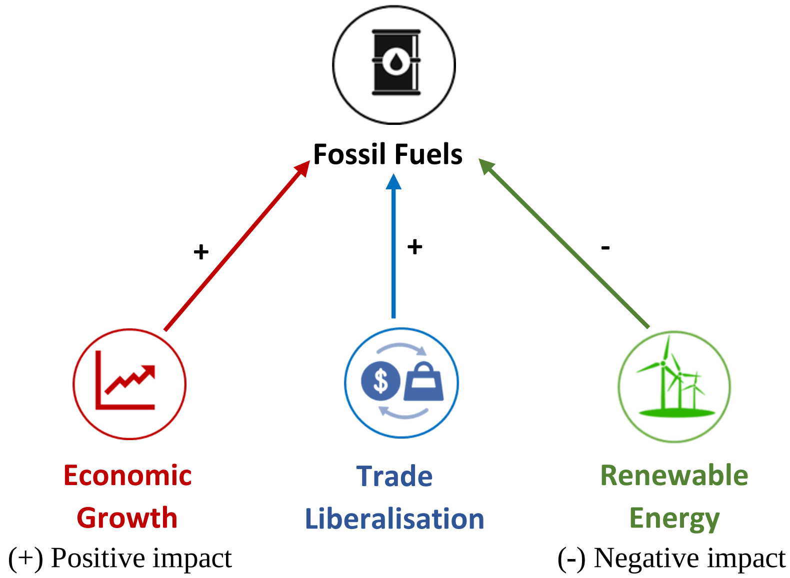

Table 2. PARDL Model estimation controlling for shocks.

Independent variables	Dependent variable (DLogFOSSIL)			
	FE		FE Robust	FE D.-K.
Constant	-1.0919	**	*	**
	Shocks			
IDBRAZIL2009	-0.4337	***	***	***
IDCOLOMBIA1997	0.3866	***	***	***
IDCOLOMBIA1999	-0.3657	***	***	***
IDCOLOMBIA2009	0.4424	***	***	***
IDCOLOMBIA2011	-0.4630	***	***	***
SDCOSTA_RICA1991_1994	-0.4374	***	***	***
SDCOSTA_RICA2005_2006	-0.3134	***	***	***
SDDOMINICAN_REPUBLIC1994_1995	-0.2523	***	***	***
IDDOMINICAN_REPUBLIC1998	0.6432	***	***	***
SDECUADOR1993_1994	-0.4094	***	***	***
IDECUADOR1999	-0.4020	***	***	***
IDEL_SALVADOR1991	0.8446	***	***	***
IDGUATEMALA1992	0.9872	***	***	***
SDGUATEMALA1996_1997	-0.2763	***	***	***
IDGUATEMALA1998	0.4393	***	***	***
IDPANAMA1996	-0.3851	***	***	***
	Short-run (impacts)			
DLogGDP_PC	0.6255	***	***	***
DLogREN	-0.4731	***	***	***
DLogTROPEN	0.2235	***	***	***
	Long-run (elasticities)			
LogGDP_PC (-1)	2.0488	***	***	***
LogREN (-1)	-0.3508	**	**	**
LogTROPEN(-1)	0.5912	***	*	***
	Speed of adjustment			
ECM	-0.2374	***	***	***

Notes: ***, **, * denote statistically significance at 1%, 5%, and 10% levels, respectively; the ECM denotes the coefficient of the variable **LogFOSSIL**, lagged once; (Log and DLog) denote variables in natural logarithms and first-differences of logarithms, respectively.

The obtained results suggesting that economic growth positively impacts consumption of energy from non-renewable sources are in line with those obtained by several authors that studied this relationship in the Latin America region (e.g., Koengkan et al., 2020; Koengkan, 2018b; Koengkan, 2018c; Koengkan, 2017; Rodríguez-Caballero and Ventosa-Santaulària, 2017; Pablo-Romero and Jésus, 2016; Pastén et al., 2015).

Such positive impact in the LAC countries is due to the region's high sensitivity to changes in economic activity, with. rapid economic growth exerting a positive effect on consumption of energy from non-renewable sources (Pablo-Romero and Jésus, 2016).

This rationale is accepted by several authors, such as Koengkan et al. (2020), and Koengkan (2018b), according to whom the Latin America region has experienced strong economic growth, which required an even more significant increase in energy use. However, an assessment of the Andean community countries in South America, developed by Koengkan (2018c), produced a different interpretation of this positive impact of economic growth on the consumption of non-renewable energy. According to the author, the analysed countries are dependent on the consumption of energy for growth and an increase of 1% in the energy demand increases economic activity by 0.5%.

Other authors who studied the effect of renewable energy policies on environmental degradation, such as Fuinhas et al. (2017), also confirm that Latin America countries display high economic dependence on energy from fossil fuel sources, due to the fact that some of them are major energy producers (e.g., Argentina, Brazil, Colombia; Mexico, Venezuela (RB), and Ecuador), and others are significant importers (e.g., Brazil, Chile, Dominican Republic, Uruguay, Paraguay).

Omri et al. (2014) provided another explanation for this positive impact. According to these authors, economic capitalisation, the development of infrastructure and trade openness in LAC countries have a positive influence on investment and on economic activity and, consequently, on the consumption of energy.

The possible explanation for the negative impact of the consumption of renewable energy on non-renewable one in the LAC countries is the abundance of renewable energy sources i.e., solar, photovoltaic, wind, hydropower, geothermal, and waste, which stimulates investment in renewable energy technology and consequently decreases the consumption of energy from non-renewable sources (Fuinhas et al., 2017).

According to Koengkan (2018b), this negative impact demonstrates that the renewable energy policies in the LAC countries are effective and capable of encouraging the development of renewable energy technologies and the consumption of energy from renewable sources. The author also interprets such results as evidence that the renewable energy technologies used in these countries are effective in reducing the consumption of energy from non-renewable sources and environmental degradation.

The reduction of fossil fuel consumption by that of renewable energy confirms the process of “energy transition” in LAC countries. According to Hauff et al. (2014), the term “energy transition” indicates a growing trend in the share of renewable energy sources to reduce the consumption of fossil fuels. Indeed, this term clearly portraits the objective of reducing environmental degradation.

Finally, the positive impact of trade openness on the consumption of non-renewable energy is in line with authors that investigated this relationship (e.g., Koengkan, 2018c; Sebri and Ben-Salha, 2014; Houssain, 2011; Cole, 2006; Jena and Grote, 2008). According to Koengkan (2018c) and Houssain (2011), trade openness encourages the expansion of industrialisation and a rapid economic development, consequently increasing the consumption of energy from non-renewable sources. Cole (2006) concurred, pointing out that trade openness increases per capita income by approximately 1%, consequently increasing the demand for energy approximately between 0.05% and 0.3%.

However, Sebri and Ben-Salha (2014) provided a different interpretation for this impact. According to them, trade openness attracts investment to the energy sector, mainly to non-renewable energy, due to the abundance of non-renewable energy sources in the LAC countries, andhigher investment levels stimulate the consumption of energy. Other authors, for example, Jena and Grote (2008), point out that industrialisation processes promoted by trade liberalisation, following scale, technological and comparative advantage effects, exert a positive impact on economic growth and on the consumption of energy. This confirms that trade openness exerts a positive effect on the consumption of energy, as trade liberalisation enhances industrialisation and investment, which positively affect economic growth and increase demand for energy.

5. Concluding remarks

The empirical results from the PARDL model indicated that in the in the LAC region, in both the short and the long runs, the impact and elasticity of the variables economic growth and trade openness are positive and statistically significant at the 1% level. Both variables thus contribute to the increase in consumption of energy from non-renewable sources. Nevertheless, the impact and the elasticity of the variable consumption of renewable energy is negative and statistically significant at the 1% and 5% levels, indicating that such consumption contributes to decrease that of energy produced with fossil fuels.

Therefore, the positive impact of trade openness on the consumption of fossil fuels reveals that the process of globalisation by trade liberalisation in LAC countries is not sufficient to attract more investment, which encourages the R&D in energy efficiency technologies, and equipment that reduces the consumption of energy from non-renewable energy sources by households and firms.

This investigation is not free from limitations inherent to the research process. The dimension of the analysed time series were limited by the availability of data for the variable consumption of renewable energy, which is limited to the period between 1990 to 2014 for all selected countries.

In spite of data limitations, the obtained results have relevant policy implications and warnings. They suggest that policymakers in LAC countries should take advantage of the process of globalisation via trade liberalisation to reduce the costs of renewable energy technology. Indeed, the reduction of these costs is possible with the creation of tariff and non-tariff barriers on products and technologies that improve energy efficiency during the process of trade liberalisation. Energy-efficiency product standards and labelling are also an important policy mechanism to reduce the consumption of fossil fuels and CO2 emissions.

This investigation makes a significant contribution to the literature for several reasons. First, it adds to knowledge on how economic growth and trade openness increase the consumption of fossil fuels in LAC countries. Second, it shows how the consumption of renewable energy decreases the consumption of energy sourced from fossil fuels. Third, the empirical results of this investigation are informative for governments and policymakers with respect to the current model of trade openness, where LAC countries do not take advantage of liberalisation to increase investment that encourages the R&D in energy efficiency technologies, and equipment that reduces the consumption of energy. Moreover, this investigation also supports policymakers and governments reflections on the current mechanisms that are used in trade liberalisation and which are not beneficial for the environment. Fourth, this study can originate new research about the effects of trade openness on technological progress in the energy sector, to identify whether the process of trade liberalisation enhances energy efficiency and encourages the process of the energy transition.

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