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Energy consumption and economic growth: The case of transition economies

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ABSTRACT
This study investigates the causality relationship between energy consumption and economic growth in 17 transition countries, which are Albania, Armenia, Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Moldova, Poland, Romania, Russian Federation, Slovenia, Ukraine, and Georgia. Empirical findings indicate that there is unidirectional causality from economic growth to energy consumption in the long run. The results support for conservation hypothesis suggests that energy conservation policies have no effect on economic growth. They can simultaneously achieve policy goals concerning growth and energy.

KEYWORDS
Causality; cointegration; energy consumption; growth; unit root

Introduction

When the energy crisis in the 1970s negatively affected economic growth in many countries, the relationship between economic growth and energy consumption drew a great deal of attention in academic circles, and many studies have been conducted on this relationship, called the link between energy consumption and growth. Many of the studies initially conducted were on the US economy,[1] but the number of studies on other developed and developing countries has also increased in the last 20 years, and today, there is a quite sizeable literature on the link between energy consumption and growth.

Knowing the direction of causality between energy consumption and economic growth is especially important for policymakers as the applicability of energy conservation policies varies accordingly. There are four possible relationships of causality between economic growth and energy consumption identified. First is the causality from economic growth to energy consumption. Causality from economic growth to energy consumption is interpreted as an indicator that the economy in question is not energy-dependent. In this case, the effect of energy conservation policies on economic growth is either minimal or nonexistent (conservation hypothesis). The second causality is from energy consumption to economic growth. This type of causality indicates that energy conservation policies have negative effects on economic growth and that these economies are energy-dependent (growth hypothesis). Thus, in economies where the causality between economic growth and energy consumption is in this direction, measures concerning energy consumption may affect economic growth. The third case is when there is no relationship of causality between energy consumption and economic growth. In this case, energy consumption and economic growth are unrelated and energy consumption does not have any effect on economic growth (neutrality

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[1]The first study on this subject was conducted by Kraft and Kraft (1978), who examined the relationship between the two variables in the US in the period 1947–1974, and found causality from economic growth to energy consumption. However, findings of later studies showed that no such relationship of causality existed.

hypothesis). Finally, there may be a two-way causality between energy consumption and economic growth. Two-way causality indicates that energy consumption and growth affect one another simultaneously, that they are complements of one another, and that energy policies to improve efficiency in energy consumption do not have a negative effect on economic growth (see Asafu-Adjaye, 2000; Mahadevan and Asafu-Adjaye, 2007; Akinlo, 2008; Apergis and Payne 2009; Noor and Siddiqi, 2010; Odhiambo, 2010).

Although there are many studies on the causality between energy consumption and economic growth in developed and developing countries, the number of studies on transition economies is very limited. Yet, these countries, as Apergis and Payne (2009) argue, play a very important role in world energy markets, both as producers of oil and gas, and as centers where these resources are distributed. Apergis and Payne (2009) examined the relationship between economic growth and energy consumption in 11 countries within Commonwealth of Independent States, and found that a one-way causality from energy consumption to economic growth exists in the short term, and a two-way causality exists in the long term. In 13 Eurasian countries, Apergis and Payne (2010a) found two-way causality between energy consumption and economic growth, both in the long term and in the short term. In these countries, renewable energy consumption and economic growth simultaneously affect one another. Apergis and Payne (2010b) also examined the relationships of causality among carbon dioxide emissions, energy consumption, and real output in 11 countries of Commonwealth of Independent States, and found a two-way causality between energy consumption and output in the short term. Reynolds and Koledzieji (2008) found a one-way causality from petrol production to GDP and a one-way causality from GDP to coal and gas production in Russia. Acaravci and Ozturk (2010) examined the long-term relationship and causality between electricity consumption and economic growth in 15 transition economies. In these countries, energy conservation policies do not have any effect on real output in the long term. Ozturk and Acaravci (2010) examined the causality between energy consumption and GDP in Albania, Bulgaria, Hungary, and Romania. They found a two-way and strong relationship between the two variables in Hungary, and failed to find any long-term relationship between energy consumption and per capita real GDP in Albania, Romania, and Bulgaria.

In this study, the relationship of causality between energy consumption and economic growth in 17 transition economies was examined within the framework of a multivariate model that included prices as well. In the study, a set of two panels (one of which includes Russia, and the other one excludes it) was used in order to determine the reflection of results to other countries by following the studies of Apergis and Payne (2010a). The study aims to contribute to the empirical literature on the link between energy and growth in these countries.

Data and methodology

As mentioned above, this study examines the causal relationship between energy consumption and economic growth in 17 transition countries, which are Albania, Armenia, Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Moldova, Poland, Romania, Russian Federation, Slovenia, Ukraine, and Georgia. Annual time series data, which covers the period 1992–2005 period, is used. The data was obtained from World Development Indicators 2008. The variables used in the model are GDP per capita (constant 2000 US $), per capita energy use (kg of oil equivalent), employment to population ratio, and energy price (GDP deflator). Y, L, E, and P represent GDP, employment, energy use, and energy price, respectively.

Panel unit root test

As with standard cointegration tests, it is important to know the stationarity properties of the data to ensure that incorrect inferences are not made. Testing for stationarity in panel data differs somewhat from conducting unit root tests in standard individual time series. Therefore, first, the stationary properties of the data using the Im et al. (2003) (hereafter IPS) panel unit root test are investigated.

Im et al. (2003) modified Levin and Lin's (1992) framework by allowing for heterogeneity of the coefficient on the lagged dependent variable. The authors recommend the use of group-mean LM statistics in order to test for the null hypothesis that the coefficient on the lagged dependent variable is equal to zero across all members of the panel. Standard ADF regressions are estimated, and LM statistics are calculated. In simplistic terms, one calculates a statistic termed the t-bar statistic by the authors; this is based on the average of the augmented Dickey Fuller t-statistics for individual countries. The authors have calculated the critical values for the components of their tests by using stochastic simulations, and they demonstrated that t-bar statistics converge to a standard normal distribution as the number of observations and the numbers of countries tend to infinity.

The form of IPS unit root test is

$$t_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{i,t}(p_i) \quad (1)$$

where $t_{i,t}$ is the individual ADF t-statistics for the unit root tests and $p_i$is the lag order in the ADF regression, then the test statistic can be calculated as

where t_{NT} is defined above and the values for $E[t_{iT}(p_i, 0)]$ and $\text{var}[t_{iT}(p_i, 0)]$ are obtained from the results of Monte Carlo simulations carried out by IPS and are available from their table (2); they have tabulated them for various time periods and lags. When the ADF has different augmentation lags (p_i) the two terms $E(t_T)$ and $\text{var}(t_T)$ in the equation above are replaced by the corresponding group averages of the tabulated values of $E(t_T, p_i)$ and $\text{var}(t_T, p_i)$, respectively.

The resultant test statistic $\Omega_{\bar{t}}$ converges to a standard normal distribution as T and N ~ ∞; therefore, unit root hypothesis can be tested by comparing the value obtained to the standard normal critical values.

Table 1 reports the results of the IPS panel unit root tests for both panel data sets. The panel unit root tests reveal that each variable is integrated of order one.

Panel cointegration test

Given the variables are integrated of order one, the next step is to test for panel cointegration among the variables. One of the most frequently used panel cointegration tests in the literature is the Pedroni (1999) panel cointegration test. This test allows heterogeneity in the cointegration vector, allows dynamic and fixed effects to be different between the sections of the panel, and also allows the cointegrated vector to be different between the sectors under the alternative hypothesis. In its simplest form, this consists of taking no cointegration as the null hypothesis and using the residuals derived from the panel analogue of an Engle and Granger (1987) static regression to construct the test statistic and tabulate the distributions. The cointegration equation is as follows:

Table 1. IPS panel unit root tests.

A: Levels	Russia (included)	Russia (excluded)
Y	−0.228(0.409)	−0.030(0.487)
P	0.228(0.590)	0.025(0.510)
L	0.118(0.547)	0.024(0.509)
E	0.521(0.699)	0.770(0.779)
B:First Differences		
ΔY	−1.587(0.0562)	−1.498(0.066)
ΔP	−4.400(0.000)	−4.561(0.000)
ΔL	−3.505(0.000)	−2.846(0.002)
ΔE	−4.463(0.000)	−5.089(0.000)

Y, *L*, *E*, and *P* represent GDP, employment, energy use, and energy price, respectively. The number of lags was selected using Schwartz Information Criterion (SIC). Time trend was included in the panel unit root tests.

$$Y_{it} = \alpha_{it} + \delta_i t + \beta_{1i} L_{it} + \beta_{2i} E_{it} + \beta_{3i} P_{it} + e_{it} \tag{2}$$

where $i = 1, \ldots \ldots, N$ for each country in the panel and $t = 1, \ldots \ldots, T$ refers to time period. The parameters α_{it} and δ_i allow for the possibility of country-specific fixed effects and deterministic trends, respectively. e_{it} is the residual. To test the null hypothesis of no cointegration, a regression is estimated as follows:

$$\varepsilon_{it} = \lambda_{it} \varepsilon_{it-1} + \upsilon_{it} \tag{3}$$

For within-dimension, null and alternative hypothesis are as follows::

$$H_0 : \lambda_i = 1 \ \textit{for all } i$$
$$H_1 : \lambda_i = \lambda < 1 \ \textit{for all } i$$

By contrast, for the between-dimension, they are given by

$$H_0 : \lambda_i = 1 \ \textit{for all } i$$

$$H_1 : \lambda_i < 1 \ \textit{for all } i$$

Pedroni (1999) suggested two types of tests. The first is based on the within-dimension approach and includes four statistics. They are the panel-v statistics, panel-p statistics, panel PP statistics, and panel-ADF statistics. These statistics pool the autoregressive coefficients across different members for the unit root tests on the estimated residuals. The second test by Pedroni (1999) is based on the between-dimension approach, which includes three statistics. They are the group p-statistics, group PP-statistics, and group ADF-statistics. These statistics are based on estimators that simply average the individually estimated coefficients of each member. Small sample size and strength powerful of all of these seven tests are discussed in Pedroni (1999). In samplings in which the cross-section unit number is above 100, all statistics produce sufficiently persuasive results. In smaller panels, on the other hand, proofs are variable. However, as time dimension of the panel is small ($T \approx 20$), Pedroni (1999) states that group ADF-statistics and panel-ADF statistics are generally the best indicators.

Table 2 indicates both the within- and between-dimension panel cointegration test statistics for each panel data set. All seven panel cointegration tests reject the null hypothesis of no cointegration at 1% significance level for both panel data sets. Thus, cointegration test results show that there is a long-run relationship between variables.

Panel causality test

Next, this study examined the direction of causality between the variables by using the Granger (1969, 1988) causality test. Engle and Granger (1987) show that if nonstationary variables are cointegrated, a vector autoregression in first differences will be mis-specified. This study used a panel-based error correction model to account for the long-run relationship using the two-step procedure from Engle and Granger (1987). The first step is estimation of the long-run model

Table 2. Pedroni panel cointegration test.

Pedroni residual cointegration test	Test statistics (Russia included)	Test statistics (Russia excluded)
Within-dimension		
Panel v-stat	27.39(0.00)	27.69(0.00)
Panel rho-stat	2.95(0.00)	2.89(0.00)
Panel PP-stat	−5.04(0.00)	−4.61(0.00)
Panel ADF-stat	−4.11(0.00)	−3.81(0.00)
Between-dimension		
Group rho-stat	4.69(0.00)	4.61(0.00)
Group PP-stat	−6.93(0.00)	−6.07(0.00)
Group ADF-stat	−3.50(0.00)	−3.07(0.00)

The number of lags was selected using Schwartz Information Criterion (SIC).

specified in Eq. (2) to obtain the estimated residuals. The second step is to estimate the Granger causality model with an error correction model as follows:

$$\Delta Y_t = \eta_1 + \sum_{i=1}^{a} \beta_{1i}\Delta Y_{t-i} + \sum_{i=1}^{b} \lambda_{1i}\Delta L_{t-i} + \sum_{i=1}^{c} \alpha_{1i}\Delta E_{t-i} + \sum_{i=1}^{d} \pi_{1i}\Delta P + \psi_1 ECT1_{t-1} + \varepsilon_t \tag{4}$$

$$\Delta L_t = \eta_2 + \sum_{i=1}^{h} \beta_{2i}\Delta Y_{t-i} + \sum_{i=1}^{k} \lambda_{2i}\Delta L_{t-i} + \sum_{i=1}^{l} \alpha_{2i}\Delta E_{t-i} + \sum_{i=1}^{m} \pi_{2i}\Delta P + \psi_1 ECT2_{t-1} + \nu_t \tag{5}$$

$$\Delta E_t = \eta_3 + \sum_{i=1}^{n} \beta_{13}\Delta Y_{t-i} + \sum_{i=1}^{p} \lambda_{3i}\Delta L_{t-i} + \sum_{i=1}^{r} \alpha_{3i}\Delta E_{t-i} + \sum_{i=1}^{s} \pi_{3i}\Delta P + \psi_1 ECT3_{t-1} + \theta_t \tag{6}$$

$$\Delta P_t = \eta_4 + \sum_{i=1}^{q} \beta_{4i}\Delta Y_{t-i} + \sum_{i=1}^{w} \lambda_{4i}\Delta L_{t-i} + \sum_{i=1}^{x} \alpha_{4i}\Delta E_{t-i} + \sum_{i=1}^{z} \pi_{4i}\Delta P + \psi_1 ECT4_{t-1} + \xi_t \tag{7}$$

where Δ denotes first differencing and ECTs are the lagged residuals derived from the long-run cointegrating relationship in Eq. (2). The error correction model is used for correcting disequilibrium in the cointegration relationship, as well as to test for long- and short-run causality among cointegrated variables. The sources of causation can be identified by testing for the significance of the coefficients of explanatory variables in Eqs. (4)–(6). Short-run causality can be tested by looking at the significance of the coefficients of each explanatory variable in Eqs. (4)–(6). The short-run effect can be considered transitory. Long-run causality can be tested by looking (i) at whether the coefficient of error correction term is significant; (ii) jointly at whether coefficients of explanatory variables and coefficient of the error correction term are significant. The significance of the error correction term indicates the long-run relationship of the cointegrated process, and so movements along this path can be considered permanent.

Panel I in the table shows long- and short-term causalities when Russia is included, and Panel II shows long- and short-term causalities when Russia is excluded. Long- and short-term causalities between energy consumption and economic growth do not change with the inclusion or exclusion of Russia. Relationships of causality between the remaining variable are also the same for both panels. Thus, findings concerning causality summarized below apply to data from both panels.

Panels I and II of Table 3 show the long- and short-run causality, which are estimated by using the error correction model. As the table shows, there is a two-way causality between energy consumption and growth in the short term. In the long term, on the other hand, there is a one-way causality between energy consumption and economic growth, from growth to energy consumption. One-way causality from growth to energy consumption indicates that energy consumption does not have any effect on the economic growth of these countries in the long term, and supports the neoclassical view that the demand for energy sources is a function of production. Because they are not energy-dependent, these countries have quite a large margin of action in formulating their energy policies. In addition, because it is not a limiting factor in their economic growth processes, they can simultaneously achieve policy goals concerning growth and energy. With a long-term and environmentally sensitive energy policy that gives priority to alternative sources of energy, coupled with more efficient and effective use of resources, they can accelerate economic growth.

Because the aim was to examine the relationship of causality between energy consumption and economic growth within the framework of a large model, causality between other variables was not discussed, being content with reporting findings concerning the direction of causality. There is a two-way causality between employment and energy in the long term. Employment and demand for energy simultaneously affect one another. Because capital and labor are complements of one another in the production process, use of a more energy-intensive capital results in an increase in the demand for labor in the long term. There is a one-way causality between growth and employment, from employment to growth. Because labor is the main factor in production, increase in

Table 3. Granger causality based on error correction model.

PANEL I (Russia included)					
Dependent variable	Short-run causality				Long-run causality
	ΔY	*ΔL*	*ΔE*	*ΔP*	*ECT (t-sta.)*
ΔY[a]	–	4.86[e] (0,008)	4.136[f] (0,043)	0.052 (0.818)	0.027 [1.752] (0.081)
ΔL[b]	0.609 (0.435)	–	0.173 (0.677)	0.002 (0.964)	−0.244[e] [−6.088] (0.000)
ΔE[c]	4.487[e] (0.003)	0.513 (0,474)	–	0.269 (0.604)	−0.260[e] [−4.690] (0.000)
ΔP[d]	0.066 (0.797)	0.005 (0.939)	0.035 (0.851)	–	−0.006 [−0.312] (0.755)
PANEL II (Russia excluded)					
Dependent variable	**Short-run causality**				**Long-run causality**
	ΔY	***ΔL***	***ΔE***	***ΔP***	***ECT (t-sta.)***
ΔY[a]	–	3.626 (0.058)	11.816[e] (0.000)	0.169 (0.681)	0.003[f][2.460] (0.014)
ΔL[b]	0.542 (0.462)	–	0.257 (0.612)	0.004 (0.946)	−0.240* [−5.857] (0.000)
ΔE[c]	4.392[f] (0.037)	0.082 (0.364)	–	0.215 (0.643)	−0.268 [e][−4.677] (0.000)
ΔP[d]	1.97E−05 (0.996)	0.0007 (0.978)	0.065 (0.798)	–	−0.006 [−0.293] (0.769)

The lag orders used in the Error-Correction Models (ECM) were selected using the Schwarz Information Criterion (SIC). Values in parentheses are the *p*-values. Values in separator are t values. [e] and [f] denote 1% and 5%, respectively. Panel I: [a]: R^2= 0.77, Adj. R^2=0.74 DW=1.93 *F*-ist=25.32(0.000); [b]: R^2= 0.31, Adj.R^2=0.23, DW=1.78, *F*-ist=3.96 (0.000); [c]: R^2= 0.30, Adj.R^2=0.21, DW=1.84, *F*-ist=3.32(0.000); [d]: R^2= 0.63, Adj.R^2=0.57, DW=2.13, *F*-ist=10.97(0.000).
Panel II: [a]: R^2= 0.78,Adj.R^2=0.75 DW=1.93 *F*-ist=31.20(0.000); [b]: R^2= 0.31, Adj.R^2=0.23, DW=1.76, *F*-ist=3.93 (0.000); [c]: R^2= 0.31, Adj. R^2=0.21, DW=1.80, *F*-ist=3.32(0.000); [d]: R^2= 0.63, Adj.R^2=0.57, DW=2.13, *F*-ist=10.92(0.000)).

Table 4. Causality.

PANEL I (Russia included)		Panel II (Russia excluded)	
Long-run	Short-run	Long-run	Short-run
Y → L	*Y ← L*	*Y → L*	*Y ← L*
Y → E	*Y ↔ E*	*Y → E*	*Y ↔ E*
Y No causality P	*Y No causality P*	*Y No causality P*	*Y No causality P*
L ↔ E	*L No causality E*	*L ↔ E*	*L No causality E*
L ← P	*L No causality P*	*L ← P*	*L No causality P*
E ← P	*E No causality P*	*E ← P*	*E No causality P*

Y, *L*, *E*, and *P* represent GDP, employment, energy use, and energy price, respectively.

employment results in an increase in output in the long term. Energy prices, on the other hand, are the granger cause of employment in the long term. There is no causality between energy prices and growth, but energy prices are the granger cause of energy consumption in the long term. Unidirectional causality from energy prices to energy consumption can be interpreted as indicating that price elasticity of the demand for energy is elastic in these countries. In the short term, there is no relationship of causality between growth and employment, growth and energy prices, employment and energy, and employment and energy prices. All of the long-run and short-run causality relations between the variables are given in Table 4.

Conclusion

This study examined the relationship of causality between energy consumption and economic growth using data from 17 countries in the period 1992–2005 within the framework of a multivariate model. Data from two separate panels, one of which included Russia and the other did not, were used. Long-term and short-term causality test results did not change with the inclusion or exclusion of Russia. Because the focus was on the relationship between energy consumption and growth, relationships between other variables were not discussed.

In the countries under study, there was a bidirectional causality between energy consumption and economic growth in the short term, whereas in the long term, there was a unidirectional causality from growth to energy consumption. Test results indicating a unidirectional causality between energy consumption and economic growth in these countries in the long term support the neoclassical view. In these countries, production as an input is not a major input of the function; on the contrary, the demand for energy is a varying function of output. When economic growth increases, so does the demand for energy. The fact that output is not a varying function of the demand for energy shows that these countries are not energy-dependent. Thus, policy goals concerning economic growth and energy can be achieved simultaneously in these countries. In addition, it can be argued that because it is not a limiting factor for economic growth, there is a large margin of action in formulating environmentally sensitive energy policies. Yet, it is certain that energy will be of increasing importance for these countries, which are in transition to a market economy, to be able to preserve high levels of growth and keep approaching developed countries. Thus, energy policies in these countries should be formulated in such a way as to guarantee a stable supply and efficient use of energy, and to minimize its effects on the environment.

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