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Energy Consumption and Economic Growth Nexus in Selected Transition Economies: Quantile Panel-Type Analysis Approach[1]

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Seçilmiş Geçiş Ekonomilerinde Enerji Tüketimi Ekonomik Büyüme İlişkisi: Kantil Panel Tipi Analizi Yaklaşımı[2]

Abstract

In this study, impacts of energy consumption on economic growth is investigated for transition economies case. For this purpose, Unconditional Panel Quantile regression (UQR) approach proposed by Firpo, Fortin and Lemieux (2009) is applied, using panel data from 13 selected transition countries between 1996 and 2014. Results show that the impact of energy consumption increases until the 40. Quantile apart from the decrease between 10. to 20. quantiles and then starts to decrease rapidly. This reverse U shaped change may be due to sectoral policy changes.

Keywords : Transition Countries, Energy Consumption, Economic Growth, Unconditional Quantile Regression Analysis.

JEL Classification Codes : O40, Q43.

Öz

Bu çalışmada enerji tüketimi ve ekonomik büyüme arasındaki ilişki geçiş ekonomileri özelinde incelenmiştir. Bu amaçla, Firpo, Fortin ve Lemieux (2009) tarafından önerilen Koşulsuz Kantil Regresyon (KKR) yöntemi 13 seçilmiş geçiş ekonomisine ait 1996 - 2014 arası panel veri seti kullanılarak uygulanmıştır. Sonuçlar enerji tüketiminin etkisinin 40. kantile kadar 10. ve 20. kantiller arasındaki azalma hariç arttığını daha sonra ise hızla düştüğünü göstermektedir. Bu ters U şeklindeki değişim sektörel politika değişikliklerinden kaynaklanıyor olabilir.

Anahtar Sözcükler : Geçiş Ülkeleri, Enerji Tüketimi, Ekonomik Büyüme, Koşulsuz Kantil Regresyon Analizi.

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[2] *Bu makale Sosyoekonomi Derneği ile Hacettepe Üniversitesi Piyasa Ekonomisini ve Girişimciliği Geliştirme Merkezi tarafından Hollanda'nın Amsterdam şehrinde, 28-29 Ekim 2016 tarihlerinde düzenlenen "İkinci Uluslararası Sosyoekonomi Derneği Yıllık Buluşması"nda sunulan çalışmanın gözden geçirilmiş ve genişletilmiş halidir.*

1. Introduction

Energy plays an important role in an economy, so the linkages between energy consumption and economic development is widely researched in the literature. Yet, current literature focuses on the general impact of energy consumption or the causality between two and there is little to no evidence on how does it changes among different quantiles of economic development. Even though transition countries had to overcome similar problems and applied likewise policies in the process, today they are totally different in every means. Furthermore, they are in the different phases of transition to free market economy. Therefore, we believe that their differences should be investigated carefully and a better suited framework should be used for analysis.

In order to show the effect of energy consumption on economic growth in different levels of economic development, unconditional quantile regression (UQR) approach proposed by Firpo, Fortin and Lemieux (2009) is chosen in this study since traditional quantile regression estimates the relationship between energy consumption and economic development at different quantiles of the conditional development distribution and it is inappropriate for comparing impacts of different quantiles against each other as described in the following sections.

The aim of this paper is to analyze the relationship between energy consumption and economic growth in 13 selected transition countries for the period of 1996-2014 by using Unconditional Quantile Regression Approach to highlight the differences among different quantiles. This paper proceeds as follows: the next section briefly reviews the previous studies. In the section after, data and the models are given. The fourth section presents the methodology and empirical results. Finally, conclusions are presented.

2. Literature Review

In the past three decades, numerous studies have been conducted to examine the links between energy consumption and economic growth. Kraft & Kraft (1978)'s pioneering study on the topic found one-way causality flowing from growth to energy consumption for USA over 1947 - 1978 period by using Sims - Granger methodology.

Dergiades et al. (2013) examined the linear and non-linear causality between energy consumption and economic growth in Greece for the period 1960-2008. The empirical results reveal that there is a significant one-way both linear and non-linear causality from total useful energy to economic growth. Ouedraogo (2013) investigated the the long-term relationship between energy access and economic development for 15 African countries for the period between 1980 - 2008 by using recently developed panel co-integration techniques. The results show that GDP and energy consumption move together in the long term. Baranzini et al. (2013) investigated the linkages between energy consumption and economic development in Switzerland over the period of 1950-2010 by using bounds testing techniques to different energy types. The results show that there is robust long-term one-way causality from real GDP to transport fuel, heating oil and electricity consumption.

Fuinhas et al. (2012) analyzed the relationship between economic growth and primary energy consumption in Spain, Greece, Italy, Portugal and Turkey over the period of 1965-2009 by using ARDL bounds test approach. The findings show that there is two-way causality between economic growth and primary energy consumption in the both long and short term, hence they imply that the feedback hypothesis is valid for the sample. Belke et al. (2011) examined the nexus between real GDP and energy consumption for 25 OECD countries in the period of 1981-2007. They included energy prices to their study as a control variable and estimated a trivariate model. Their findings assert that all variables are co-integrated. Furthermore, causality tests show that there is two-way causality between energy consumption and economic growth in the long term. Shahiduzzaman (2012) investigated the causality between energy consumption and economic output in Australia over the 1960-2009 period, using Granger causality, VECM approach and Toda-Yamamoto tests. They found two-way causality between energy usage and GDP. Results show that energy is an important variable for Australian production sector. Lee & Chang (2005) examined the relationship between GDP, total energy consumption and consumption of oil, gas, electricity and coal as its components for Taiwan, over the period 1954 - 2003 by using unit root and the co-integration tests which allow structural breaks. According to their findings, there is two-way causality between GDP and total energy and coal consumption and one-way causality from oil, gas and electricity consumption to GDP. Consequently they assert that the energy plays an essential role for Taiwan economy.

Yıldırım et al. (2014) studied the causality between economic growth and energy consumption in 11 countries by using bootstrapped autoregressive metric causality method and Toda-Yamamoto procedure. The findings reveal that there is no causality between energy consumption and economic growth in Korea, Indonesia, Egypt, Pakistan, Philippines, Mexico, Bangladesh and Iran while there is one-way causality from energy consumption to economic growth. They also argued that Turkish economy is dependent to energy consumption. Zortuk & Karacan (2016) investigated the same case for 17 transition countries, using bootstrap panel causality analysis and found that there is no causality between two variables in general, they further argued that because of inefficient infrastructure in some countries energy use has negative effects on economic growth in some countries.

Cheng *et al.* (1998) examined the multivariate causality between energy consumption and employment taking enviromental implications in U.S. as a control variable. Results show that there is no causality from energy consumption to employment. Asafu-Adjaye (2000) investigated the relationship between energy consumption and income for India, Indonesia, the Philippines and Thailand by using co-integration and ECM techniques. According to their findings, there is one-way Granger causality from energy to income for India and Indonesia and two-way Granger causality for Thailand and Philippines in the short term, while there is no causality between these in the long term.

Akkemik et al. (2012) examined the causality relationship between energy consumption and GDP for a heterogeneous panel dataset consisting of 79 countries over 1980-2007 period by using Granger causality. They demonstrated that there is causality

relationship between these variables. Moreover, panel causality tests show that two-way causality is observed in 57 out of 79 countries, one-way causality is observed in 7 out of 79 countries and no causality is observed in 15 out of 79 countries. Hu & Lin (2008) examined non-linear long-term equilibrium relationship between GDP and energy consumption for Taiwan data over the period of 1982:1-2006:4 by using threshold co-integration test. The threshold co-integration test justifies that there is a long-term relationship between these variables.

Table: 1
Related Literature

Authors	Method	Data	Result
Glasure & Lee (1997)	Co-integration and Error-correction models	South Korea and Singapore (1961-1990)	-No co-integration for South Korea -Enery Consumption→Income for Singapore
Cheng and Lai (1997)	Hsiao's Granger causality	Taiwan (1955-1993)	Economic Growth→Energy Consumption
Cheng *et al.* (1998)	Hsiaso's version of Granger causality	U.S.	No co-integration
Asafu-Adjaye (2000)	Co-integration and Error-correction models	India, Indonesia, the Philippines and Thailand	No co-integration
Chang *et al.* (2001)	Vector Error-correction models	Taiwan	-Employment↔Output -Employment↔Energy consumption, -Energy consumption → Output
Soytas and Sari (2003)	Vector-Error correction models	G-7 Countries	-Economic Growth↔Eenergy Consumption in Argentina -Economic Growth→Energy Consumption in Italy and Korea -Enery Consumption → Economic Growth in Turkey, France, Germany and Japan
Fatai *et al.* (2004)	Error-correction models	Australia, India, Philippines, Thailand, Indonesia and New Zealand (1960-1999)	- Enery Consumption → Economic Growth in India and Indonesia - Enery Consumption ↔ Economic Growth in Thailand and The Philippines
Lee & Chang (2007)	Co-integration test for structural breaks	Taiwan (1954-2003)	Enery Consumption → Economic Growth
Hou (2009)	Hsiao's Granger causality	China	-Economic Growth↔Eenergy Consumption
Payne (2009)	Toda-Yamamoto causality tests	U.S. (1949-2006)	No co-integration
Lee & Chien (2010)	Toda Yamamoto (1995) Granger causality	G-7 Countries (1960-2001)	Energy consumption → income in Canada, Italy and the UK Economic growth → energy consumption in France and Japan No causality in Germany and U.S.
Belke *et al.* (2011)	Dynamic OLS and ECM model	25 OECD countries (1981 - 2007)	Energy consumption ↔ Economic growth
Fuinhas *et al.* (2012)	ARDL bounds test approach	Spain, Greece, Italy, Portugal and Turkey (1965-2009)	Energy consumption ↔ Economic growth
Shahiduzzaman (2012)	Granger causality, VECM approach and Toda-Yamamoto tests	Australia (1960-2009)	Energy consumption → Economic growth
Shaari *et al.* (2013)	Granger causality	Malaysia	One-way causality EC→EG
Dergiades *et al.* (2013)	Granger causality and Non-linear causality test	Greece (1960-2008)	Total useful energy → economic growth
Ouedraogo (2013)	Panel co-integration techniques	15 African countries (1980-2008)	GDP → Energy consumption
Baranzini *et al.* (2013)	Bounds testing techniques	Switzerland (1950-2010)	-Real GDP → Transport fuel -Real GDP → Heating oil -Real GDP → Electricity consumption
Yıldırım *et al.* (2014)	Bootstrapped autoregressive metric causality approach and Toda-Yamamoto procedure	Next 11 countries (1971-2010)	-No co-integration in Bangladesh, Korea, Indonesia, Egypt, Pakistan, Philippines, Mexico and Iran Energy consumption → Economic growth in Turkey

Note: "X→Y" indicates causality from X to Y and "X←Y" indicates causality Y to X.

Table (1) shows that Granger causality test, Toda - Yamamoto procedure, Hsiao's version of Granger causality, vector error-correction model and co-integration tests are popular in energy - growth literature.

3. Data and Model

The aim of this paper is to investigate the relationship between Energy consumption and GDP per Capita in 13 selected transition countries for 1996-2014 period. The Energy consumption (*LEC*) variable is represented by energy consumption (kg of oil equivalent per capita) (Source: World Development Indicators) and economic growth (*LGDP*) is represented by the growth in GDP per Capita (per capita, PPP constant 2005 international $) (Source: WDI). All variables are transformed to their logarithmic forms and denoted as follows:

[*LGDP*: Gross Domestic Product per Capita and *LEC*: Energy consumption]

Table: 2
Descriptive Statistics

	LGDP				***LEC***			
	Min.	*Max.*	*Mean*	*SD*	*Min.*	*Max.*	*Mean*	*SD*
Albania	8.960	8.108	8.568	0.274	6.521	5.895	6.333	0.206
Belarus	9.333	8.373	8.910	0.345	7.999	7.787	7.884	0.076
Czech Republic	10.100	9.701	9.855	0.152	8.405	8.241	8.338	0.041
Croatia	9.757	9.298	9.539	0.155	7.650	7.384	7.540	0.076
Hungary	9.792	9.369	9.649	0.146	7.913	7.803	7.850	0.035
Latvia	9.696	8.877	9.281	0.298	7.653	7.386	7.528	0.081
Lithuania	9.775	8.965	9.403	0.270	7.949	7.619	7.859	0.095
Slovak Republic	9.923	9.354	9.622	0.202	8.159	8.035	8.118	0.033
Slovenia	10.211	9.715	9.982	0.155	8.250	8.064	8.145	0.054
Romania	9.360	8.808	9.054	0.197	7.654	7.386	7.489	0.078
Bulgaria	9.391	8.729	9.053	0.240	7.918	7.707	7.710	0.059
Poland	9.762	9.164	9.442	0.187	7.893	7.748	7.813	0.048
Estonia	9.885	9.051	9.562	0.262	8.340	8.143	8.241	0.067
All	10.211	8.108	9.371	0.441	8.405	5.895	7.764	0.496

Data Source: World Bank Development Indicators 2016.

Transition countries included in this study are namely Albania, Belarus, Czech Republic, Croatia, Hungary, Latvia, Lithuania, Slovak Republic, Slovenia, Romania, Bulgaria, Poland and Estonia. Mentioned data set is an unbalanced panel with a total of 208 observations. Table (2) reports the summary statistics of the variables by country.

The model which defines the long-term relationship between real GDP per Capita and energy consumption is as follows:

$$LGDP_{it} = \alpha_i + \beta_i LEC_{it} + \varepsilon_{it} \quad (1)$$

In equation (1), i symbolizes countries as $i = 1, \dots, N$ and t represents time as $t = 1, \dots, T$. α_i coefficient is autonomous and β_i is long-term elasticity coefficient.

4. Econometric Methodology and Empirical Results

In this paper, emprical anaylses consist of three stages. Firstly, cross correlation between individual countries is investigated by Pesaran CD test. Pesaran CD test has the necessary sample size properties when T exceeds N, as is case in this study. Test statistics for Pesaran CD is given by equation (2):

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \tag{2}$$

where $\hat{\rho}$ is estimated pairwise correlation of the residuals. Testing cross-section dependence has a particular importance since transition countries have common geographical, economic and political properties.

Second, Pesaran CADF unit root test is applied to data. Pesaran CADF test is one of the so called second generation unit root tests which allow cross correlation among individiuals. Developed by Pesaran (2004), CADF test is basicly the cross-sectionally weighted form of the Im et al. (2003). CIPS test statistic for CADF test is given by equation (3):

$$CIPS = \frac{1}{N} \sum_{i=1}^{N} t_i(N,T) \tag{3}$$

Finally, equation (1) is estimated by unconditional quantile regression (UQR) estimators. After replacing dependent variable with recentered inflation function (RIF) proposed by Firpo, Fortin and Lemieux (2009), UQR can be estimated by any estimator. RIF is given by equation (4):

$$RIF(Y; q_\tau, F_Y) = q_\tau + \frac{\tau - \mathbb{I}\{Y \leq q_\tau\}}{f_Y(q_\tau)} \tag{4}$$

where q_τ is the value of the dependent variable (Y) at the τ. quantile. F_Y is the CDF of Y and $f_Y(q_\tau)$ is the density of dependent variable at q_τ. In UQR quantiles are defined preregression, thus the model is not influenced by independent variables and elasticities can be investigated on unconditional quantiles (Borgen, 2016). UQR further gives the opportunity to compare coefficients estimated in different quantiles (Firpo, Fortin and Lemieux, 2009).

Table: 3
Pesaran CD test for the cross-sectional dependence in error terms

	Test statistics	Prob.
LEC	30.593	0.000*
LGDP	37.071	0.000*

*Note: * and ** indicate significance at the 1% and 5% respectively.*

Since cross-sections are dependent, traditional panel unit root tests are inapropriate. Instead, we perform Pesaran (2007) Cross-Sectionally Augmented IPS (CADF) test. CADF allows cross-sectional dependence by assuming that the variables can be specified by a joint factor.

Table: 4
Second generation panel unit root test

	Pesaran CIPS	Prob.
LEC	-2.26	0.000*
LGDP	-2.78	0.002*

*Note: * and ** indicate significance at the 1% and 5% respectively.*

According to table (4), *LGDP* and *LEC* series are stationary at levels, therefore it is possible to estimate long-run elasticities. Nevertheless, both the $LGDP$ and LEC are haunted by cross-sectional dependence, thus standard errors estimated with Gaussian assumptions will be biased. For this purpose, we have reported cluster bootstrapped standard errors too. Bootstrapped standard errors are robust against cross-sectional dependence (Konya, 2006). Table (5) shows coefficient estimations along with the cluster-robust standard errors, which relaxes $i.i.d$ assumption on the error term (Borgen, 2016) and cluster bootstrapped standard errors.

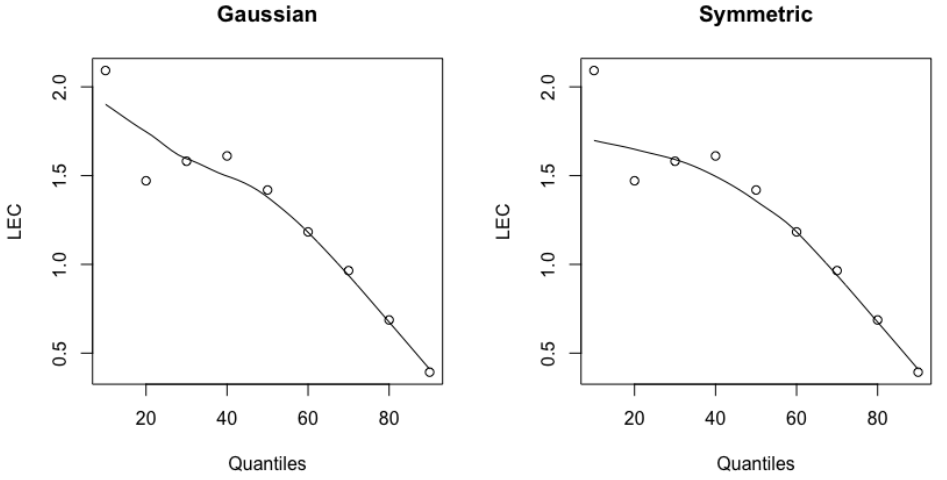
Table: 5
Unconditional Quantile Regression Results

Quantiles	Var.	Coeff.	Robust SE	Prob.	C. Bootstrap SE	C. Bootstrap P.	F
Q(10)	LEC	2.092	0.701	0.011*	0.661	0.002*	11.99**
	c	-8.04	5.757	0.187	5.523	0.147	
Q(20)	LEC	1.471	0.913	0.133	0.816	0.073***	11.56**
	c	2.225	7.491	0.722	6.752	0.687	
Q(30)	LEC	1.581	0.867	0.093***	0.802	0.05**	8.35**
	c	-3.38	7.106	0.642	6.612	0.609	
Q(40)	LEC	1.611	0.832	0.077***	0.653	0.014**	10.36**
	c	-3.544	6.82	0.613	5.427	0.514	
Q(50)	LEC	1.419	0.749	0.082***	0.554	0.011**	13.74**
	c	-1.848	6.142	0.769	4.618	0.689	
Q(60)	LEC	1.183	0.635	0.087***	0.483	0.015**	9.98**
	c	0.205	5.205	0.969	4.033	0.959	
Q(70)	LEC	0.965	0.528	0.093***	0.442	0.03**	6.1**
	c	2.07	4.334	0.641	3.69	0.575	
Q(80)	LEC	0.687	0.427	0.134	0.348	0.049**	4.52**
	c	4.41	3.503	0.231	2.894	0.128	
Q(90)	LEC	0.393	0.28	0.186	0.211	0.065***	5.38**
	c	6.95	2.297	0.011**	1.756	0.000*	

*Note: *, ** and *** indicate significance at 1%, 5% and 10% respectively.*

Differences between robust standard errors and cluster bootstrapped standard errors are arising from cross-sectional dependence. As it can be seen, robust standard errors are upward biased. According to table (5), in the lower quantiles LEC has more effect on $LGDP$ (particularly in 10. quantile, which is an outlier), yet starting from median quantile this effect dramatically diminishes.

Graph: 1
Coefficient Changes Across Different Quantiles



Scatter plots in Graph (1) show the reverse U shaped effect of LEC on $LGDP$ with the increasing quantiles. We have further estimated a LOESS regression to better illustrate the case. While least squares estimators are used for the Gaussian estimation, M-Estimator is used for the Symmetric. Nevertheless, estimated curves are heavily effected by 10. quantile and regression estimations are not able to fully capture the increasing effect at the lower quantiles.

5. Conclusion

This article, containing data from 13 selected transition countries for the period between 1996 and 2014, is an attempt to investigate the relationship between energy consumption and economic growth. In order to shed light onto the nexus, cross-section dependence is investigated at first. Since cross-section independence assumption is violated, unit root properties of GDP per Capita and energy consumption series are investigated with a second generation unit root test which allows cross correlation among individual countries. Following unit root tests, unconditional quantile regression approach is applied to model (1) and coefficients are estimated in order to interpret the relationship between GDP per Capita and energy consumption. UQR is a handy tool for investigating the variation across the unconditional income distribution and compare different levels of GDP per Capita. Estimation results shows that income elasticity first increases and then decreases progressively. Graph (1) points out where this conversion starts and how it affects as the income increases. This could be due to sectoral policies since less developed countries generally focus on energy heavy industrial sectors and more developed countries focus on

service and financial sectors. Furthermore, individual and public energy consumption, which has no positive effects on production tends to increase in more developed countries.

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