ENERGY USE AND ECONOMIC GROWTH IN SPAIN. A COINTEGRATION ANALYSIS

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Abstract

The impact of the energy use on the economic growth has led to divergent opinions. While some analysts suggest that the energy is the prime source of value, others consider that it is neutral to growth. In the present study, we are trying to test the link between the energy use and the output growth, both on long and short-term, in the case of Spain. Starting from the neo-classical one-sector aggregate production technology function, where the input variables are the capital, the labour and the energy consumption, and the output variable is the real GDP, we will develop a vector error-correction (VEC) model to test if there is a Granger causality between the output growth and the energy use on short term. For the long term, we will use the Johansen method to identify the presence of some cointegration vectors between the output, labour, capital and energy use. The results may have implications for the development of the public policy strategies.

Key words: energy use, economic growth, Spain

JEL Code: O13, P18

Introduction

Energy plays an important role not only for the economic activity, but also for the social development. Energy is seen both as a production factor and as a strategic commodity that represents the basis for international relations, shaping the world economy and politics (Esen and Bayrak, 2017).

Yet, the energy issues did not receive too much attention in the literature until 1970s. The mainstream economists considered that capital, labour and land are the main factors of production, while goods such as fuels represent intermediate inputs. Therefore, the theory of growth focused especially on the primary inputs, in particular on capital and land, and to a much lesser extent on the role of energy in the growth process. The important role of energy as a production input started to be investigated only after the oil crisis of the 1970s, the studies addressing the energy-related issues from different perspectives. Some of the researches considered the energy a technical problem and, thus, stated that, in order to fulfil the increasing demand of energy, it is necessary to improve the existing production technologies or to develop new technologies (Krugman and Wells, 2010). Other studies regarded the energy as an economic problem. From this perspective, the increased energy demand leads to outrageous oil prices that raise the costs of other energy resources (Kavrakoğlu, 1981). Another group of studies indicate that energy problems result from the gradual depletion of the energy resources around the world (Chapman and Barker, 1991).

Despite the wide approach of the causal relationship between energy consumption and economic growth, no consensus has yet been reached. Meanwhile, the energy policy makers have to solve the global warming issue, fact that increases the need of deepening the researches on energy consumption, economic growth and carbon dioxide.

Recently, the increasing energy consumption in the European Union countries has raised serious development constraints. It is assumed that, in the next twenty years, the energy consumption will continue to grow with around fifty percent (Dudzeviciute and Tamosiuniene, 2014). Therefore, an increasing share of renewable energy in the energy mix of a country might represent a solution for the growing future demand of energy. Apart from contributing to the long-term availability of energy supply, the renewable energy may reduce the environmental impact associated with fossil fuels and promote regional development, as they can be used in less developed areas without conventional energy sources (Pirlogea and Cicea, 2012).

The aim of the present paper is to identify the nature and the direction of the relationship between energy consumption and output growth in the case of Spain. In order to reach this purpose, the research methodology included Johansen cointegration analysis, for the long run, and Granger causality tests, for the short time.

1 Theoretical background

The largest part of the literature debating the energy issues has focused on determining the direction of the relationship between the energy consumption and the growth, this direction being highly relevant for the policy makers. Therefore, the literature mentions four hypotheses regarding the possible outcomes of the causality (Apergis and Payne, 2009). The first hypothesis – the growth one – suggests that energy consumption is an essential component of growth and, consequently, a decrease in energy usage leads to a decrease in the real GDP. This hypothesis refers to the ‘energy dependent’ economies, which requires policies aimed at improving access to energy for population and industries. The opposite results might be found in the conservation hypothesis, based on a unidirectional causal relationship running from real GDP to energy consumption. In this case, the economic growth causes the energy consumption, so, lower energy consumption may have little or no negative impact on real GDP. Therefore, the policies aimed at increasing the energy efficiency will have no adverse impact on economic growth. The third view refers to the feedback hypothesis. This states that energy consumption and real GDP affect each other simultaneously. The last one – the neutrality hypothesis – indicates that reducing energy consumption does not affect the economic growth or vice versa. Therefore, the energy conservation policies would not have any impact on the real GDP.

This relationship between energy consumption and economic growth has received increasing attention after 1970s energy crises. The researches were pioneered by Kraft and Kraft (1978), who observed a unidirectional relation from GNP to the energy in the case of USA, between 1947 and 1974. The same results were found by Abosedra and Baghestani (1989). Yet, the study conducted by Yu and Choi (1985) on various states shows different conclusions. While in USA, UK and Poland there is no relationship between the energy consumption and the GNP, in Philippines the causality was from energy consumption to GNP and in South Korea the relation was from GNP to energy consumption. Meanwhile, Hwang and Gum (1991) suggests that, in Taiwan, there is a bi-directional causality between GNP and energy consumption.

More recent studies also showed different results for different countries or, even for the same state, in different periods of time. A broader research was conducted by Lee (2006) on eleven developed states, during the period 1960-2001. His results underlined that, while in Canada, Belgium, Netherlands and Switzerland the GDP is the cause of energy consumption, in England, Germany and Sweden there was no causality relation between the two variables. Starting from these findings, a subsequent research of Lee and Chang (2007) investigated this relationship on 22 developed states and on 18 pre-developed economies. This study showed that, while for the developed countries there was a bi-directional relationship, in the pre-developed states a relationship from GDP towards energy consumption was noticed.

In the case of the EU countries, an extensive research was conducted for 27 member states, which were analysed during the period 1990-2010. The findings pointed out different results for the short and long-run. Thus, if on the short-term, there was no clear relationship between economic growth and energy consumption, in the long-run, the energy consumption, based on renewables and petroleum products, is likely to stimulate the economic development of the EU-27 (Pirlogea and Cicea, 2012). Another study, which investigated only 19 EU states on the long-run, found that there is a positive relationship between energy consumption, CO_2 emissions and economic growth only for Denmark, Germany, Greece, Iceland, Italy, Portugal and Switzerland (Acaravci and Ozturk, 2010). In the case of Spain, it was noticed that the energy consumption, based on natural gas and petroleum products, is likely to stimulate the economic growth on both short and long-term (Pirlogea and Cicea, 2012).

2 Data and methods

To reach our purpose, we will use the data provided by World Bank for the period 1970-2015. The annual time series used are Energy use (kg of oil equivalent per 1.000.000 inhabitants) (E), GDP (constant 2010 US $) (Y), Labour force, total (L) and Gross capital formation (constant 2010 US $) (K). The data was naturally logged.

We consider both the long-run and the short-term analysis. For the long run, we use the Johansen cointegration analysis and for the short period we use the Granger causality tests to see if there is a relationship between the variables Y and E.

2.1 Descriptive analysis of the variables and the production function

The variables taken into account include a total of 46 annual observations, for the period 1970-2015.

Tab. 1: Descriptive analysis of the variables

Variable	Obs	Mean	Std. Dev	Min	Max
Y1 (gdp)	46	9.58e+11	3.29e+11	4.58e+11	1.48e+12
L1 (labor)	46	1.71e+07	3870806	1.26e+07	2.36e+07
K1 (capital)	46	2.28e+11	9.63e+10	1.11e+11	4.39e+11
E1 (energy)	46	9.44e+10	3.13e+10	3.80e+10	1.44e+11

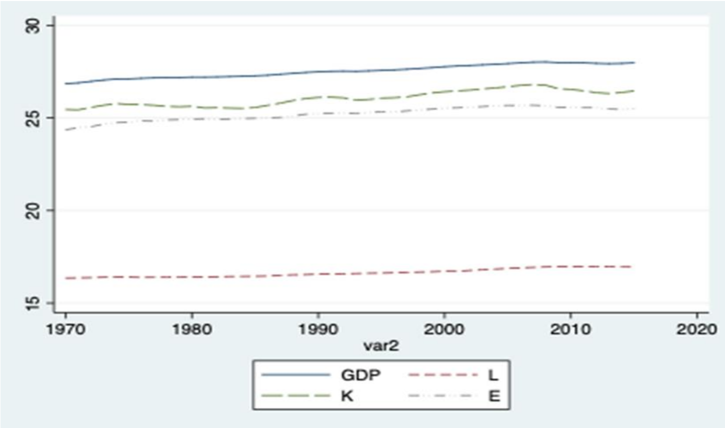
Source: Author's calculations based on data provided by World Bank for the period 1970-2015

Tab. 2: Descriptive analysis of the variables, after logging data

Variable	Obs	Mean	Std. Dev	Min	Max
Y	46	27.52832	.3548332	26.85002	28.02608
L	46	16.62886	.2191448	16.35127	16.97735
K	46	26.0659	.4209116	25.4350	26.80697
E	46	25.21039	.362205	24.36025	25.69185

Source: Author's calculations based on data provided by World Bank for the period 1970-2015

Fig. 1: Evolution of variables in the period 1970-2015



Source: Author's calculations based on data provided by World Bank for the period 1970-2015

Our model will be based on a neoclassical production function, where the dependent variable is GDP (Y) and the dependent variables are capital, labour and energy consumption (Ghali, 2004):

$$Y_t = f(K_t, L_t, E_t).$$

For the variance analysis we will differentiate this equation:

$$dY_t = Y_k dK_t + Y_L dL_t + Y_E dE_t$$

According to Ghali's model (2004), if we divide the terms of the differential equation by Y_t, we will get the relationship between the growth rates of the analysed variables:

$$\dot{Y}_t = a\dot{K}_t + b\dot{L}_t + c\dot{E}_t,$$

where a, b and c are the elasticities of Y depending on the variations of K, L and E.

2.2 Stationarity tests

Johansen cointegration analysis involves the analysis of non-stationary time series at zero level and their stationarity at a higher level. To apply the stationary tests, we need a model with autoregressive vectors, in order to identify the lags that will be taken into account.

We define the general form of the regression function used for the stationary tests.

$$\Delta X_t = \mu + \gamma X_{t-1} + \sum_{j=1}^{p} \alpha_j \, \Delta X_{t-j} + \beta_t + \omega_t$$

The VAR model is developed with all the four variables, gross domestic product (Y), labour (L), capital (K) and energy consumption (E). AIC selection order criteria indicates the presence of a lag = 2. As can be seen from the Table 3, both FPE and HQIC tests indicate the same number of lags.

Tab. 3: Selection-order criteria

Sample: 1974 - 2015	Number of obs = 42							
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	186.365		16		2.0e-09	-8.68406	-8.68406	-8.51857
1	448.117	523.5	16	0.000	1.7e-14	-20.3865	-20.0832	-19.559*
2	470.477	44.721	16	0.000	1.2e-14*	-20.6894*	-20.1435*	-19.2
3	483.506	26.057	16	0.053	1.5e-14	-20.5479	-19.7593	-18.3965
4	500.832	34.653*	16	0.004	1.6e-14	-20.611	-19.5798	-17.7977
Endogenous: Y L K E								
Exogenous: _cons								

Source: Author's calculations based on data provided by World Bank for the period 1970-2015

For stationarity, we apply the Augmented Dickey-Fuller test for unit root and the Phillips-Perron test, for all four variables. We also test the non-stationarity level and the stationarity in the first difference, for a lag of 2.

The results of Phillips-Perron test show that all variables are stationary for the first difference (dY, dL, dK and dE). The Augmented Dickey-Fuller test for unit root highlights that the variables dY, dK and dE are stationary at level 1. For the dL variable, no stationarity was obtained in the Augmented Dickey-Fuller test, but the Phillips-Perron test shows that it is stationary in the first difference. According to the methodology of the two tests, if stationarity is achieved in at least one of the tests, then the variable is considered stationary.

Therefore, we can argue that all the analysed time series are non-stationary at zero level and stationary at level one. Thus, the criteria for determining the Johansen time cointegration relationship are met.

3 Results and discussions

3.1 Johansen cointegration

In order to identify the cointegration relationship, we develop the VAR model for all four variables, with 2 lags, for the period 1972-2015, meaning 44 observations.

Tab. 4: Vector autoregression, var Y L K E, lags(1/2)

Sample: 1972 - 2015	Number of obs = 44
Log likelihood = 483.8305	AIC = -20.35593
FPE =1.74e-14	HQIC = -19.81457

Det(Sigma_ml) = 3.30e-15	SBIC = -18.89614				
Equation	Parms	RMSE	R-sq	chi2	P>chi2
Y	9	.017781	0.9977	18907.1	0.0000
L	9	.01119	0.9978	20094.53	0.0000
K	9	.059324	0.9828	2517.206	0.0000
E	9	.031763	0.9923	5667.148	0.0000

Source: Author's calculations based on data provided by World Bank for the period 1970-2015

Equations obtained for a confidence interval of 95% (* = non-significant for 95% confidence interval) are:

$$Y = 0{,}543^{*} + 1{,}455Y_{t-1} - 0{,}756Y_{t-2} + 0{,}356^{*}L_{t-1} - 0{,}055^{*}L_{t-2} + 0{,}013^{*}K_{t-1} - 0{,}055^{*}K_{t-2} + 0{,}061^{*}E_{t-1} + 0{,}109^{*}E_{t-2}$$

$$L = -0{,}244^{*} + 0{,}337^{*}Y_{t-1} - 0{,}306^{*}Y_{t-2} + 1{,}150L_{t-1} - 0{,}219^{*}L_{t-2} - 0{,}019^{*}K_{t-1} + 0{,}015^{*}K_{t-2} - 0{,}021^{*}E_{t-1} + 0{,}046^{*}L_{t-2}$$

$$K = -1{,}091^{*} + 1{,}088Y_{t-1} - 1{,}421^{*}Y_{t-2} + 1{,}642L_{t-1} - 1{,}004^{*}L_{t-2} + 0{,}981K_{t-1} - 0{,}305^{*}K_{t-2} - 0{,}416^{*}E_{t-1} - 0{,}096^{*}L_{t-2}$$

$$E = 0{,}642^{*} + 1{,}048^{*}Y_{t-1} - 0{,}506^{*}Y_{t-2} + 0{,}373^{*}L_{t-1} - 0{,}736^{*}L_{t-2} + 0{,}067^{*}K_{t-1} - 0{,}084^{*}K_{t-2} + 0{,}557E_{t-1} + 0{,}082^{*}L_{t-2}$$

Cointegration analysis can be done, all variables being integrated I (1). We apply the Johansen test for the VAR model described above. Initially, we apply the restricted trend model.

Tab. 5: Johansen tests for cointegration, restricted trend

Trend: rtrend				Number of obs = 44	
Sample: 1972 - 2015				Lags = 2	
				5%	
maximum rank	parms	LL	eigenvalue	trace statistic	critical value
0	20	451.96486	.	84.5993	62.99
1	28	468.66922	0.53200	51.1906	42.44
2	34	482.17374	0.45873	24.1815*	25.32
3	38	490.48765	0.31470	7.5537	12.25
4	40	494.26452	0.15775		

Source: Author's calculations based on data provided by World Bank for the period 1970-2015

The results show the presence of a cointegration vector. For a higher accuracy of the analysis, we also apply the trend model. Figure 1 shows that all data series have a slightly increasing trend.

Tab. 6: Johansen tests for cointegration

Trend: trend		Number of obs = 44			
Sample: 1972 - 2015		Lags = 2			
					5%
maxium rank	parms	LL	eigenvalue	trace statistic	critical value
0	24	457.27792	.	73.9732	54.64
1	31	472.59665	0.50158	43.3357	34.55
2	36	485.63167	0.44706	17.2657*	18.17
3	39	490.49652	0.19839	7.5360	3.74
4	40	494.26452	0.15741		

Source: Author's calculations based on data provided by World Bank for the period 1970-2015

As it results from Table 5 and 6, both the restricted trend model and the trend model show the presence of a cointegration vector. Therefore, there is a long-term cointegration relationship between the variables of the model, which means that there is a correlation between the energy consumption and the output growth.

3.2 Granger causality

Since we have found at least one cointegration vector, we will test whether there is a short-term causality between the energy consumption and the output variation.

As it can be seen from Table 7, Y is the Granger cause for E (line 2), but there is no short-term causality between the energy consumption and the economic growth (line 1).

Tab. 7: Granger causality Wald tests

	Equation	Excluded	chi2	df	Prob > chi2
1	Y	E	.19705	2	0.906
	Y	ALL	.19705	2	0.906
2	E	Y	18.518	2	0.000
	E	ALL	18.518	2	0.000

Source: Author's calculations based on data provided by World Bank for the period 1970-2015

Conclusions

The analysis of the relationship between the energy consumption and the GDP growth in Spain, during the considered period, generates a number of relevant results.

The long-term analysis shows that there is a link between the GDP evolution and the increasing energy consumption. This is normal, as long as the energy is an intensive production factor used in all phases and in all branches of the economy, especially in industry. During the 1980s and 1990s, Spain's development was based on the expansion of the industrial sector, especially metallurgy and machine construction. The short-term analysis has shown that GDP growth has led to an increase in energy consumption. This proves, once again, that much of the Spain's economic growth is based on energy-consuming industries and, at the same time, the significant increase in the national income has led to a raise in the energy consumption. However, we cannot argue that the investments and consumption in the energy industry have generated a short-term GDP growth. Therefore, we cannot say that there is a significant impact of the energy consumption on the economic growth. The determination relationship is the reverse, the economic growth generating increased energy consumption. Our findings are consistent with the conservation hypothesis, debated in the literature.

It is important to underline that in Spain, the economic growth has also determined investments in the energy sector, as a natural consequence and as a result of the free market functioning, based on the stimulus that demand exerts on the supply. Therefore, strategic measures of energy policy are not necessarily required, because the free market effectively responds to the challenges of the sustainable growth.

Acknowledgment

This article is funded by the Ministry of Research and Innovation within Program 1 – Development of the national RD system, Subprogram 1.2 – Institutional Performance – RDI excellence funding projects, Contract no.34PFE/19.10.2018.

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