ENERGY CONSUMPTION AND ECONOMIC GROWTH IN CENTRAL AND EASTERN EUROPEAN COUNTRIES: A PANEL DATA ANALYSIS

Sławomir Śmiech - Monika Papież

Abstract

The paper examines causal relationship between energy consumption and economic growth using Pedroni's panel cointegration test based on the annual panel data for Central and Eastern European countries over the period 1995–2010. Towards the end of the 20th century, the political and economic systems of those countries began the process of transformations, as a result of which all of them experienced a leap forward and accelerated economic growth. This allowed us to examine both short- and long-term causality between energy consumption and economic growth. Taking into consideration rapid economic changes experienced by the countries analysed, a set of variables was extended to include real gross fixed capital formation and labour force. The results obtained indicate that the variables remain in long-term equilibrium. Short-term relationship between energy consumption and GDP is bidirectional. Moreover, real gross fixed capital formation and labour force cause GDP growth.

Key words: Energy consumption, Economic growth, Panel cointegration tests, Granger causality

JEL Code: C33, Q43

Introduction

The results of the analyses of the links between energy consumption and GDP obtained so far are ambiguous. According to Yu and Choi (Yu & Choi, 1995), Ferguson, Wilkinson, and Hill (Ferguson, Wilkinson & Hill, 2000), Toman and Jemelkova (Toman & Jemelkova, 2003), and Apergis and Payne (Apergis & Payne, 2009a, Apergis & Payne, 2009b), such ambiguity may arise from different climatic conditions, different consumption patterns, different level of economic development, or the application of different methodologies and different periods analysed. The choice of Central and Eastern European countries to some extent reduces the problem of heterogeneity among the countries. All the countries considered in the study have

covered a similar path of modernizing their economies during the last 20 years, which has led to their membership in the European Union. Because of this, they had to comply with the requirements regarding environment protection. As neighbours, the countries have similar climate. However, they differ with respect to the ways of obtaining energy sources and the structure of energy production (Papież, 2013, Śmiech, 2013).

The aim of this paper is to analyse relationship between energy consumption and economic growth. Such relations are explained by the following theories (Ozturk, 2010). Firstly, the growth hypothesis states that energy consumption serves a vital role in economic growth both directly (input in the production process) and indirectly (complement to labour and capital inputs). Secondly, according to the conservation hypothesis, energy conservation policies introduced to reduce energy consumption may not have an unfavourable impact on real GDP. Thirdly, the neutrality hypothesis claims that energy consumption, as a tiny component of overall economy, has no impact on real GDP. Fourthly, the feedback hypothesis assumes that real GDP and energy consumption are interrelated and may by treated as complementary to each other.

At present, the question of relationship between energy consumption and GDP is especially acute. The issue of limiting both CO2 emission and energy production obtained from non-renewable energy sources is being discussed in Europe. On the other hand, Europe has been deeply affected by the global financial crisis, which has led to a drastic deterioration in the standard of living in many countries. Thus, the issue of limiting energy production and CO2 emission is so vital.

The aim of the study is to examine the relationship between energy consumption and GDP. Taking into consideration the problem of omitted variable bias, we decided (Apergis & Payne, 2009b) to add measures of capital and labour into the set of variables. In order to analyse the relationship between energy consumption and economic growth in Central and Eastern European countries panel cointegration based on Pedroni's test (Pedroni, 1999, Pedroni, 2001) was used.

The paper is structured in the following way: Section 2 presents methodology, the data and the discussion of the methods and results are given in Section 3, while Section 4 contains the main conclusions.

2 Methodology

A two-step procedure was applied to test panel cointegration. During the first step cointegration of variables was tested. The equation (1) is the basis of unit root test:

$$y_{it} = \rho_i y_{it-1} + \delta_i X_{it} + \varepsilon_{it} \qquad (1)$$

where $i = 1,...,N$ for each country in the panel, $t = 1,...,T$ refers to the time period, X_{it} represents exogenous variables (heterogeneity in trends, fixed effect). Levin, Lin and Chu (Levin, Lin & Chu, 2002) test assumes homogeneous parameters in equation (1). Im, Pesaran and Shin (Im, Pesaran & Shin, 2003) allows for heterogeneity and allows for different order of serial correlation (in ADF specification). Maddala and Wu (Maddala & Wu, 1999) suggest comparable unit root test autoregressive variety of panel unit root test.

After confirming the existence of panel unit root, the second step followed, in which panel cointegration tests were carried out. We applied Pedroni's cointegration test (Pedroni, 1999, Pedroni, 2001), which allows for heterogeneity in both dynamics and error variance in the panel. First, we estimated long term equilibrium:

$$\ln GDP_{it} = \alpha_{it} + \delta_i t + \gamma_{1i} \ln EC_{it} + \gamma_{2i} \ln L_{it} + \gamma_{1i} \ln K_{it} + \varepsilon_{ii} \qquad (2)$$

where GDP, EC, L, K denote real GDP, energy consumption, labour force and real gross fixed capital formation respectively, $\alpha_{it}, \delta_i, \gamma_{1i}$ parameters. To test the null hypothesis of no cointegration set of Pedroni unit root tests were determined.

The parameters of the long-term equilibrium equation were estimated with the use of the between-group fully modified OLS (FMOLS). FMOLS estimator is more flexible than dynamic OLS (DOLS) for alternative hypothesis and suffers much less from small sample size distortion than the within-group estimator (Pedroni, 2000). In order to investigate short term causality, panel vector correction model was estimated.

3 Data and empirical results

The analysis of causal relationship between energy consumption and economic growth based on the annual panel data was carried out for nine Central and Eastern European countries (Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia) over the period 1995–2010. The following variables from the World Bank Development Indicators were chosen for the analysis: real GDP (GDP) in constant 2000 U.S. dollars and energy consumption (EC) in kg of oil equivalent. Taking into consideration rapid

economic changes experienced by the countries analysed, a set of variables was extended to include real gross fixed capital formation (K) in constant 2000 U.S. dollars and labour force (L) in millions. All variables were in natural logarithms.

The first step in the estimation of dynamic panels was to test if the variables contain unit roots. In this study, selected the three panel unit root tests, namely Levin–Lin–Chu (LLC) test (Levin, Lin & Chu, 2002), Im, Pesaran and Shin (IPS) test (Im, Pesaran & Shin, 2003), and Fisher-type tests using Augmented Dickey–Fuller (F-ADF) (Maddala & Wu, 1999). Table 1 presents the results of the panel unit root tests. The null hypothesis stated that the panel series had a unit root (nonstationary). It can be seen from Table 1 that each variable was integrated of order one, i.e. I(1).

Tab. 1: Results for panel unit root tests

Variable	Ln GDP	Ln EC	Ln K	Ln L	Δ LnGDP	Δ Ln EC	Δ Ln K	Δ Ln L
LLC	-1.47 *	-1.67*	-0.14	-0.24	-2.50***	-5.09 ***	-2.11 ***	-5.73***
IPS	1.52	-1.714*	1.29	1.92	-3.36 ***	-5.92 ***	-2.72 ***	-5.09***
F- ADF	8.52	26.98*	14.51	10.05	46.05***	66.38 ***	37.09 ***	56.88 ***

Note: ***, **, * indicate statistical significance at 1, 5 and 10 percent level of significance, respectively

Given that each variable contains a panel unit root, the set of Pedroni's panel cointegration tests were carried out to examine whether there was a long-term relationship between the variables used. The results obtained for the tests are presented in Table 2. They reveal the rejection of the null hypothesis of no cointegration for all tests at 1% or higher level of significance, except the panel and group rho-Statistic.

Tab. 2: Pedroni results for panel cointegration tests

Within dimension test statistics			**Between dimension test statistics**	
Panel v-Statistic	9.32 ***		Group rho-Statistic	2.14
Panel rho-Statistic	1.30		Group PP-Statistic	-4.30 ***
Panel PP-Statistic	-3.07 ***		Group ADF-Statistic	-7.48 ***
Panel ADF-Statistic	-5.32 ***			

Notes: ***, **, * indicate statistical significance at 1, 5 and 10 percent level of significance, respectively

Since the cointegration relationship was established, the fully modified OLS (FMOLS) technique for heterogeneous cointegrated panels was used to estimate parameters of long-term equilibrium relationship. The FMOLS results are presented in Eq. (3):

$$\ln GDP = \underset{(5.97)^{***}}{12.64} + \underset{(7.29)^{***}}{0.281}\ln EC + \underset{(19.75)^{***}}{0.286}\ln K + \underset{(0.78)}{0.125}\ln L \qquad (3)$$

where the numbers in parentheses denote the values of t-statistics.

The coefficients in Eq. (3) are positive and statistically significant at the 1% significance level (except for labour force variable). Because the variables are expressed in natural logarithms, the coefficients can be interpreted as elasticity estimates. The results indicate that a 1% increase in energy consumption increases real GDP by 0.281%; a 1% increase in real gross fixed capital formation increases real GDP by 0.286%; and the influence of the labour force on the real GDP was not found.

Tab. 3: Panel Granger causality results

Dependent variable	Source of causation (independent variables)					
	Short term - F-statistics					Long term - t-statistics
	Δ Ln GDP	Δ Ln EC	Δ Ln K	Δ Ln L		ECT
Δ Ln GDP		6.872 ***	3.106 *	15.753 ***		-4.191 ***
Δ Ln EC	2.821*		0.161	0.061		0.489

Notes: ***, **, * indicate statistical significance at 1, 5 and 10 percent level of significance, respectively

The existence of a panel long-run cointegration relationship between economic growth and energy consumption allowed us to estimate a panel vector error correction model. Table 3 presents the results of the short-term and long-term Granger causality tests. The results indicate that energy consumption, real gross fixed capital formation, and the labour force have statistically significant impact in the short run on real GDP. Moreover, the error correction term is statistically significant at the 1% level also denoting a relatively slow speed of adjustment to long-term equilibrium. Similarly, real GDP has a statistically significant impact on energy consumption. So, short-term causality results indicate that there is bidirectional causality between energy consumption and economic growth. However, the error correction term is statistically insignificant, which suggests that energy consumption is not responsive to adjustments towards long-term equilibrium.

4 Conclusions

The model developed for Central and Eastern European countries allowed us to evaluate the relationship between consumption and real GDP. With a short-term perspective, bidirectional causality of both variables was observed, which not the case was with a long-term perspective (more justified in planning development). In this case both variables (after taking into

consideration fixed capital formation and labour force) are in equilibrium, and the deviation from this equilibrium is corrected only by real GDP. This means that the changes in the consumption level will trigger changes (a drop) in the growth rate of GDP. An increase or a drop of GDP (in relation to long-term equilibrium) will not result in the adjustment of energy levels. Such results confirm the growth hypothesis, which indicates a key role of consumption in maintaining economic growth. If the priority of Central and Eastern European countries is to maintain the rate of economic growth, energy conservation should not proceed too fast, as limiting energy consumption will lead to a downturn in economic activity.

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Contact

Sławomir Śmiech
Cracow University of Economics, Department of Statistics,
Rakowicka 27 st., 31-510 Cracow, Poland
smiechs@uek.krakow.pl

Monika Papież
Cracow University of Economics, Department of Statistics,
Rakowicka 27 st., 31-510 Cracow, Poland
papiezm@uek.krakow.pl