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Economic growth and energy consumption: The Energy-Environmental Kuznets Curve for Latin America and the Caribbean

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ABSTRACT

This paper investigates the relationship between economic growth and energy consumption using the hypothesis postulated for the Energy-Environmental Kuznets Curve, which assumes an inverted-U shape relationship between income and energy consumption. Panel data for 22 Latin American and Caribbean countries for the period 1990–2011 were used. Absolute energy consumption was chosen as an environmental pressure indicator, because energy consumption is the major contributor of emissions pollutants. The results obtained in the estimations show that the hypothesis postulated for the Energy-Environmental Kuznets Curve is not supported for the region. On the contrary, the results show an exponential growth as Gross Value Added grows. Also, notable differences are shown between the analyzed economies.

Contents

1. Introduction

The relationship between economic growth and energy consumption has been widely studied in recent literature. Menegaki [1] found at least 51 empirical studies on the relationship between Gross Domestic Product (GDP) growth and energy consumption in the last two decades. The study of this relationship has received

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new attention from the environmental perspective. This dynamic relationship between economic growth, energy consumption and environmental pressure has been studied for different regions and countries. Among those 51 studies on the first relationship may be cited those for Europe [2,3], Latin America and the Caribbean (LAC) [4], BRIC [5,6], MENA [7,8], ASEAN [9], OECD [10,11] and Sub-Saharan African countries [12]. Among the studies on the second relationship may be cited those referring to Brazil [13], Canada [14], China [15,16], Korea [17,18], India [19], Malaysia [20], Turkey [21,22], Saudi Arabia [23] and the USA [24], among others. Knowledge of this relationship between economic growth and energy is considered to be extremely important for the development of effective energy and environmental policies to promote sustainable development.

The objective of this paper is to analyze the relationships between economic growth and energy consumption in 22 Latin American and Caribbean (LAC) countries from 1990 to 2011, with the analysis of the Energy-Environmental Kuznets Curve and the calculation of the elasticity of energy consumption with respect to GDP for each LAC country and year, being used for that purpose.

The economic growth and environmental pressure relationship has been explained by many authors through the Environmental Kuznets Curve (EKC). This curve arises under the hypothesis that there is an increasing relationship between economic growth and environmental pressure until some turning point of income per capita, from which point further increases in income lead to improved environmental quality [25]. The starting point of the EKC is found in the paper by Grossman and Krueger [26]. The authors show that there is an inverted-U-shaped form between income levels and environmental pressure. Later, Panoyotou [27] was the first to introduce the term “Environmental Kuznets curve" in the economic literature, relating the form of this curve to the original Kuznets curve [28] which postulates the existence of a relationship of an inverted-U between income and inequality. These results were later supported by other works, such as [29,30,31]. A whole review of this topic can be found in [32–34,35].

In the current literature various indicators have been used to measure the environmental pressure in this curve. The choice of one indicator is not an easy task, as it is difficult to implement only one indicator to reflect all the different impacts that human activity has on the environment. The choice of any indicator will generate biases, although as Luzzati and Orsini [36] state, the choice of energy consumption decreases the biases regarding the possible substitution of one pollutant for another, non-controllable one, in an attempt to reduce the environmental pressure. Hence, Dasgupta et al. [37] established that while the EKC is observed for certain controllable pollutants, their reductions are offset by other more toxic emissions.

According to Aslanidis [38], the use of energy consumption as an indicator to measure the environment pressure is coherent, as the CO_2 emissions are directly related to energy use. Saboori and Sulaiman [39] state that there is evidence showing that the main reason behind the increase of CO_2 emissions can be attributed to energy consumption, especially the burning of fossil fuels like oil, gas and carbon. Also, Zilio and Recalde [40] establish that the energy consumption turns out to be responsible for almost 77% of the total CO_2 emissions, as every economic activity requires a direct or indirect form of consumption of fossil fuels, heat or electricity to operate.

Using energy consumption as an indicator of the environmental pressure in previous studies has propagated the term “Energy-Environmental Kuznets Curve”. Among the first studies that used energy consumption as an indicator of environmental pressure was that by Suri and Chapman [41]. Subsequently, this indicator has been used in multiple studies such as [36,42–46,39].

Despite the large number of empirical investigations made to date regarding the EKC, the results are not conclusive [47–51]. In this sense, Kaika and Zervas [34] stated that results are at best mixed. Therefore, as stated by Magnani [52], corroboration, or not, of this curve depends, among other factors, on the data sample and time period used. Auci and Becchetti [53] find that the shape of the relationship between GDP and emissions appears to be quite sensitive to changes in the estimation period. Likewise, others authors, like Yang et al. [54] for example, highlighted that differences have been observed when considering, or not, time-series characteristics of panel data. On the other hand, some authors have pointed out that corroboration of the ECK hypothesis also depends on the country sample showing the different empirical results between regions and countries [55,56]. That is why the results cannot be generalized between different countries and time.

In the case of LAC countries, the analysis is particularly interesting as they are composed of developing countries. In this regard, Zilio [57] states that several of the arguments that support the EKC hypothesis do not generally hold in the economies, societies and institutions of developing countries. Thus, the analysis for these countries is often linked with globalization and free trade agreements with developed countries that have influenced the increased industrialization of Latin American countries. Grossman and Krueger [26] conclude that environmental degradation is directly dependent on the structure of the economy. Environmental degradation tends to increase when there is a change from an agricultural to an industrialized economy, and similarly, the degradation tends to decrease with a change from industrialization to a service based economy. Kaika and Zervas [35] state that developing countries are supposed to be in the early stages of development, and therefore on the upward section of the EKC. Nevertheless, the authors highlighted that nothing implies that these countries are expected to face growth-patterns similar to rich or developed countries. In this regard, recent studies are pointing out that energy intensive industries and businesses are tending to be displaced from developed to developing countries aiming to reduce costs on environmental controls [58]. Thus, developing countries are growing in part due to this industrialization, which implies a higher level of energy use.

Despite the interest in the analysis of the EKC for LAC countries, empirical studies seem to be few. Among those few studies can be mentioned that by [59]. The author estimated a parametric EKC function using SO_2 emissions as an indicator of environmental pressure, for 12 Latin American and Caribbean countries. Additionally, the study by Zilio and Recalde [40] analyzed the relationship between energy consumption and economic growth for 21 countries of the region by estimating a quadratic parametric function. Likewise, Al-mulali et al. [60] analyze the effect of economic growth, financial development and renewable energy on CO_2 emission in LAC countries. Additionally, there are a few studies referring to a particular LAC country. Thus, Pao and Tsai [13] study the relationships between CO_2 emissions, energy consumption, and economic growth in Brazil. Robalino-López et al. [61] analyze the relationship between CO_2 emissions, economic growth and the EKC in Venezuela, and Robalino-López et al. [62] analyze whether the EKC hypothesis holds in Ecuador. The last two studies use different scenarios to make forecasts of CO_2 emissions in a forthcoming period.

Following the research of these previous authors, in this paper is explored the relationship between economic growth and energy consumption for 22 Latin American and Caribbean countries by estimating an Energy-Environmental Kuznets Curve. For that purpose a quadratic and cubic parametric function is estimated. Absolute energy consumption is used as an indicator of the environmental pressure. The use of absolute energy consumption

as an indicator of environmental pollution seems to be appropriate, because, as Luzzati and Orsini [36] state, what really matters, at the Nature level, is the level of pollution per region not per capita. The methodology employed and the calculation of the elasticities, allow both the analysis of the evolution of these elasticities through time and the analysis of these elasticities between all 22 countries.

The paper is organized as follows. In Section 2 the methodology is explained. Section 3 details the database used, and describes the evolution of energy consumption and growth in the 22 countries. The results of the estimates are presented and discussed in Section 4. Finally, the conclusions of this study are shown in Section 5.

2. Methodology

This study analyzes the relationship between energy consumption and economic growth by estimating a function that relates energy use and Gross Value Added per capita (GVApc) in order to test the Energy-Environmental Kuznets Curve hypothesis.

The standard cubic EKC specification used in previous literature to provide the flexibility function [63], expressing the variables in terms of natural logarithms, may be written as follows:

$$E_{it} = A_{it} + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 + e_{it} \quad (1)$$

Where E is the natural logarithm of energy, expressed in thousands of barrels of oil equivalent. Y is the natural logarithm of GVApc. A represents the sum of an annual temporal effect common to all countries called *time effects* and an individual effect constant for each country called *country effects*, i is equal to 1, 2, …,22, for the 22 countries of the sample and t is the time in years from 1990 to 2011. $\beta 1$, $\beta 2$, $\beta 3$ are the parameters of the function to be estimated in order to test the EKC hypothesis. The EKC exists if $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 \leq 0$ [64]. Finally, e is a random error term. The use of absolute energy consumption as an indicator of environmental pollution has been taken to reflect the total human pressure, as in Luzzati and Orsini [36].

With the aim of estimating this function properly, the data were converted to deviations from the geometric mean of the sample. Using a dash over the variables to indicate these deviations, it is possible to rewrite [1], as follows:

$$\overline{E}_{it} = \delta_t + \alpha_i + \beta_1 \overline{Y}_{it} + \beta_2 \overline{Y}_{it}^2 + \beta_3 \overline{Y}_{it}^3 + e_{it} + C_{it} \quad (2)$$

where a control variable (C) has been included, which expresses the share of agriculture employment in the total national employment for each country. Similar variables have been included in previous studies to take into account the possible effect of the different economic structure of each country [65–66].

The function (2) is estimated taking into account, or not, the cubic term of the variable Y, in order to approach previous estimates which have sometimes used quadratic functions and at other times used cubic functions. Among others, the studies by [40,58,67–68] may be highlighted in the first group and by [36,45,69–70] in the second. However, according to Luzzati and Orsini [36], parametric estimations with cubic terms give a greater range and flexibility to the model.

From the estimation of parameters of Eq. (2), the elasticity of energy consumption with respect to GDPpc for each Latin American and Caribbean country and year can be obtained as follows:

$$\mathrm{ela}_{it} = \beta_1 + 2\beta_2 \overline{Y}_{it} + 3\beta_3 \overline{Y}_{it}^{\,2} \quad (3)$$

Eq. (3) shows that the elasticities derived from the Eq. (2), are neither constant over time nor between countries. These elasticities allow an explanation of whether, in this period, the percentage variation in GVApc leads to increases or decreases in energy consumption and by what percentage.

If the EKC exists then the turning point can be calculated by making the energy (E) elasticity respect to Y equal to zero, (i.e., making the derivative of the energy with respect to Y equal to zero). Therefore, the elasticity values can be also used to test the EKC hypothesis. If the EKC exists, the turning point holds where the elasticity is equal to zero. Positive values of elasticities show that energy consumption increase when the Y does. If it is higher than one, then energy is increasing more than proportionally. Negative values shows that energy decrease when Y increase. Then, the Kuznets Curve exists when elasticity is equal to zero and change from positive to negative values when Y increases.

3. Data

A panel data of 22 Latin American and Caribbean countries in the period 1990–2011, for which there is sufficient statistical information, is used to estimate [3]. The countries included in the sample are as follows: Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Trinidad and Tobago, Uruguay and Venezuela.

Energy Consumption, Gross Value Added (GVA) and total population data are taken from the *Environmental Statistics and Indicators*, *Economic Indicators and Statistics* and *Social Statistics and Indicators* subclasses of the CEPALSTATS [71], respectively. Energy consumption is expressed in thousands of barrels of oil equivalent, total annual GVA by country is expressed at prices in millions of constant dollars and total population is expressed in thousands of persons at mid-year. Agricultural employment data were taken from the Employment and Social Protection subclass of the World Development Indicators of the World Bank [72]. These are expressed as a percentage of total national employment within the country.

Table 1 shows the main descriptive statistics of the variables used in this model. The 'overall' statistics refer to the whole sample; while the 'between' statistics refer to the standard deviation, and the minimum and maximum of the averages for each individual country. Furthermore, the 'within' statistics refer to each individual country and to the variation from each individual country's average. If a variable does not change over time, its 'within' standard deviation will be zero. Table 1 shows that the typical standard deviation of the data is higher across countries than across time for the variables.

Fig. 1 shows the evolution of energy consumption (left graph) and the GVApc (right graph) for the 22 Latin American and Caribbean countries (each represented by a different color) during the period 1990–2011. The values are spread around the thick black line, which represents the average of the countries'values for each year.

The left graph shows that all the countries have a relatively positive trend in energy consumption, with a period of stagnation from 2000 to 2006, and an increasing trend since then. Among countries with a higher volume of energy consumption are Brazil, Mexico, Argentina and Venezuela, while the low level of consumption of Barbados is highlighted. Al-mulali et al. [73] argue that Latin America and the Caribbean have experienced a substantial increase in energy, both renewable and non-renewable.

According to the data provided by the World Bank [72], Fig. 2 shows that energy consumption in these countries has a high dependency on fossil energy, between 70% and 75% of the total energy consumption in the region. This is despite the high hydropower production for several countries in the region, and the attempt to gradually modify the array of power generation to a

Table 1
Descriptive statistics.

Variables (Napierian logarithm)		Mean	Standard deviation	Min	Max	Observations
Energy consumption	overall	10.80	1.46	7.20	14.30	$N=484$
	between		1.47	7.50	13.94	$n=22$
	within		0.22	10.09	11.42	$T=22$
GVApc	overall	8.143343	0.67	6.73	9.61	$N=484$
	between		0.67	6.89	9.49	$n=22$
	within		0.16	7.67	8.64	$T=22$

Source: Own production from CEPALSTATS [71].

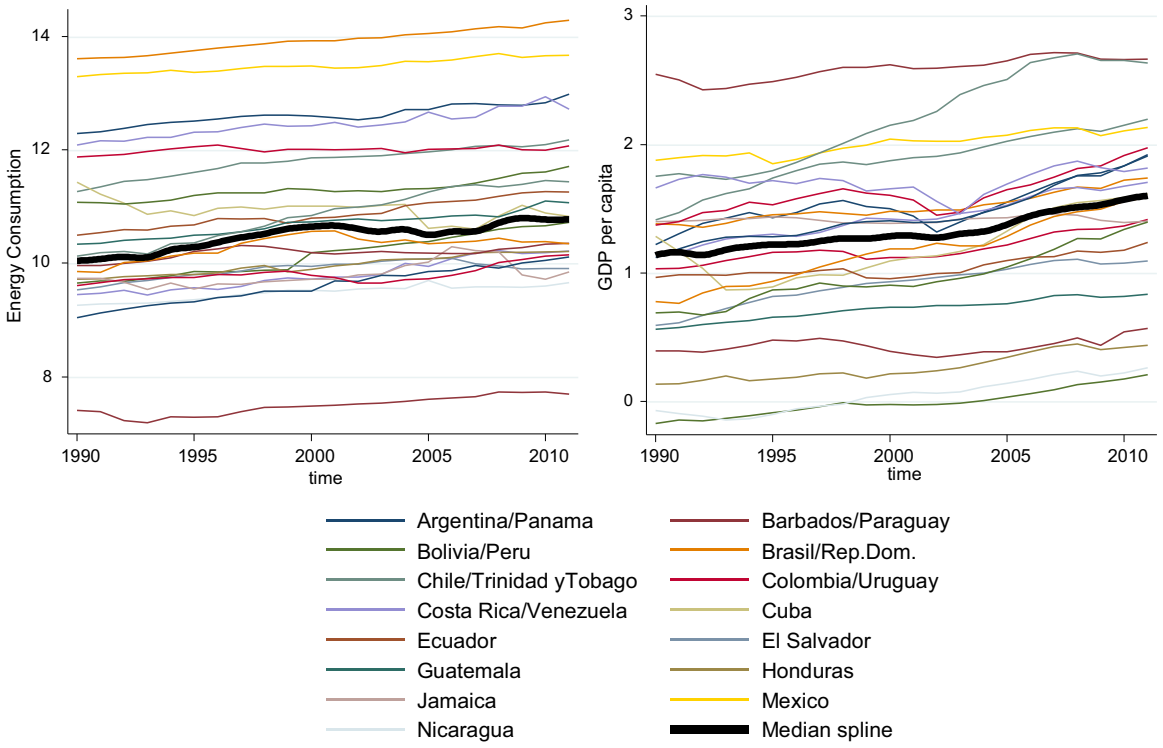

Fig. 1. Evolution of energy consumption and GVApc (1990–2011). (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)
Source: Own production from CEPALSTATS [71]

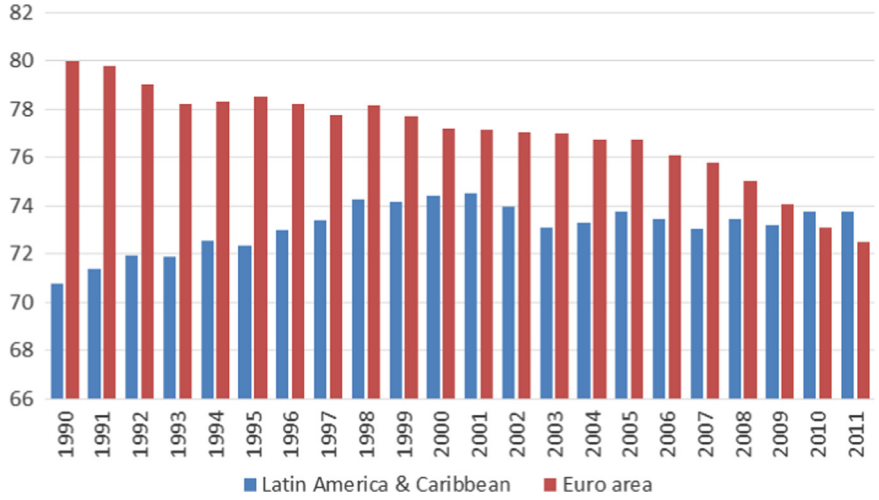

Fig. 2. Percentage of fossil fuel consumption of total energy consumption in Latin America and the Caribbean and the European Union.
Source: Own production from WDI [72]

cleaner and more efficient energy. The trend shows these percentages are similar to the evolution of the average energy consumption per capita in Fig. 1. A growing trend, with a period of stagnation, and growth at the end of the period, with an overall positive development, can be seen. Note that this evolution is very different from the EU countries, where a negative trend is shown over the entire period. This difference with regard to European countries makes the analysis of the relationship between energy and growth in Latin American and the Caribbean countries more interesting.

The right graph of Fig. 1 shows that GVApc also has a positive growth rate throughout the period, while it can be seen that large differences exist between countries. Barbados is the country with the highest GVApc in the region, unlike Bolivia and Nicaragua, which have the lowest levels. However, in the period 1990–2011, the country with the highest growth was Trinidad and Tobago, although it is noteworthy that other countries showed significant growth such as Chile, Panama, Dominican Republic and Peru. On average, the analyzed countries showed a 3.1% growth rate, for the period. This is despite the fact that the majority of the countries which belong to this region are generally considered to be developed or underdeveloped.

4. Results and discussions

Table 2 shows the results of estimating [2] for the panel of 22 Latin American and Caribbean countries during 1990–2011. Column A shows the results of estimating this function when the cubic term is omitted, Column B when that variable has been included to provide greater flexibility to the function, and finally, Column C which also includes the control variable, to take into account the heterogeneity that occurs between countries. All estimates included time and individual dummies. The estimates were made by using the generalized least squares method in the presence of autocorrelation, heteroscedasticity and contemporaneous correlation, according to the results of the Wooldridge [74] test for autocorrelation, the Wald test for homoscedasticity, proposed in Greene [75], and the Pesaran [76] test for contemporaneous correlation.

β_1 coefficients are positive and significant ranging between 0.45 and 0.33. The value of this coefficient represents the value of the elasticity at the central point of the sample. At that point the elasticity is positive, indicating that an increase of one percent in the GVApc generated from that value increases the energy consumption. Positive values of the remaining coefficients (β_2 and β_3) show that at any time, the increase in GVApc generates increases in energy consumption, so the EKC hypothesis is not verified in these countries, in the period considered. These results are in line with the results obtained by Zilio and Recalde [40] when estimating a quadratic function to test this hypothesis. The positive

Table 2
Results.

	A	*B*	*C*
β_1	0.4536*** (00.39)	0.3348*** (0.0075)	0.3600*** (0.0089)
β_2	0.1186*** (0.0027)	0.1423*** (0.0034)	0.0742*** (0.0023)
β_3		0.1690*** (0.0031)	0.1608*** (0.0034)
C			0.0035*** (0.0000)

Note: Standard errors are shown in parenthesis.
All estimates included time and individual dummies.
Source: Own production
**Significant level for 5%.
*Significant level of 10%.
*** Significant level at 1%.

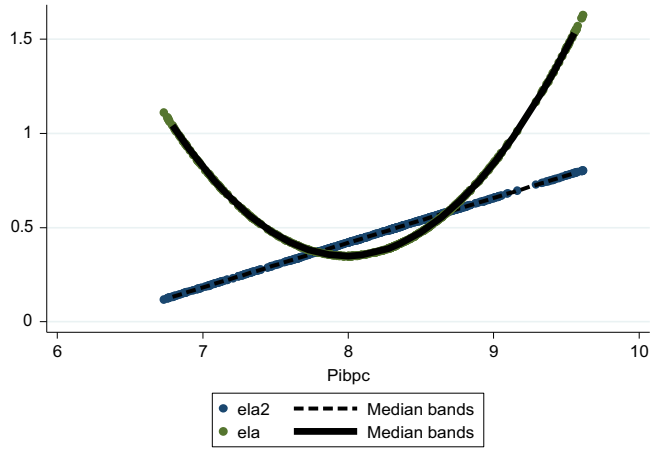

Fig. 3. Estimated elasticity of energy consumption with respect to GVApc.
Source: Own production

value of β_2 in all the estimations shows that the elasticity increases with the GVApc in these countries globally, whilst the positive value of β_3 shows that this growth is exponential after a certain level of income.

Fig. 3 shows the values of the energy consumption elasticity for each GVApc level, when the elasticities are calculated according to [3] by using the values of the estimated coefficients of the quadratic function (ela2) and the cubic function (ela) as shown in Column C. In particular, the elasticity for each country and year was calculated according to:

$$ela2_{it} = 0.45 + 2 * 0.12\overline{Y}_{it}$$

$$ela_{it} = 0.36 + 2 * 0.07\overline{Y}_{it} + 3 * 0.16\overline{Y}_{it}^{\ 2}$$

The elasticity values show that the ECK is not supported in any case, as the value of the elasticity never equals zero. In the first case, it can be seen that as GVApc increases, so does the elasticity of energy consumption. In the second case, the cubic function allows more flexibility, and the elasticity presents a U-shaped form. Initially, for low values of GVApc, as it rises the elasticity decrease, while always being positive. This elasticity decrease may be related to the fact of an initial development, in line with Ozcan [77] and Wang et al. [15], who consider that pollution levels may relatively decrease as a country develops when the development level is low or very low. This decrease, however, becomes positive from a certain GVApc level, from which point it begins to grow exponentially. The value at which the elasticity of energy tends to grow rapidly (8 in Fig. 3) is a value lower than the average value of GVApc for the whole sample. Therefore, the energy consumption of all countries tends to show a rapidly growing trend as their economies grow. In this sense, it can be said that as the developing economies tend to grow to reach GVApc levels of developed countries, energy consumption will tend to experience exponential growth in these countries if there are no changes in the way they are producing. Consequently, LAC countries cannot apply the argument of *wait and grow* [78] to improve environmental conditions, but must apply active energy policies.

The growing elasticities observed may be related, as stated by Pablo-Romero and Sanchez-Braza [79] to the industries that have been installed in recent years and also to the international trade growth that may be reducing the energy use in development countries while increasing in developing ones [58,80]. In that sense, Steckel et al. [81] argue that it is unlikely that lower income countries are able to develop without increasing their energy consumption. These authors believe that the use of energy is needed to increase economic growth. The energy increase is

observed not only in the highest energy use in households but also in the energy needs arising from the development of infrastructure and economic capitalization and trade development. Thus, although the LAC countries investments undertaken in recent years are having positive effects on economic growth, these investments are also generating an increase in energy use and CO_2 emissions, as stated in Omri et al [82]. Therefore, as these authors recommend, policymakers should pay attention to investments in environmental quality to avoid *pollution haven* traps. In this regard, previous studies show that accompanying investments with green technological progress, replicating the new environmental techniques applied in developed countries for example [83], may lead to a fast improvement in the efficient use of energy [84–85]. Nevertheless, some authors such as Pablo-Romero and Sanchez-Braza [79] and Peters et al. [80] have pointed out that these gains in energy efficiency are finite and therefore will not be capable of counteracting the growing energy needs of economic growth. Van Ruijven et al. [86] state that LAC countries are projected to have a higher GDP growth than that historically observed, and little change in energy intensity and energy mix, with a rise in emissions being projected as a consequence. Therefore, in addition to energy efficiency policies, LAC countries should also undertake changes in the productive structure and promote measures to diversify energy mixes, reducing the high dependency on fossil energy [40,83] in order to be able to counteract the effects of economic growth on energy consumption. Robalino-López et al. [61] show that Venezuela could reduce emissions and improve the energy intensity by changing the productive structure and increasing the share of renewable energies in the total energy consumption.

Additionally, it may be inferred from the estimated results that the elasticity of energy consumption is not constant throughout the period and between the countries. Fig. 4 shows the elasticity of energy consumption with respect to GVApc for each country which is represented by a different colored line when calculated according to ela_{it}. All the elasticities calculated are positive, so that in no case did GVApc growth result in decreased energy consumption in Latin America and the Caribbean. These elasticity values are spread around a thicker black line, which represents the average of the values for each year. It can be seen that a few countries have elasticity much higher than the average, as is the case of Nicaragua, Bolivia, Barbados, and Trinidad and Tobago, while many countries are very close to the average elasticity of each year. This diversity shows the different behavior of each country, suggesting that, according to Magnani [32], the results cannot be generalized across different countries and time periods.

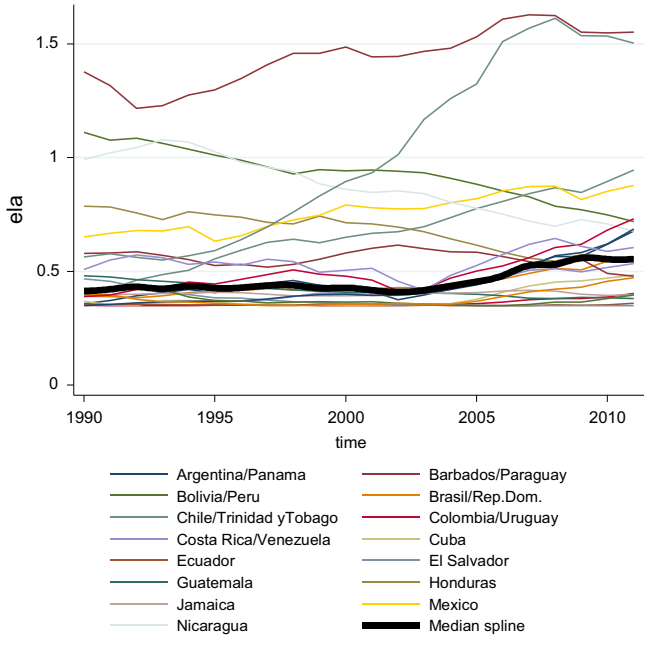

Fig. 4. Elasticity of energy consumption with respect to GVApc for the 22 Latin American and Caribbean countries.
Source: Own elaboration

The general evolution of the elasticities with time was constant until 2004, with a clear positive trend since then, which continues in most countries. This relative increase in energy consumption may be linked to the energy needs of the production destined for exports of goods and services in these countries. In this sense, Villamil [87] argues that the average rate of economic growth in Latin America has increased significantly since 2004, which is due to the economic expansion of the product promoted and led by exports of large regional economies such as Venezuela, Argentina, Peru and Colombia. Thus, Fuentes [88] states that since mid-2003, the improvement in the terms of trade of most countries in the region opened a new phase of higher growth and relative stability.

The general evolution of the elasticity of energy consumption with respect to GVApc differs noticeably in the case of some countries. Barbados and Trinidad and Tobago have an elasticity greater than one, which shows that the energy consumption in these countries is growing more than economic growth. In that sense, Lorde et al. [89] argue that alongside economic growth, energy consumption in Barbados has increased steadily in recent decades. Likewise, significant increases in GVApc have led to large energy consumption increase in Trinidad and Tobago, resulting in much higher than average elasticity. For their part, Bolivia, Honduras and Nicaragua show a negative trend, associated with low GVApc levels for these countries, as shown in Fig. 1.

On the other hand, Brazil, Mexico, Venezuela, Argentina and Colombia are the countries with the higher energy consumption across the region, with Brazil having the highest. Sheinbaum et al. [90] show that Brazil is tenth in the world in energy consumption, even though 45% of this comes from renewable energy, primarily hydroelectric.

The results therefore show differences between the value and the evolution of the elasticities of energy consumption with respect to GDP per capita among the LAC countries. As stated above, it is especially worth noting the high elasticity of Barbados and Trinidad and Tobago. Therefore, a more intense energy policy is needed in these countries. Additionally, increasing elasticities for Mexico, Chile, and to a lesser extent for Argentina and Colombia in the latter years of the analyzed period should also be noted. In these countries, with notable economic growth forecasts in the coming years [91], it is also particularly necessary to apply intense energy policies to mitigate the effects of economic growth on the environment.

Nevertheless, important differences are observed between these countries, which will require different specific policies. In this sense, for example in Mexico, the potential of renewable energy has not been adequately exploited, perhaps due to their fuel resources, and some incentives to promote this energy will be necessary to achieve the goal of the country's General Law for Climate Change of generating 35% of its energy needs from renewable sources by 2024 [92]. Meanwhile, Chile also has large energy needs for its growing economy. However, unlike México, Chile has no fuel resources. Thus, it is necessary to develop a renewable energy policy to avoid becoming more dependent on external sources. Chile has favorable conditions for the deployment of renewable energy plants and some policies have already been undertaken. However, some measures may be taken to overcome several obstacles, such as grid barriers, limited access to project financing and water securement problems [93].

Therefore, it is considered appropriate to develop specific national energy plans in LAC countries, with detailed energy efficiency and renewable energy targets and appropriate incentives to achieve them.

5. Conclusions

This paper investigates the relationship between energy consumption and economic growth by using the hypothesis postulated by the Energy-Environmental Kuznets Curve and panel data for a sample of 22 Latin American and Caribbean countries. Absolute energy consumption was chosen as an indicator of environmental pressure.

The results obtained from the estimates show no evidence that the relationship between economic growth and energy consumption, in the long term, assume an inverted U-shape for this region, which rejects the hypothesis postulated by the Energy-Environmental Kuznets Curve. The results show that, for the countries of the region, the energy consumption is very sensitive to changes in GVApc and tends to show a rapidly growing trend as their economies grow, showing an exponential energy consumption growth. This means that as the countries of Latin America and the Caribbean show economic growth, they are demanding an even greater increase in energy consumption. Therefore, the argument of *wait and grow* may not be a good option for LAC countries, but the application of active energy policies in order to control the energy consumption growth may be appropriate. As previous studies stated, energy efficiency policies may not be capable of counteracting the growing energy needs of economic growth, so LAC countries should also undertake changes in the productive structure and promote measures to diversify energy mixes, thereby reducing the high dependency on fossil energy in order to reduce the environmental effects of economic growth.

Additionally, the results show that the elasticity of energy consumption with respect to GVApc is not constant throughout the period, and between the countries, but always positive. Therefore in no case did GVApc growth result in decreased energy consumption in LAC countries. Likewise, the general evolution of the elasticities with time was almost constant until 2004, with a clear positive trend since then, its value being around 0.5 at the end of the period. Nevertheless, the results also show differences between the value and the evolution of the elasticities of energy consumption with respect to GDP per capita among the LAC countries. Barbados and Trinidad and Tobago show the highest elasticities at the end of the studied period, being higher than one, which reflects that energy consumption in these countries is growing more than economic growth. Therefore, an intense energy policy is recommended in these countries. Additionally, the results show notable increasing elasticities for Mexico, Chile, and to a lesser extent for Argentina and Colombia, at the end of the period. Therefore, as a notable economic growth has been forecast for them in the coming years, it may also be necessary to apply intense energy policies in these countries to control the effects of economic growth on the environment. Consequently, it is considered appropriate to undertake and monitor specific national energy plans in LAC countries, with detailed energy efficiency and renewable energy targets, and incentives to achieve them. For their part, Bolivia, Honduras and Nicaragua show a negative elasticity trend, associated with low GVApc levels.

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