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ENERGY PRODUCTIVITY, ENERGY DEPENDENCE AND ECONOMIC GROWTH IN EXTENDED EUROPE

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ABSTRACT

Purpose: Energy is used in all areas of production and is crucial for economic growth. This study aims to empirically analyze the relationship between energy productivity, economic growth, and energy use in 35 European countries, for the period of 1990-2015.

***Methodology*:** European countries are divided into two groups, namely developed and developing economies. To account for structural breaks, a panel cointegration test that allows for multiple structural breaks is applied to two groups of countries.

Findings: Multiple breaks are found by the Westerlund (2006) test in the group of emerging countries, suggesting that energy policies within Europe should differ by country. Structural breaks in emerging European economies suggest that these countries are more fragile to both external and internal shocks. The results of the study also show that economic growth in developing countries increases energy dependency, while economic growth in developed European countries causes an increase in energy efficiency.

Originality: This study aims to enrich the literature in two aspects. First, it analyzes energy dependence and efficiency at the same time. Secondly, it examines developed and developing European countries in two separate sub-samples by observing structural breaks in the relationship between energy dependence, energy efficiency and growth.

***Keywords**:* Economic Growth, Energy, Panel Estimations, Energy Productivity, Structural Breaks.
JEL Codes: O40, Q43, C33.

GENİŞLETİLMİŞ AVRUPA ÜLKELERİNDE ENERJİ VERİMLİLİĞİ, ENERJİ BAĞIMLILIĞI VE EKONOMİK BÜYÜME

ÖZET

Amaç: Enerji üretimin her alanında kullanılmakta ve ekonomik büyüme için çok önemlidir. Bu çalışma, 1990-2015 yılları arasında 35 Avrupa ülkesindeki ekonomik büyüme, enerji tüketimi ve enerji verimliliği ilişkisini ampirik olarak analiz etmeyi amaçlamaktadır.

Yöntem: Avrupa ülkeleri gelişmiş ve gelişmekte olan ekonomiler olarak iki ayrı gruba ayrılmıştır. Yapısal kırılmaları dikkate almak için iki ülke grubuna çoklu yapısal kırılmalı panel eşbütünleşme testi uygulanmıştır.

Bulgular: Gelişmekte olan ülkeler grubunda Westerlund(2006) test sonuçları birçok yapısal kırılma bulunması Avrupa enerji politikalarının ülkeler için ayrı olması gerektiği sonucunu çıkarmaktadır. Gelişmekte olan Avrupa ekonomilerindeki çok sayıdaki yapısal kırılma bu ekonomilerin içsel ve dışsal şoklara karşı daha kırılgan olduğunu göstermektedir. Çalışma sonuçları ayrıca gelişmekte olan ülkelerde ekonomik büyümenin enerji bağımlılığını arttırdığını, öte yandan gelişmiş Avrupa ülkelerinde ekonomik büyümenin enerji verimliliğinin artmasına sebep olduğunu göstermektedir.

Özgünlük: Bu çalışma literatürü iki açıdan zenginleştirmeyi hedeflemektedir. Öncelikle, enerji bağımlılığını ve verimliliği aynı anda incelemektedir. İkinci olarak, enerji bağımlılığı, enerji verimliliği ve büyüme ilişkisini yapısal kırılmaları gözlemleyerek gelişmiş ve gelişmekte olan Avrupa ülkelerini iki ayrı alt örneklem grubunda incelemektedir.

***Anahtar Kelimeler**:* Ekonomik Büyüme, Enerji, Panel Tahmin, Enerji Verimliliği, Yapısal Kırılmalar.
JEL Kodları: O40, Q43, C33.

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1. INTRODUCTION

Energy resources are one of the most important drivers of an economy. An abundance of energy resources is a significant advantage for any economy, however, sometimes it can become a curse. Countries of the EU are not blessed with non-renewable energy resources and are dependent on imports. The EU imports about 80% of oil and 60% of natural gas that they consume (Eurostat, n.d.). The high-energy dependence creates limitations in an economy particularly in terms of costs planning that are affected by the rising prices of petroleum products. The European Commission (2019) reports that rising prices of fossil fuels, particularly crude oil, caused the cost of imported energy products to increase by 26% to 266 billion Euros in 2017. In addition, the report estimates that rising oil prices may cause a 0.4% drop in GDP in 2017.

To diminish the adverse impact of energy dependence on economic growth, European policy focuses on improving energy efficiency (European Commission, 2019). Increases in energy efficiency or productivity can also generate externalities, thus promoting economic growth. Money saved from energy efficiency improvements can be reinvested in the economy to promote further growth. Externalities are the result of technological innovation, the objective of which is to improve energy productivity, and can lead to an increase in production for other areas through the diffusion of technology (Jaffe et al., 2004). Technological development can be sustained through the diffusion of trade and national innovations (Krugman,1979). Hence, trade plays a crucial role in energy productivity through competition and the diffusion of technology. For this reason, this paper takes into account trade effects as well as energy efficiency.

This work analyzes the impact of energy productivity on economic growth in terms of trade openness and energy dependency taking into account structural breaks. This study analyses 35 European countries and Turkey covering the period of 1990-2015. Estimations were conducted for countries, which were allocated into two groups, developed and emerging countries. The group of emerging economies includes 15 countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Slovenia, Slovakia, and Serbia. The second group includes 20 developed countries: Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Island, Italy, Luxemburg, Malta, Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey, and United Kingdom.

Although the importance of energy efficiency has been stressed by the policy makers of EU, the empirical relationship between economic growth and productivity has not been analyzed extensively in the literature. Further, those which investigates this relationship mostly use industry-based data rather than aggregates (Boyd and Pang, 2000; Zhang et al., 2011; Wan et al., 2015).

The novelty of this study can be defined in two ways. First, structural break analysis suggests that emerging economies in Europe are more fragile to both internal and external shocks. Dependence on imported energy along with lower levels of energy efficiency led emerging countries behind the developed economies in the Europe. The production gap between developed Europe and Emerging Europe seems to be widening and to narrow the corresponding gap, increasing energy efficiency in emerging states is crucial. Further, both empirical analyses and policy recommendations should consider the differences in fragility to shocks in two country groupings. In macro panel studies analyzing Europe as a whole group might lead the researcher to miss the different structural changes in these two groups. In terms of policy purposes, taking into consideration of fragility to shocks, energy efficiency policies as well as goals for Emerging Europe should be country specific.

Second, the dynamics of the relationship between economic growth and energy is different in two country groupings. According to causality analysis in this paper, economic growth causes higher energy dependency in emerging countries, indication of beginning phase of economic development (Judson et al., 1999). On the other hand, for developed Europe economic growth leads to higher energy productivity in developed economies. In developing Europe, since both the consumption and efficiency levels are low, in order to increase production more imported energy is needed. For example, in 2015, according to the International Energy Agency (IEA) statistics, European Union average energy use per capita is 3,278 kg of oil, energy use in Germany for the same year is 3,818 kg of oil and in Romania it is only 1,592 kg of oil equivalent per capita (IEA,2019).

The rest of this paper is structured in the following way. The next section reviews leading studies in the literature on energy productivity. Section 3 discusses the methodology used in estimations. Section 4 reports empirical results and their discussion. Final section outlines concluding remarks.

2. REVIEW OF EMPIRICAL LITERATURE

The literature presents numerous studies concerning the empirical relationship between the impact of energy use and renewable energy use on economic output. The impact of energy use on economic output is examined extensively in the literature, see for example Lee (2005), Lee and Chang (2005), Mehrara(2007), Al-Iriani (2006), Soytas and Sari (2003), Narayan and Smyth (2008), Huang et.al. (2008), Apergis and Payne (2009). However, the linkage between energy productivity and economic output is not examined much in a macro sense. Further, the results of the studies in the literature are highly controversial regarding the direction of causality between energy consumption and economic growth (see Ozturk (2010) for a detailed review of the literature).

On the other hand, studies that focus on the impact of energy productivity rather than the consumption are mostly limited to specific sectors. The results of these studies indicate that total productivity may be affected by externalities in energy productivity. Boyd and Pang (2000) studied the relationship between productivity and energy efficiency employing microdata at the factory level in the glass industry. Their empirical results provide evidence of high-energy intensity causing lower factory productivity. Furthermore, their research indicates that energy efficiency may create numerous non-energy benefits. From a macro perspective, energy productivity can also influence economic development in non-energy ways. For example, research on energy efficiency influences any other technologies that are energy-driven and lead to a growth in total productivity.

Zhang et al. (2011) for example analyzed income and energy efficiency relations in 23 developing countries from 1980 through 2005. Their results showed that due to the growth of industry, energy efficiency deteriorated with the increase in per person income to a level, after which energy efficiency starts to increase. Another study on energy efficiency examines the trade spillover effects on the convergence of the energy productivity for 16 EU economies, Wan et al. (2015). Their analysis posits that 30 to 40% of the unobserved deviation in energy productivity across Europe is justified by trade flows for the period 1990-2005.

The magnitude of the effect of energy consumption on economic growth also depends on the country’s level of energy dependence. Energy exporter countries benefit from cheap energy as an input in production. This creates a comparative advantage in resources of production and consequently higher profit compared to energy importing countries. In other words, due to lower energy input costs in exporting countries, energy consumption has a greater share in economic development in countries that export energy resources compared to importing countries (Damette and Seghir, 2013; Jalil, 2014; Chen and Galbraith, 2011). Furthermore, due to lower energy costs, energy efficiency may become an important part of energy exporting countries as well, leading to an accelerating rise in production. For example, Norway is one of the European leaders in energy export and is characterized by high levels of energy productivity. At the same time, energy-importing countries have higher energy input costs and, if misused, the returns to energy consumption are lower. Energy productivity plays a vital role in energy importing countries. A specific example also included in this study is Germany, where higher energy productivity enables the country to achieve higher economic growth compared to neighboring countries.

This study contributes to the empirical literature in couple of ways. First, via examining the energy productivity and economic growth in a macro panel framework, it fills a gap in the literature. In that sense it becomes hard to compare the findings of this paper with a similar study. As mentioned before, the literature either takes energy consumption as a variable or employs energy productivity mostly in industry level analyses. Second, consideration of structural breaks is important since number of serious events related to energy has occurred and it prevents the bias in examination of cointegration (Narayan and Smyth, 2008). Third, the empirical model also controls for energy dependence and trade openness which have direct effect on the outcome as mentioned earlier (Damette and Seghir, 2013; Jalil, 2014).

3. METHODOLOGY and DATA

The balanced panel of 35 European countries is employed in this study covering the period 1990-2015. The data for this study is extracted from Eurostat and the WDI online databases (The World Bank, 2019). Economic output is presented by annual real GDP calculated in constant 2010 US dollars. Labor presents the national estimate of the total workforce. The real gross capital formation is employed for capital and is measured in constant 2010 US dollars. Energy dependence is calculated as a ratio of energy resources imports to total energy consumption. Energy productivity is measured as a ratio of GDP to gross inland energy consumption. Finally, trade represents a share of total trade to GDP.

The study analyzes an influence of energy productivity on economic growth in the augmented version of the standard Cobb-Douglas production function framework (see Benhabib and Spiegel, 1994) with consideration of structural breaks. Two subsets of countries are estimated in this study, namely advanced and emerging countries. To distinguish the separate effect of energy dependence, the study also controls for energy dependency. The Cobb-Douglas production function combines productivity, capital, and labor as in Equation 1.

$$Y = AK^{\alpha}L^{\beta} \quad (1)$$

where Y presents economic growth, A represents total factor productivity expressed in the form of a technological factor. K and L present capital and Labor, respectively. The parameters α and β are the product elasticities of physical and human capital, respectively. This study extends the standard production function by trade openness, energy productivity, and imported energy, assuming that these variables are important factors of technological productivity (Equation 2).

$$Y_{it} = f(K_{it}, L_{it}, TR_{it}, EP_{it}, EI_{it}) \quad (2)$$

The augmented production function can be expressed by Equation 3.

$$Y_{it} = \alpha_{it} + +\beta_{1i}K_{it} + \beta_{2i}L_{it} + \beta_{3i}TR_{it} + \beta_{4i}EP_{it} + \beta_{4i}EI_{it} + \varepsilon_{it} \quad (3)$$

where Y_{it} is economic growth, K_{it} and L_{it} present capital and labor, respectively. TR_{it} is presented by a ratio of total trade to GDP, energy productivity is expressed as EP_{it}, and energy dependence is expressed as EI_{it} and calculated as the ratio of imported energy resources to total energy use. The subscripts i and t are related to the estimated country and year, respectively. All data are estimated in natural logarithms.

3.1. Tests for Unit Root Estimations

This study considers structural breaks in estimations, therefore unit root tests with structural breaks consideration are employed. Additionally, conventional unit root tests that do not allow for structural breaks, are applied for the robustness check.

The conventional unit root tests include the Levin et al. (2002), (LLC), the Im et al. (2003) (IPS), the Breitung (2000), the Augmented Dickey-Fuller (ADF) and Philip Perron (PP) Fisher type tests, (Maddala and Wu, 1999; Choi, 2001). The homogeneity condition is imposed on coefficients of ADF regression by the LLC test, which allows intercept and trend to change across individual series. The IPS test on the other hand allows for both the autoregressive coefficient and slope of the ADF regression. Fisher-type tests do not require a balanced panel and are non-parametric tests, Maddala and Wu (1999) designed a test that combines the probability values estimated for every cross-section.

An alternative test employed that does not consider structural breaks is the Hadri (2000) test. This unit root test is designed for a heterogeneous panel and extended to a panel with a deterministic trend that contains fixed and time effects. The LLC, the IPS, the Breitung, the IPS, and Fisher-type tests have the null hypothesis of non-stationarity in estimated panels. The Hadri test's null hypothesis is stationarity.

Im et al. (2005) revealed that consideration of structural breaks in a panel where they do not exist does not cause the loss of power and significant distortions. However, ignorance of structural breaks in unit roots estimations may lead to significant distortions and loos of the test's power. Im et.al. (2005) improved the Schmidt and Phillips (1992) unit root test by extending it to a panel test with consideration of up to two structural breaks in the trend and in constants. The minimum Lagrange Multiplier (LM) statistics are used to estimate the date of a break in the Im et. al. (2005) test.

3.2. Tests for Stability Estimations

To estimate the stability of the parameters in the cointegration relationship, this study employs the Hansen (1992) test; following Ketenci (2013). The test is using completely modified OLS residuals and has a condition of series non-stationarity (Phillips and Hansen, 1990). The L_c statistics (Hansen,1992) is employed in this study to examine the stability of the regression. The L_c statistics compare the null hypothesis of cointegration with constant parameters to the alternative hypothesis of a change in coefficients without cointegration.

3.3. The Westerlund (2006) Cointegration Test

To test for a cointegration in the regression model, the Westerlund (2006) test is employed. The panel cointegration test considers multiple structural shifts in series. Series of European countries, employed in this study, namely economic output, physical capital, labor, trade, energy productivity, and imported energy may be passed through numerous structural shifts in the estimated period at a domestic and international level. Therefore, the cointegration test that allows for structural shifts is applied in this study.

4. EMPIRICAL RESULTS

4.1. Estimation of Unit Roots

To analyze the unit root characteristics of variables, three alternative unit root tests were employed: the IPS, the ADF, and the Hadri tests. Table 1 presents the results of unit root estimations. The prerequisite of Hansen's (1992) stability test is that the variables must be non-stationary. The unit root was found in levels of all series except capital. Table 1 shows that the unit root process was not detected in the first differences of variables for both developed and emerging countries groups.

Table 1 provides results of unit root estimations that ignore the presence of structural breaks. However, to get stronger evidence of the presence of a unit root in unstable as well as stable series, the panel unit root tests proposed by Im et al. (2005) were applied, allowing for one and two structural shifts in series. The stability test of Hansen (1992) can be performed only for non-stationary variables with consideration of structural changes. Therefore, the LM panel unit root test is employed, which allows up to two structural changes.

Table 1. Unit root tests

	Developed		*Emerging*	
	Level	*Δ*	*Level*	*Δ*
Y				
IPS[3]	3.22	-5.65*	3.79	-7.92*
ADF[3]	19.26	110.53*	7.82	119.67*
Hadri[4]	9.93*	6.56*	15.51*	3.91*
K				
IPS[3]	4.23*	-9.88*	-2.64**	-9.87*
ADF[3]	88.89*	172.84*	49.80*	150.37*
Hadri[4]	5.79*	-1.04	5.83*	0.13
L				
IPS[3]	-1.63	-7.90*	-2.07*	-6.11*
ADF[3]	61.91*	138.45*	47.41**	94.26*
Hadri[4]	12.17*	4.63*	11.01*	3.72*
TR				
IPS[3]	0.12	-11.93*	0.61	-14.26*
ADF[3]	41.39	210.30*	27.97	217.76*
Hadri[4]	16.14*	-0.82	13.99*	-0.85
EPROD				
IPS[3]	5.12	-12.12*	-1.73**	-9.29*
ADF[3]	10.01	214.26*	58.64*	143.12*
Hadri[4]	14.49*	-1.09	8.93*	5.43*
EIMP				
IPS	0.92	-9.79*	-0.76	-9.70*
ADF	37.96	174.08*	35.35	147.28*
Hadri	2.25*	5.94*	8.44*	1.37

Notes: One lag is specified in estimations, constant and trend are included. * Symbolizes the level of significance at 5%. [3] The null hypothesis of non-stationarity. [4] The null hypothesis of stationarity.

Table 2 and Table 3 present results of the LM unit root test for one and two structural shifts in series, respectively. The results illustrate the rejection of the stationarity hypothesis, indicating the unit root presence in all series. The LM statistics for individual countries often failed to reject the stationarity hypothesis where only one structural shift was allowed. The tests in which two structural shifts were allowed exhibited stronger power to reject the null hypothesis of the series' stationarity. The tests in which two structural shifts were allowed exhibited stronger power to reject the null hypothesis of the series' stationarity. The years in common for developed countries in which sudden structural shift occur are consistent with the global economic crises and sharp increase in oil periods (such as 2010 following 2009 global crisis and 2000-2004 period in which global energy prices starts to increase). Emerging countries also are affected by the global crises but further they experience structural shifts in years other than global crisis years. Although these two groupings have common structural changes in their growth process, Emerging countries have a different pattern in terms of structural changes in their economies.

Table 2. Estimation of the unit root, one structural shift

	Developed		*Emerged*	
	Min LM	*LM statistic*	*Min LM*	*LM statistic*
Economic growth				
LM	-12.06	-17.95*	-5.12	-9.32*
Shift	2006		2011	
Lag	7		8	
Capital				
LM	-3.93	-18.01*	-6.51	-16.53*
Shift	2005		2004	
Lag	4		5	
Labor				
LM	-4.23	-19.68*	-3.27	-17.55*
Shift	2004		2000	
Lag	0		8	
Trade				
LM	-3.32	-22.83*	-4.98	-13.78*
Shift	2004		2007	
Lag	0		7	
Energy Productivity				
LM	-4.32	-15.68*	-1.49	-13.44*
Shift	2005		2002	
Lag	4		6	
Energy Dependence				
LM	-6.06	-15.65*	-4.23	-15.18*
Shift	2004		2005	
Lag	7		7	

Notes: 5% significance level is symbolized by *. (Lee and Strazicich, 2003).

Table 3. Estimation of the unit root, two structural shifts

	Developed		*Emerging*	
	Min LM	*LM statistic*	*Min LM*	*LM statistic*
Economic growth				
LM	-45.09	-46.93*	-6.38	-24.33
Shift 1		2006		2005
Shift 2		2013		2009
Lag		0		8
Capital				
LM	-8.21	-34.83	-10.69	-32.53
Shift 1		2002		2002
Shift 2		2006		2006
Lag		8		5
Labor				
LM	-7.92	-40.64	-8.49	-38.44*
Shift 1		2001	2002	
Shift 2		2005	2007	
Lag		8		8
Trade				
LM	-5.46	-42.65	-8.55	-33.85*
Shift 1		2000		2006
Shift 2		2009		2012
Lag		4		8
Energy Productivity				
LM	-10.63	-38.69	-4.43	-23.61
Shift 1		2005		2001
Shift 2		2008		2004
Lag		7		2
Energy Dependence				
LM	-7.52	-44.29*	-8.17	-34.77
Shift 1		2001		2001
Shift 2		2010		2010
Lag		5		8

Note: 5% significance level is symbolized by *. (Lee and Strazicich, 2003).

4.2. The Hansen (1992) Stability Test

After confirming the non-stationarity of series, the stability of Hansen (1992) is employed. The estimation results are presented in Table 4. The Lc statistics rejected the hypothesis of a constant parameter in all countries except Ireland. The results clearly show that, except for Ireland, all estimated countries have experienced a sudden structural shift in the model. The findings of Table 4 are consistent with the findings of Table 1, Table 2, and Table 3. Both developed and emerging economies of Europe experience one or more structural change during the period of analysis.

Table 4. Stability tests

Emerging Countries	*Lc Test*	*p-value*	*Developed Countries*	*Lc Test*	*p-value*
Albania	15.34	<0.01	Island	5.19	<0.01
Bulgaria	6.31	<0.01	Greece	12.33	<0.01
Czech Republic	3.95	<0.01	Spain	2.44	<0.01
Estonia	3.56	<0.01	France	5.73	<0.01
Croatia	4.75	<0.01	Cyprus	2.02	<0.01
Latvia	4.16	<0.01	Italy	2.21	<0.01
Lithuania	8.92	<0.01	Luxemburg	2.02	<0.01
Hungary	6.54	<0.01	Malta	12.17	<0.01
Poland	6.57	<0.01	Netherlands	4.09	<0.01
Romania	1.55	<0.01	Austria	7.16	<0.01
Slovenia	8.89	<0.01	Portugal	2.77	<0.01
Slovakia	7.39	<0.01	Sweden	9.41	<0.01
Macedonia	5.75	<0.01	Finland	1.54	<0.01
Serbia	4.74	<0.01	Ireland	0.59	>0.2
Bosnia And Herzegovina	3.15	<0.01	United Kingdom	3.47	<0.01
			Turkey	7.69	<0.01
			Switzerland	1.49	<0.01
			Belgium	10.27	<0.01
			Denmark	3.34	<0.01
			Germany	1.85	<0.01

Notes: The GAUSS program is used to calculate p-values. Statistics can be found in Hansen (1992).

4.3. Cointegration Test Results

Considering the stability test results reported in Table 4, the Westerlund (2006) panel cointegration test can be employed. Tables 5 and 6 provide results of the test estimations for developed and emerging European countries, respectively. The second column presents the number of estimated breaks, where the third column shows years of estimated breaks.

Estimations of the Hansen test reveal that all estimated countries are unstable. Maximum five structural shifts are allowed in estimations. Estimations for every group of countries are divided in Panel A and B, where structural shifts are considered in a constant, and in both constant and trend of the regression, respectively. Estimations reveal expected results of the structural breaks presence in emerging economies and a few shifts in the group of developed countries, Turkey (2001), Denmark (2003), and Sweden (2011). These results stress the importance of groupings in terms of analyzing the impact of energy productivity on economic output. Developing countries are more fragile to both internal and external shocks, as seen in Table 5 and Table 6, multiple structural breaks are detected in emerging countries. Europe is a net energy importer, years of identified structural breaks are associated with increases in energy prices and lower production levels in emerging Europe.

The null hypothesis of cointegration is rejected when shifts are considered in constant and in both, constant and trend. Estimations provide enough evidence to derive that panel series are not cointegrated when structural breaks are allowed in estimations.

Table 5. The Westerlund (2006) test, developed countries

Countries	*Shifts number*	*Year*	*Countries*	*Shifts number*	*Year*
Panel A	*Shifts in constant*		*Panel B*	*Shifts in constant and trend*	
Belgium	0		Belgium	0	
Denmark	1	2003	Denmark	0	
Germany	0		Germany	0	
Island	0		Island	0	
Greece	0		Greece	0	
Spain	0		Spain	0	
France	0		France	0	
Cyprus	0		Cyprus	0	
Italy	0		Italy	0	
Luxemburg	0		Luxemburg	0	
Malta	0		Malta	0	
Netherlands	0		Netherlands	0	
Austria	0		Austria	0	
Portugal	0		Portugal	0	
Sweden	1	2011	Sweden	0	
Finland	0		Finland	0	
United Kingdom	0		United Kingdom	0	
Norway	0		Norway	0	
Turkey	0		Turkey	1	2001
Switzerland	0		Switzerland	0	
LM statistics	27.097*		LM statistics	12.401*	

Note: The Bai and Perron (2003) approach is employed to estimate structural shifts. Maximum 5 breaks are allowed by the procedure. * Rejects the null hypothesis of long-run relationships at the significance level of 5% (based on the bootstrap p-values).

Table 6. The Westerlund (2006) test, emerging countries

Countries	*Shifts number*	*Year*	*Countries*	*Shifts number*	*Year*
Panel A	*Shifts in constant*		*Panel B*	*Shifts in constant and trend*	
Albania	3	2003, 2007, 2011	Albania	3	1994, 2002, 2009
Bulgaria	3	2002, 2006, 2010	Bulgaria	5	1993, 1998, 2003, 2008, 2012
Czech Republic	3	1994, 2001, 2005	Czech Republic	4	1993, 2001, 2008, 2012
Estonia	4	1998, 2003, 2007, 2012	Estonia	3	1999, 2004, 2008
Croatia	3	1999, 2004, 2009	Croatia	3	2000, 2008, 2012
Latvia	4	1993, 2001, 2005, 2012	Latvia	4	1995, 2000, 2006, 2010
Lithuania	5	1994, 1999, 2003, 2007, 2011	Lithuania	2	2001, 2008
Hungary	3	1999, 2003, 2012	Hungary	5	1993,1997, 2004, 2008, 2012
Poland	5	1994, 1998, 2002, 2006, 2010	Poland	1	1999
Romania	3	2001, 2005, 2012	Romania	3	1993, 2000, 2009
Slovenia	3	2000, 2005, 2009	Slovenia	3	2004, 2008, 2012
Slovakia	4	1995, 2002, 2006, 2012	Slovakia	4	1993, 2000, 2004, 2008
Macedonia	3	2004, 2009	Macedonia	3	1993, 2000, 2011
Serbia	4	1994, 2004, 2008, 2012	Serbia	3	1998, 2002, 2008
Bosnia and Herzegovina	2	1995, 2004	Bosnia and Herzegovina	5	1995, 1999, 2004, 2008, 2012
LM statistics	41.098*		LM statistics	41.442*	

Note: The Bai and Perron (2003) approach is employed to estimate structural shifts. Maximum 5 breaks are allowed by the procedure. * Rejects the null hypothesis of long-run relationships at the significance level of 5% (based on the bootstrap p-values).

4.4. Results of the Granger Causality Test

The Granger (1969) causality test is employed to analyze causality among energy productivity, energy dependence, and economic growth for two groups of countries. Table 7 illustrates the results of the Granger causality test. Results reveal different relations in different groups; thus, in emerging countries, unidirectional causality runs from energy productivity to economic growth and from economic growth to energy dependence. This finding suggests that for the emerging country grouping, the past values of the energy productivity appear to contain information on predicting the changes in economic growth. However, in developed countries, one direction causality was detected between economic growth and energy productivity. The causality test results demonstrate that emerging and developed countries follow different growth models. Emerging countries' performance is highly related to energy dependency, while developed countries' economic growth is significantly determined by energy productivity. Capital acquired by emerging countries is mainly used for the import of new energy resources, increasing energy dependency, creating a risk for independent development and economic growth. However, developed countries use the surplus of capital for energy productivity improvement, which in turn leads to faster economic growth.

Table 7. The Estimations of Granger causality

	Emerging countries	*Developed countries*
Energy productivity does not Granger cause economic output	4.55*	0.49
Economic output does not Granger cause energy productivity	0.44	2.85*
Energy dependence does not Granger cause economic output	2.14	0.05
Economic output does not Granger cause energy dependence	3.62*	0.21

Note: * Rejects the hypothesis of no causality at 5% significance level

5. CONCLUDING REMARKS

In this paper, the group of European countries is divided into two sub-samples, 15 emerging and 20 developed countries. This work aims to analyze relationships among economic growth, energy productivity, and energy dependence in Europe for the period 1990-2015. The allowance of structural breaks in the model reveals the absence of the long-run relationships, while their ignorance leads to the presence of cointegration in the regression model and misleading policy implications.

The structural break analysis suggests that emerging economies in Europe are more fragile to both internal and external shocks. During the 1990-2015 period, while there are multiple structural breaks for emerging economies, there are no structural shifts in developed economies, except for Turkey (2001), Denmark (2003), and Sweden (2011). Policies designed for the emerging countries should be differentiated and panel analyses should consider grouping these countries separately. The years in common for developed countries in which sudden structural shift occur are consistent with the global economic crises and sharp increase in oil periods whereas emerging countries experience structural shifts in years other than global crisis years. Although these two groupings have common structural changes in their growth process, Emerging countries have a different pattern in terms of structural changes in their economies. These findings suggest that Emerging economies are more fragile to external or internal events, even a slight increase in oil price or political turmoil may have a stronger effect in the economy compared to similar events effect on a developed economy.

Two main findings of the study are as follows: First, energy dependency is highly significant in the economic growth of emerging countries. Energy is essential for emerging economies to sustain economic growth. However, dependence on imported energy along with lower levels of energy efficiency led these countries behind the developed economies in the region.

Second, the direction of causality differs among emerging and developed European economies. Economic growth in developed economies leads to higher energy productivity. This result underlines the importance of energy efficiency policies in emerging economies to be designed to stimulate economic growth and hence reduce the negative impact of energy dependency on economic growth.

Examining the empirical relationship between energy efficiency and economic performance at the aggregate level, distinguishes this paper in the literature. The effect of energy efficiency on production is widely examined in the literature in industry specific studies (Boyd and Pang (2000), Zhang et al. (2011), Wan et al. (2015)), whereas macro level studies mostly focus on the effect of energy consumption rather than the energy efficiency on economic growth (Ozturk, 2010).

By including energy productivity into macro panel framework, this study attempts to open new research directions in the assessment of public policies for energy importing countries. Future research should consider the role of energy prices and taxes and energy regulation on the economic system to examine the dynamics behind the lower energy efficiency levels in those countries and their degree of fragility against price shocks.

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