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THE NEXUS BETWEEN ENERGY CONSUMPTION AND ECONOMIC GROWTH: THE CASE OF MÉXICO

Sibe Jacob Pegou*

Chiatchoua Cesaire**

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Abstract

This study examines the relationship between energy consumption and economic growth in Mexico within a multivariate framework in order to determine the degree to which energy consumption influences economic growth prospects in Mexico. Throughout this study, we look at the relationship between different forms of energies and economy growth. We used the granger causality test, which enabled us to verify the direction of causality between the variables of interest; the Breusch-Godfrey Serial Correlation LM test, to test for serial correlation of the stochastic variable and the ADF to test for stationary of the model. The results showed that there is a bi-directional relationship between economic growth and energy consumption in Mexico. Looking at all the sectors of usage of energy, we found that electricity produced from coal, nuclear and hydroelectric sources impact positively on economic growth, whereas electricity produced from natural gas and oil highly negatively impact on economic growth.

Keywords: Mexico, energy consumption; growth; granger-causality, Breusch-Godfrey serial correlation LM Test.
JEL Classifications: F43; Q43.

* Profesor-investigador del Tecnológico de Estudios Superiores de Chimalhuacán, Estado de México. <chiatchoua@yahoo.co.uk>.
** Profesor-investigadoren la Universidad de Dschang, Camerún. <sibejp@yahoo.fr.

Resumen

Este estudio examina la relación entre el consumo de energía y el crecimiento económico en la economía de México, con el fin de determinar el grado de influencia del consumo de energía en las perspectivas de crecimiento de esta economía. Se utilizó la prueba de causalidad de Granger para verificar la dirección de la causalidad entre las variables de interés; la prueba La Grange Multipliers (LM) de correlación de serie de Breusch-Godfrey para probar la correlación de serie de la variable estocástica y el ADF para probar la estacionalidad del modelo. Los resultados muestran una relación bidireccional entre el crecimiento económico y el consumo de energía en México. En cuanto a los sectores de la utilización de la energía, se encontró que la electricidad producida a partir del carbón, de la energía nuclear y de la hidroeléctrica impactan positivamente en el crecimiento económico, mientras que la electricidad generada a partir del gas natural y petróleo impactan negativamente.

Palabras claves: México, consumo energético; crecimiento económico; causalidad de Granger; prueba LM de correlación de serie de Breusch-Godfrey.
Clasificación JEL: F43, Q43.

1. Introduction

The ability of a country to have a sustainable energy production and supply is of primary goal, so is the energy-growth nexus to policy makers and economist. Countries are multiplying efforts to generate more and more energy at the same time striving not to depend much on energy importation, in other to maintain a sustainable and reliable supply, which is a core for energy independence.

For the past decades, Mexico has enacted many reforms to have control over its resources, and today, the most prominent one is that of energetic reform. Because energy consumption increases with economic development and consumption of energy improves living standards Rosenberg (1983), Mexico is working towards its energy reform to be able to have full control over its energy consumption and production. The country is now enacting the energetic reform in other to boost its growth and development through the expectation of more jobs creation.

According to Kebede *et al*. (2011) a higher level of socioeconomic development is associated with well-developed energy consumption. In this study we endeavor to look at the relationship between energy consumption and economic growth in Mexico. Authors like Binh (2011), Adom (2011) have come to the conclusion that energy consumption and economic growth have a unidirectional, bidirectional causality depending of the nature of the countries and its natural endowments. Payne (2010) concluded that the evidence on causal relationship between electricity consumption and economic growth is mixed.

The controversy between the direction of the causal relationship between energy consumption and economic growth has motivated us to look at the direction of the causal relation between these variables in Mexican economy, if any cointegration exists between these variables as far as the Mexican economy is concerned. The main objective of this study is to examine the relationship between energy consumption and economic growth and to look at what specific segments of electricity consumption do influence economic growth in Mexico.

To meet these objectives we will use a multivariate framework in order to determine the degree to which energy consumption influences growth prospects. Section 2 discusses the various hypotheses associated with the energy consumption and economic growth literature. Section 3 reports an overview about the energy conditions in Mexico, while Section 4 presents data, methodology, and the empirical results. Concluding remarks and recommendations lead us to highlight some policy implications in Section 5.

2. The energy consumption-growth literature

The relationship between energy consumption and economic growth has been extensively examined in the literature with varying results across countries. In a sixteen country study, Nachane *et al*. (1988) found a unidirectional causality from commercial energy consumption per capita to real Gross Domestic Product (GDP) per capita for Argentina and Chile and bidirectional causality in the cases of Brazil, Colombia, and Venezuela.

In another multicountry study, Murray *et al*. (1992) conclusion was that of a unidirectional causality between real GDP and electricity consumption for Colombia. In a twelve country study of G7 and emerging markets, Soytas *et al*. (2003) came out with results of bidirectional causality between energy consumption and GDP per capita. Cheng (1997) provided evidence of unidirectional causality between energy consumption and real GDP. In a panel of eighteen developing countries, Lee (2005) found that a unidirectional causality exist between energy consumption a real GDP.

In a study of net energy exporting developing countries, Mahadevan *et al*. (2007) provided support for bidirectional causality between energy consumption per capita and real GDP per capita. In another panel of eleven oil exporting countries, Mehrara (2007) mentioned in his findings the existence of a unidirectional causality relationship between real GDP per capita and commercial energy consumption per capita. In a study of Organization of the Petroleum Exporting Countries (OPEC), countries, Squalli (2007) results proved a unidirectional causality between electricity consumption per capita and real GDP per capita. Firouz (2011) using a Markov-switching VAR modeling for the US concluded in favor of bidirectional causality up to 2000 and no causality afterwards.

Lau *et al*. (2011) performing a research on 17 Asian countries using a panel data regression analysis concluded that there was a causality running from energy consumption to growth in the short-run, while in the long-run, there was a causality running from growth to energy consumption. Finally but not exhaustive, Adom (2011) and Kwakwa (2012) examining the relationship between energy consumption and growth for the economy of Ghana, explained that on an aggregate as well as on a disaggregate level causality runs from economic growth to energy consumption, while Binh (2011) after performing a similar analysis for the case of the economy of Vietnam, supported the assertion of the neoclassical evidence, by stating that energy consumption is an assisting factor to economic growth.

There are, however, only a handful of papers about investigating energy consumption in Mexico. Cheng (1997), Narayan *et al*. (2008) carried out studies on the relation between economic growth and energy consumption in Mexico using the Granger test and they came out with the same conclusion that there is no causal relationship between economic growth and energy consumption in Mexico; whereas Murray *et al*. (1996) using the same Granger causality test concluded that there is a unidirectional relationship between GDP growth and electricity consumption, they went forward to show that electricity consumption grange causes economic growth in Mexico.

Due to the controversial nature of the result of these authors, we are going to try out with a new set of test to ascertain the nature of the causality between

Economic growth and Energy consumption in Mexico. We are then looking forward to test whether or not energy consumption has an effect on economic growth in Mexico, and if that be the case, what is the direction of the relationship? This will enable us to be able to come out with meaningful policy making proposals. This is going to be done using the granger causality test, which will enable us to verify the direction of causality between the variables of interest; the Breusch-Godfrey Serial Correlation LM test to test the serial correlation of the stochastic variable and the Augmented Dickey-Fulier (ADF) to test the stationarity of the model.

This study can be defined as complementary to the previous empirical papers. However, it differs from the existing literature in some aspects. First, it employs the ordinary least square model analysis method. Second, it uses Augmented Dickey-Fulier (ADF) unit root test, and the Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM) test; also it looks on the various components of energy consumption that affect economic growth in Mexico.

3. The energy sector in Mexico

Mexico is surrounded by the Atlantic and the Pacific Ocean, this gives the country natural endowments, among which the availability of abundant natural resources due to its closeness to the oceans, Its Gulf is one of its most important close to sea natural resources. This natural advantage has made the country to be an oil producer and this has been so for a very long time, yet the production of fuel in Mexico has been dangling in contrast to its consumption. When we discuss about energy, most people think only on fuel and electricity. These are just some of the forms of energy that have been exploited for many years and also form part of the basis for the development and progress of our complex civilization. Conventional fuels include: oil, natural gas, coal and nuclear energy, we can also add the vast energy of the rivers that is harnessed for hydroelectric power.

Within the period of 2000 to 2009, the national energy consumption grew by an annual average of 2.2%, while GDP did averaged 1.2%. In this sense, the national energy consumption grew from 6806.5 petajoules in 2000 to 8.247 petajoules in 2009, reflecting an increase of 21.1%.[1] As a result of this,

[1] Nacoud, G, A. (2012). "Evolución del Consumo de Energía en México" *Financiamiento de la Salud en México*, México, p. 128.

national consumption increased per capita energy consumption within the same period (2000 to 2009), from 69.1 to 76.7 gigajoules, meaning a growth of 11%. From the foregoing, it is evident that energy consumption per capita in Mexico registered an upward trend, which requires greater energy production at the national level, and thus more resources and investment in the sector.[2] In table 1, we can see the percentage distribution in the use of different types of energy sources for electricity generation.

Coal features a high degree of penetration in the major economies of the world. Under the recent environment of uncertainty and substantial changes in international oil prices, it has resulted in many oil-dependent countries to significantly reduce the use of these fuels for power generation. The trend is different in the case of Mexico; natural gas is the first source of electric generation. The chart in figure 1 shows the relationship between the value of exports and the value of imports of crude oil in the country, including oil, natural gas, petroleum and petrochemicals.

As can be seen, in the nineties the value of exports amounted to around seven times the value of imports. However, in the last two decades the trend has been downward, if not reversed such that if not addressed Mexico could definitely become an importer of oil in the coming years. In addition to the decline in oil production, that fell by 26% between 2004 and 2012 as on figure 2. The deterioration in the trade balance of oil is explained by increase in import of gasoline, natural gas and petrochemicals. In terms of refined products, the plant available in Mexico has limited levels of operational efficiency resulting to negative profitability margins as compared to other oil-producing countries.

Mexico refining capacity in relation to its oil production capacity is extremely limited. Its daily production reached 2.51 million barrels of crude oil, with an average daily refinery capacity of only 1.2 million barrels, it is possible to measure the size of the deficit presented in this activity. Thus, while in 1997 imports of gasoline accounted for 25% in Mexico, it then leap to 49%[3] in 2012 reached.

There is a considerable difference between the growths in supply and demand according to production of natural gas. Between 2008 and 2012, domestic production decreased by 7%, while domestic consumption increased by 9%.

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[2] SIE (2009).

[3] Mexican Government (2013). "Energetic reform", México.

This gap had to be filled by imports, so that a considerable increase of the same was recorded. Within a period of 15 years, that is between 1997 and 2012 the proportion of imported gas for domestic consumption increased by 30% that is from 3% to 33% as shown on figure 3.

Summarizing, natural gas is the fuel that is used in greatest proportion in Mexico in 2009 table 1. In the last two decades, the trend of oil, gasoline, natural gas, coal and petrochemicals has been downward. This is caused by the increase of the domestic demand and the facilities available in Mexico in terms of refined products have reduced levels of operational efficiency. If there is no change, México would be a net importer of energy fuels in coming years. As a way to improve the energy balance of the country, one important objective of the energy policy is the energy reform and also a tendency to stimulate the renewable energy sector by authorities being the promotion of energy based on renewable sources.

4. Data and the methodology

In this section, we will discuss the methodology and theoretical framework, after running the model; we will present the interpretation of results. Next, we will follow with the impact of total energy consumed on economic growth and finally, we will show the impact of total specific type of energy consumption of economic growth.

4.1. Methodology and theoretical framework

This section explores the relationship between energy consumption and economic growth; it is derived from the original Cobb Douglas model, where we have introduced energy component as propounded by recent literature concerning economic growth. The Cobb Douglas Model is as follows:

$$Y_t = AK_t^{\alpha} L_t^{\beta} \tag{1}$$

where Y_t is gross domestic product in period *t*, *K* is capital and *L* labor and *A* the productivity factor and α *and* β are the deterministic parameters of increasing, diminishing and/or constant return to scale. Recently scholars have proved that not only labor and capital should be accounted for GDP growth, but also energy consumption, technology changes and some other specific variables, which was specified by Cobb Douglas as productivity factor (A). So we can rewrite the Cobb Douglas model as.

$$Y_t = A' K_t^{\alpha} L_t^{\beta} E_t^{\delta} \tag{2}$$

where E represents energy consumption; A' the productivity factor less energy consumption, and the other variable being as specified previously.

In this study we used secondary annual data, collected from Word Development Indicator covering the period between 1971 and 2012. The software used to examine and analyse the impact of energy consumption on economic growth in Mexico is Eviews 8. We consider energy to be the main ingredient to produce electricity. Therefore energy consumption is decomposed as: electricity production from coal sources (ELPC), electricity production from hydroelectric sources (ELPH), electricity production from natural gas sources (ELPG), electricity production from nuclear sources (ELPN) and electricity production from oil sources ELPO). We precise in this study that energy produced is the same as energy consumed or used, because once energy is produced it cannot be stored nor saved and electricity consumed or produced is as a result of energy consumed.

a) Relationship between total energy consumption and economic growth

$$\begin{aligned} Log(GDP)_t = {} & a_0 + a_1 log(K)_t + a_2 log(L)_t + a_3 log(ENC)_t + a_4 log(K)_{t-1} \\ & + a_5 log(L)_{t-1} + a_6 log(ENC)_{t-1} + a_7 \log(GDP)_{t-1} + \mu_t \end{aligned} \tag{3}$$

b) Relationship between specific type of energy consumption and economic growth

$$\begin{aligned} Log(GDP)_t = {} & a_0 + a_1 log(K)_t + a_2 log(L)_t + a_3 log(Elpc)_t + a_4 log(Elpg)_t \\ & + a_5 log(Elph)_t + a_6 log(Elpo)_t + \mu_t \end{aligned} \tag{4}$$

4.2. Interpretation of results

In this subsection we are going to explain the motivations and reasons of the used of our model. To be able to determine the deterministic parameters of increasing, diminishing and/or constant return to scale, we used the ordinary least square method. We proceeded step by step to specify our model respecting econometric theory specifications, in other to obtain reliable estimate of the parameters. Table 3 below is the first specification of our OLS model, which shows unreliable results due to serial correlation of the residuals expressed by a very low Durbin-Watson statistic, so we proceeded, by adjusting the model to suit econometric theory. We then followed by carrying the Breusch-Godfrey Serial Correlation LM test. This test revealed a statistic labeled "Obs*R-squared" on table 4, which is the LM test statistic for the null hypothesis of no serial correlation. The zero probability value observed strongly indicates the presence of serial correlation in the residuals. Thus the test results suggest that we need to modify our original specification of the model to take account of the serial correlation. The approach we used is to include lags in the right hand side of the equation as specified on equation 5.

$$Log(GDP)_t = a_0 + a_1 log(K)_t + a_2 log(L)_t + a_3 log(ENC)_t + a_4 log(K)_{t-1} + a_5 log(L)_{t-1} + a_6 log(ENC)_{t-1} + a_7 \log(GDP)_{t-1} + \mu_t \quad (5)$$

4.3. Impact of total energy consumed on economic growth

We computed the unit root test to conclude that our model is stationary as seen on the table 5, where we reject the null hypothesis of a unit root due to the low level of the probability.

The statistic labeled "Obs*R-squared" is the LM test statistic for the null hypothesis of no serial correlation. The 30% probability value indicates the presence of no serial correlation in the residuals, because we cannot reject the null hypothesis of no serial correlation in the residuals at this level. Thus the test results lead us to conclude that the introduction of the lags to resolve the problem of serial correlation in the residual is effective. Therefore this new model is free of the serial correlation and good to be used to estimate our parameters. We can see from table 6 that $R^2 = 99\%$ meaning that the independent variables perfectly explain the dependent variable as seen on the graph in figure 4 where the actual and fitted variable curves are interwoven. The F-statistics of 19091.48 reveals that the independent variables are jointly highly significant at 1% level of significance. So we concluded that economic growth increases on average by 1.4% for any unit average increase of last year energy consumption. Thus the impact of energy consumption on economic growth is not immediate it takes an average of one year to spill over and impact on economic growth.

4.4. Impact of specific type of energy consumption of economic growth

The Durbin Watson statistic specifies that this model if free of serial correlation, so we need not to modify the second model in other to generate reliable results. Thus we keep the model without introducing the lags as seen in equation 6.

$$Log(GDP)_t = a_0 + a_1 log(K)_t + a_2 log(L)_t + a_3 log(Elpc)_t + a_4 log(Elpg)_t + a_5 log(Elph)_t + a_6 log(Elpo)_t + \mu_t \quad (6)$$

Figure 4 shows that there is a high goodness of fit in the actual and fitted values, and the very high value of R^2 could be detrimental if multicolinearity exists in the model. In our model the regression coefficients are individually statistically globally significant on the basis of the conventional *t* test, thus the sign of multicollinearity does not exist at all; so the independent variables perfectly explain the dependent variable with a strong fit of $R^2 = 99\%$. Remember that R^2 is a summary measure that tells how well the sample regression line fits the data; it tells how close the estimated GDP growth values are to their actual values.

The statistic "Obs*R-squared" is the LM test statistic for the null hypothesis of no serial correlation. The effective high probability value strongly indicates the absence of serial correlation in the residuals. This test results proves that we need not to modify our original specification of the model.

The Levin, Lin & Chu t* statistic of -8.24605 reveals that we may reject the null hypothesis of a unit root, thus the probability of 0.0000 is conclusive at 5% level of significance that the model used in this study is stationary at 1st difference as seen on the unit root test in table 10.

The probability of the F statistic being 0 is relevant of the fact that all the variables used in this model are perfectly statistically significantly different from zero, thus our model specification is suitable to estimate the impact of electricity consumption on economic growth in Mexico.

When we take a close look at the impact of electricity consumption on economic growth in Mexico, our results show that, GDP grows on average by 9% for any average unit increase of electricity production from coal sources and by an average of 0.6% for any average unit increase of electricity production from hydroelectric sources and by the same token for electricity production from nuclear sources. GDP growth rate then reduces by an average of 16% for any average unit increase of electricity production from natural gas, and it also reduces by an average of 9% for any average unit increase of electricity production from oil sources. This means that, given the present condition, Mexico should watch carefully the way it produces electricity from natural gas and oil, since those two sources of energy consumption hinder economic growth by an average 25%.

When we set the Granger causality test, we specified the number of lags in the test regressions to be 1, we expected that the variables in question ELPC ELPG ELPH ELPO, could affect GDP growth as soon as, just after one year, which is the average time within which any of the variables could help predict GDP growth, and we found that there exist a bi-direction grange causality between the independent variables and the dependent variable, except for the case of ELPO and ELPH, where there is a unidirectional grange causation that ELPO grange causes GDP growth, and the ELPH does not grange cause GDP growth. This could be due to the fact that Mexico invests more in importing oil, and as a result GDP growth could not cause ELPO, because of the externalities involved.

Table 12
Summary of the relationship between total energy consumption and economic growth

Variable	Coefficient	Standard Error	t-Statistic	P-value	Significance yes	Significance no
C	0.129343	1.458263	0.088697	0.9299		
LOG(ENC)	-1.389365	0.332985	-4.172453	0.0002*	X	
LOG(K)	0.852928	0.099087	8.607864	0.0000*	X	
LOG(L)	0.006788	0.012839	0.528658	0.6006		X
LOG (GDP (-1))	0.852582	0.140505	6.067996	0.0000*	X	
LOG (ENC (-1))	1.386819	0.307734	4.506554	0.0001*	X	
LOG (K (-1))	-0.709127	0.109703	-6.464074	0.0000*	X	
LOG (L (-1))	0.009148	0.011120	0.822654	0.4166		X
***			significant at 10%			
**			significant at 5%			
*			significant at 1%			

Source: computed by the authors from Eviews 8 output.

The p-value for energy consumption is highly significant, as well as that of the lag value of energy consumption. Thus in Mexico energy consumption influences negatively on GDP growth during the current period, but there is a spillover effect of positive energy consumption effect of the previous year energy consumption on GDP growth. Our result is highly statistically significant.

Table 13
Summary of the relationship between specific type of energy consumption and Economic Growth

Variable	Coefficient	Standard Error	t-Statistic	P-value	Significance yes	Significance no
LOG(ELPC)	0.090919	0.017048	5.333032	0.0000*	x	
LOG(ELPG)	-0.163519	0.034515	-4.737603	0.0000*	x	
LOG(ELPH)	0.006010	0.066758	0.090024	0.9288		x
LOG(ELPN)	0.006361	0.003493	1.821010	0.0774***	x	
LOG(ELPO)	-0.094351	0.052620	-1.793059	0.0819***	x	
LOG(K)	0.988646	0.025577	38.65310	0.0000*	x	
LOG(L)	-0.006250	0.011640	-0.536952	0.5948		x
***	significant at 10%					
**	significant at 5%					
*	significant at 1%					

Source: computed by the authors from Eviews 8 output.

In Mexico hydroelectric consumption is statistically not significant; this might be due to the fact that in recent year, hydroelectric consumption had increased, but not as much as electricity consumption increased in other sectors, and also the problem of global warming could have hindered the potential of the country to maximize the productivity capacity of its hydroelectric plants. Also the discovery of gas and the prospect to implement the energetic reform might have affected hydroelectric regeneration, reason why hydroelectric represented only 14.6 % of electricity production in Mexico in 2004 as compared to its 39 % in 1899 Garcia *et al*. (2004).

5. Conclusion and recommendation

Throughout this study we have looked at the relationship between economic growth and energy consumption. To be able to do so we carried out the granger causality test where we found that there is a bidirectional relationship between economic growth and energy consumption in Mexico. We explained that energy consumption is segmented into electricity production from coal, hydroelectric, natural gas, nuclear and oil sources. Our result showed that energy consumption has a positive impact on economic growth and our results are highly statistically significant, giving the low level of the P-values. Looking at all the sector of usage of energy, we found that electricity produced from coal, nuclear and hydroelectric sources impact positively on economic growth, while electricity produced from natural gas and oil highly negative impact on economic growth.

Therefore due to the fact electricity produced from oil and natural gas sources account for an average of 25% reduction of economic growth, we recommend that policy makers should endeavor to reduce importation of gas and oil, and concentrate more in producing those goods themselves. Mexico is located at the Gulf of Mexico one of the world largest reserves of natural gas and oil, so the authorities should invest more in extracting oil and gas from the Gulf and in the Atlantic Ocean which might definitely impact directly to break down the dependency of Mexican gas and oil production to importation. Doing so could give the country a comparative advantage in the production of gas and oil, and therefore becoming a stable exporter of gas and oil. This might immediately affect economic growth and invert the present tendency; such that growth should follow. Extracting and transforming gas and oil in Mexico is going to be a catalyst of economic growth. We strongly recommend that energy reform be implemented in Mexico so that its article 27 be put to place to let the country have full control over it gas and oil resources in order not to be totally vulnerable to oil chocks anymore. If energy reform is put in place, this will permit Mexico not only to become a strong oil and gas producer, but the country will be able to transform and refine the oil and gas being extracted, and thereby, creating more job, and generating more economic growth. At the same time the ability of Mexico to refine crude oil and extract gas in high seas will increase supply of energy within Mexico and therefore protect the country from external oil prices fluctuations that hinder growth and development prospect in the country. This will also enable many multinational companies to outsource in Mexico, as a result of energy prices drop due to its increased, stabled and full control over production and consumption of energy within the country. This will surely reverse the hydrocarbon balance of trade and boost the balance of payment of the country, going along side with swapping the country out of the vicious circle of energy dependency. If Mexico energy reform is implemented adequately, the country should witness a sustainable economic growth in the coming year as our finding reveals that energy consumption of the previous year positively and significantly impact on current economic growth.

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Table 1
World fuel use for electricity generation in 2009

Country	Coal %	Petroleum %	Natural gas %	Nuclear energy %	Renewable energy %
USA	55	2	15	25	3
Mexico	12	22	46	4	16
Canada	29	4	5	25	37
Germany	55	1	3	28	13
France	5	1	0.5	81.5	12
UK	42	0.5	32	20.5	5
Japan	28	17	20	30	5
China	89	1.5	1.0	2.0	6.5
Brazil	8	8	4.5	4.5	75

Source: Electricity Information 2009, Energy Balances of OECD Countries 2009, International Energy Agency. Energy Balances of Non-OCDE Countries 2009; SENER (2009).

Table 2
Importation and production

Importation of coal (million metric tons 1999-2007)								
1999	2000	2001	2002	2003	2004	2005	2006	2007
4.0	2.432	3.439	5.894	7.233	4.089	7.259	7.619	11.378
Production of coal (million metric tons) 1999-2007								
1999	2000	2001	2002	2003	2004	2005	2006	2007
10.3	11.3	11.3	11.1	9.6	9.9	10.8	11.5	12.2

Source: *http://www.coalportal.com/production_trade_data.cfm?data type=Import, Robert-Bruce Wallace* (2010).

Table 3
Regression

Dependent variable: LOG(GDP)
Method: Least squares
Sample: 1 42
Included observations: 42

Variable	Coefficient	Standard Error	t-Statistic	Probability
C	2.714054	0.541256	5.014365	0.0000
LOG(K)	1.065988	0.018982	56.15758	0.0000
LOG(L)	0.013342	0.012515	1.066086	0.2931
LOG(ENC)	-0.560467	0.147215	-3.807138	0.0005
R-squared	0.999293	Mean dependent var		11.43187
Adjusted R-squared	0.999237	S.D.dependent var		1.589005
S.E. of regression	0.043902	Akaike info criterion		-3.323316
Sum squared resid	0.073241	Schwarz criterion		-3.157824
Log likelihood	73.78963	Hannan-Quinn criter.		-3.262656
F-statistic	17891.02	Durbin-Watson stat		0.563976
Prob(F-statistic)	0.000000			

Source: computed by the authors from Eviews 8 output.

Table 4
Breusch-Godfrey serial correlation LM test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	39.51801	Prob. F(1,37)	0.0000
Obs*R-squared	21.69106	Prob. Chi-Square(1)	0.0000

Source: computed by the authors from Eviews 8 output.

Table 5
Unit root test

Group unit root test: summary
Series: ENP, GDP, K, L

Sample: 1971 2013
Exogenous variables: individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 6
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Probability**	Cross-sections	Observations
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-10.5300	0.0000	4	146
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-12.4804	0.0000	4	146
ADF - Fisher Chi-square	114.419	0.0000	4	146
PP - Fisher Chi-square	102.753	0.0000	4	156

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.
Source: computed by the authors from Eviews 8 output.

Table 6
Regression of the OLS Model reflecting the relationship between total energy consumption and economic growth

Dependent variable: LOG(GDP)
Method: least squares

Sample (adjusted): 1972 2012
Included observations: 41 after adjustments

Variable	Coefficient	Standard Error	t-Statistic	Probability
C	0.129343	1.458263	0.088697	0.9299
LOG(ENC)	-1.389365	0.332985	-4.172453	0.0002
LOG(K)	0.852928	0.099087	8.607864	0.0000
LOG(L)	0.006788	0.012839	0.528658	0.6006
LOG(GDP(-1))	0.852582	0.140505	6.067996	0.0000
LOG(ENC(-1))	1.386819	0.307734	4.506554	0.0001
LOG(K(-1))	-0.709127	0.109703	-6.464074	0.0000
LOG(L(-1))	0.009148	0.011120	0.822654	0.4166
R-squared	0.999753	Mean dependent var	26.47683	
Adjusted R-squared	0.999701	S.D. dependent var	3.563848	
S.E. of regression	0.061649	Akaike info criterion	-2.561537	
Sum squared resid	0.125420	Schwarz criterion	-2.227181	
Log likelihood	60.51150	Hannan-Quinn criter.	-2.439783	
F-statistic	19091.48	Durbin-Watson stat	2.282333	
Prob(F-statistic)	0.000000			

Source: computed by the authors from Eviews 8 output.

Table 7
Test of serial correlation

Breusch-Godfrey serial correlation LM test:			
F-statistic	1.078704	Prob. F(1,32)	0.3068
Obs*R-squared	1.337019	Prob. Chi-Square(1)	0.2476

Source: computed by the authors from Eviews 8 output.

Table 8
The OLS table reflecting the relationship between specific type of energy consumption and economic growth

Dependent variable: LOG(GDP)
Method: least squares

Sample (adjusted): 1971 2012
Included observations: 42 after adjustments

Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**Probability**
C	5.985908	2.320297	2.579803	0.0144
LOG(ELPC)	0.090919	0.017048	5.333032	0.0000
LOG(ELPG)	-0.163519	0.034515	-4.737603	0.0000
LOG(ELPH)	0.006010	0.066758	0.090024	0.9288
LOG(ELPN)	0.006361	0.003493	1.821010	0.0774
LOG(ELPO)	-0.094351	0.052620	-1.793059	0.0819
LOG(K)	0.988646	0.025577	38.65310	0.0000
LOG(L)	-0.006250	0.011640	-0.536952	0.5948
R-squared	0.999787	Mean dependent var	26.32286	
Adjusted R-squared	0.999743	S.D. dependent var	3.658820	
S.E. of regression	0.058667	Akaike info criterion	-2.664252	
Sum squared resid	0.117020	Schwarz criterion	-2.333268	
Log likelihood	63.94930	Hannan-Quinn criter.	-2.542933	
F-statistic	22776.91	Durbin-Watson stat	1.635762	
Prob(F-statistic)	0.000000			

Source: computed by the authors from Eviews 8 output.

Table 9
Serial correlation

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.976849	Prob. F(1,33)	0.3302
Obs*R-squared	1.207518	Prob. Chi-Square(1)	0.2718

Source: computed by the authors from Eviews 8 output.

Table 10
Unit root test

Group unit root test: Summary
Series: ELPC, ELPG, ELPH, ELPN, ELPO, GDP, L, K

Sample: 1971 2013
Exogenous variables: individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 7
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Probability**	Cross-sections	Observations
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-8.24605	0.0000	8	302
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-9.29842	0.0000	8	302
ADF - Fisher Chi-square	133.894	0.0000	8	302
PP - Fisher Chi-square	161.574	0.0000	8	320

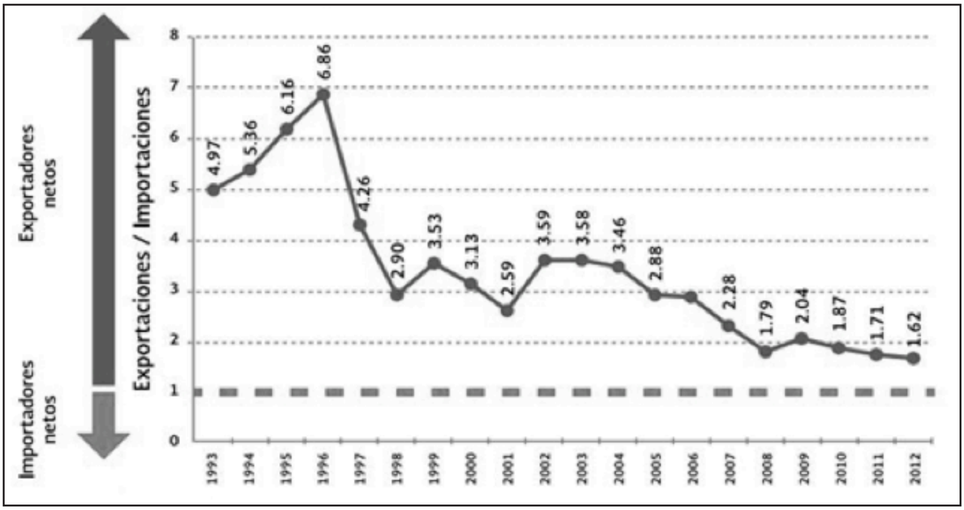
** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.
Source: computed by the authors from Eviews 8 output.

Table 11
Granger causality tests

Pairwise Granger Causality Tests
Sample: 1 42
Lags: 1

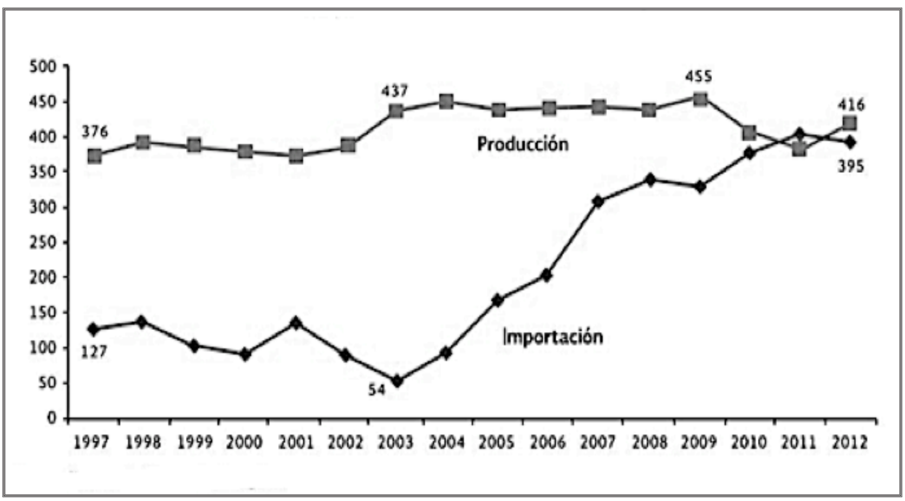
Null Hypothesis:	F-Statistic	Probability	Reject No	Reject Yes
LOG(ELPC) does not Granger cause LOG(GDP)	5.51261	0.0242		x
LOG(ELPG) does not Granger cause LOG(GDP)	13.4217	0.0008		x
LOG(ELPH) does not Granger cause LOG(GDP)	0.0054	0.9418	x	
LOG(ELPN)does not Granger cause LOG(GDP)	24.8124	0.00001		x
LOG(ELPO) does not Granger cause LOG(GDP)	23.092	0.00002		x
LOG(GDP) does not Granger cause LOG(ELPC)	10.0686	0.003		x
LOG(GDP) does not Granger cause LOG(ELPG)	5.20153	0.0283		x
LOG(GDP) does not Granger cause LOG(ELPH)	15.2205	0.0004		x
LOG(GDP) does not Granger cause LOG(ELPN)	9.07307	0.0046		x
LOG(GDP) does not Granger cause LOG(ELPO)	0.70141	0.4075	x	
LOG(GDP) does not Granger cause LOG(K)	3.96441	0.0537	x	
LOG(GDP) does not Granger cause LOG(L)	6.22584	0.0171		x
LOG(K) does not Granger cause LOG(GDP)	1.00197	0.3232	x	
LOG(L) does not Granger cause LOG(GDP)	20.8533	0.00005		x
LOG(L) does not Granger cause LOG(K)	15.5893	0.0003		x

Source: computed by the authors from Eviews 8 output.



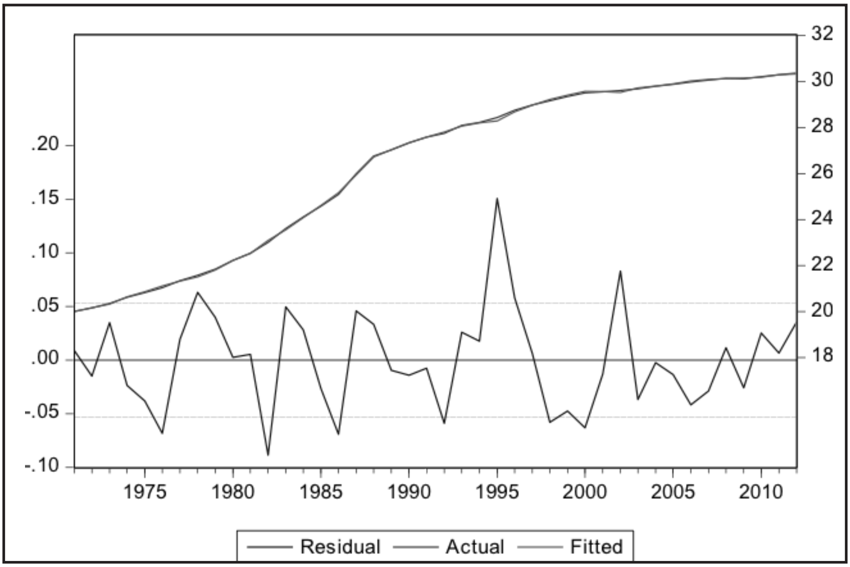
Source: CNH with information of México bank. Include petroleum, petroliferous, and natural gas and petrochemicals, Mexican government (2013).

Figure 1
Exports and imports of petroleum products



Source: energy information system, average data, Mexican government (2013).

Figure 2
Daily gasoline production and importation



Source: computed by the authors from Eviews 8 output.

Figure 3
Actual, fitted, residual graph (.)