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VZŤAH MEDZI SPOTREBOU ELEKTRICKEJ ENERGIE A HOSPODÁRSKYM RASTOM V ŠTÁTOCH OECD: PANELOVÁ KOINTEGRAČNÁ ANALÝZA SO ZOHĽADNENÍM PRIEREZOVEJ ZÁVISLOSTI

THE RELATIONSHIP BETWEEN ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH IN OECD COUNTRIES: PANEL COINTEGRATION ANALYSIS UNDER CROSS-SECTIONAL DEPENDENCE

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Predkladaná štúdia skúma vzťah medzi spotrebou elektrickej energie a hospodárskym rastom v 28 štátoch OECD v období 1980-2012. Pri zohľadnení prierezovej závislosti sa na analýzu údajov o spotrebe elektrickej energie a hospodárskom raste používajú testy jednotkového koreňa druhej generácie CADF a CIDS, pričom ich prvé diferencie sú stacionárne. Preto sa v ďalšom texte použil Westermanom (2008) vyvinutý Durbinov-Hausmanov test na preskúmanie kointegračného vzťahu medzi štatistickými radmi. Empirické výsledky poukazujú na fakt, že spotreba elektrickej energie má pozitívny vplyv na hospodársky rast.
Kľúčové slová: spotreba elektrickej energie, hospodársky rast, prierezová závislosť, jednotkový koreň, panelová kointegrácia.

In the present study, the relationship between electricity consumption and economic growth in 28 OECD countries for the period between 1980 and

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2012 was investigated. Under cross-section dependence, electricity consumption and economic growth data were analyzed using second generation CADF and CIPS unit root tests and found to be stationary at first differences. Therefore, the cointegration relationship between the series was examined by using Durbin-Hausman test developed by Westerlund (2008). According to the empirical results, electricity consumption has a positive effect on the economic growth.
Key words: electricity consumption, economic growth, cross-section dependence, panel unit roots, panel cointegration.
JEL: C33, Q40

1 Introduction

The demand for energy has been increasing each passing day along with the rapid development of technology, increasing population and changing standards of living. After the oil crises experienced in the 1970s, countries turned towards alternative energy sources. When the sources of energy are examined separately, it is observed that electricity is the most efficient and top quality source and its share within the total energy consumption has been increasing gradually. Electricity is followed by natural gas, oil, coal and biofuels, respectively (Karagöl, Erbaykal and Ertuğrul 2007, Stern and Cleveland 2004).

Although electricity is a clean and relatively safe form of energy, it has environmental effects related to its production and transmission. Almost all power plants have a certain effect on the environment.

The causality relationship between electricity consumption and economic growth has important political implications based on four hypotheses. The first of these is that if the causality is from electricity consumption to economic growth, protection policies should be developed regarding electricity production. Otherwise, the decrease in electricity consumption would have a negative effect on economic growth. In the second case, if there is a causality relationship from economic growth to electricity consumption, electricity consumption does not impede economic growth and electricity conservation policies can be safely adopted. Third, in case of bidirectional causality between electricity consumption and economic growth, since a decrease or increase in electricity consumption would affect economic growth in the same direction, the policies that will be implemented need to be determined jointly. Fourth and lastly, if there is no causality relationship between electricity consumption and economic growth, expansionary and conservation policies regarding electricity consumption do not have an effect on economic growth (Öztürk and Acaravcı 2011, Shahbaz and Lean 2012, Jumbe 2004).

The goal of this paper is to investigate relationship between electricity consumption and economic growth in 28 OECD countries for the period 1980-2012.

2 LITERATURE REVIEW

Kraft and Kraft (1998) conducted the first empirical study investigating the causality relationship between energy consumption and economic growth. In the study conducted on the US economy for the period between 1947 and 1974, a unidirectional causality relationship was found from economic growth to energy consumption.

In another study, Chen, Kuo and Chen (2007) examined 10 Asian countries for the period between 1971 and 2001 by using Johansen Cointegration Test and VECM Granger Causality Test. Their analysis detected cointegration in all the countries except for Malaysia. The results of the causality test showed the existence of bidirectional causality between economic growth and electricity consumption in China, Indonesia, Korea, Taiwan and Thailand, causality from electricity consumption to economic growth was found in Hong-Kong and causality from economic growth to electricity consumption was observed in India, Singapore, Philippines and Malaysia.

Yoo and Kwak (2010) examined the relationship between the real GDP per capita and electricity consumption per capita for 7 South American Countries. In the study conducted by using Johansen cointegration test, Hsiao Granger causality test and ECM analysis, cointegration relationship was found in Colombia and Venezuela, whereas no cointegration relationship was found to exist between the variables in Argentina, Brazil, Chile, Ecuador and Peru. It was determined that there was bidirectional causality between electricity consumption and economic growth in Venezuela, there was causality from economic growth to electricity consumption in Peru, and the direction of causality was from electricity consumption to economic growth in Argentina, Brazil, Chile, Colombia and Ecuador.

Öztürk and Acaravcı (2011) conducted a study on 11 Middle Eastern and North African countries covering the period between 1971 and 2006. The relationship between the real GDP per capita and electricity consumption per capita was tested by using ARDL and VECM Granger Causality Tests. The results indicated the existence of a cointegration relationship between the variables in 4 countries (Egypt, Saudi Arabia, Oman and Israel). A causality relationship from economic growth to electricity consumption was found in Israel and Oman and the direction of causality was from electricity consumption to economic growth in Egypt and Saudi Arabia.

Hossain and Saeki (2012) conducted an extensive study on 30 high income, 20 upper-middle income, 20 lower-middle income and 6 low income countries for the period between 1960 and 2008. They used electricity consumption per capita and real GDP per capita series, applying Panel Cointegration Test (KAO) and Panel Granger Causality Test models. The findings indicated existence of cointegration in high income and upper-middle income countries. Bidirectional causality was found between economic growth and electricity consumption for high income and upper-middle income countries, unidirectional causality was found from economic growth to electricity consumption for lower-middle income countries and no causality was found for low income countries.

Niu et al. (2013) analyzed electricity consumption per capita, real GDP per capita, consumption expenditures per capita, urbanization rate, life expectancy at birth and the adult literacy rate data from 50 countries by using Panel Cointegration Test (Pedroni) and Panel Granger causality test. The results indicated existence of cointegration. Bidirectional causality was found between electricity consumption and economic growth.

Al-Mulali et al. (2014) conducted a study on 18 Latin American countries using the data for 1980-2010. Real GDP, electricity consumption from renewable sources, electricity consumption from oil, natural gas and coal, labor, gross fixed capital formation and total trade of goods and services series were analyzed by using Panel Cointegration Test (Pedroni), Panel DOLS and VECM Granger causality test. The results of the study revealed existence of cointegration and unidirectional causality from electricity consumption to economic growth.

In another paper, Gao and Zhang (2014) analyzed the electricity consumption per capita, real GDP per capita and CO_2 emissions per capita series for 17 Sub-Saharan African countries for the period between 1980 and 2009. The results obtained by using Panel Cointegration Test (Pedroni), Panel FMOLS and Panel Granger Causality Test showed the existence of cointegration. Bidirectional causality was found between electricity consumption and economic growth.

3 METHODOLOGY

3.1 Cross-section dependence tests

In the study, first it is necessary to test cross-section dependence in order to determine panel unit root tests. If the presence of cross-section dependence is rejected in the panel data, first generation panel unit root tests can be used. However, if there is cross-section dependence in the panel data, the use of second generation panel unit root tests enables a more effective and stronger estimation.

The methods used for testing cross-section dependence in panel data sets are Breusch and Pagan (1980) LM_1 test and Pesaran (2004) CD_{LM2}test, with the following hypotheses:

H_0: There is no cross-section dependence.

H_1: There is cross-section dependence.

If the probability values are found to be smaller than 0.05 in the results obtained from Breusch and Pagan (1980) LM_1 test and Pesaran (2004) CD_{LM2} test, H_0 is rejected at 5% level of significance and it is concluded that there is cross-section dependence among the units forming the panel.

$$LM_1 = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^2 \quad (1)$$

$\hat{\rho}_{ij}$: shows the estimates of the cross-sectional correlations among residuals.

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^{T}\hat{v}_{it}\hat{v}_{jt}}{(\sum_{t=1}^{T}\hat{v}_{it})^{1/2}(\sum_{t=1}^{T}\hat{v}_{jt})^{1/2}} \quad (2)$$

Under H_0 hypothesis, there is no cross-section dependence. Under H_0 hypothesis, N is stationary and $T\rightarrow\infty$. The test statistics has a chi-square asymptotic distribution with N(N-1)/2 degrees of freedom. LM_1 test is used when the time dimension is larger than the cross-section dimension (i.e., T>N).

$$CD_{LM2} = \left(\frac{1}{N(N-1)}\right)^{1/2}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\hat{\rho}_{ij}^2 - 1) \quad (3)$$

CD_{LM2} Pesaran (2004) test statistics shows standard normal distribution under H_0 hypothesis in case of $T\rightarrow\infty$ and $N\rightarrow\infty$. CD_{LM2} test is used when the time dimension is larger than the cross-section dimension (i.e., T>N).

3.2 Panel unit root test

In the simple dynamic heterogeneous panel data model, the observation on the i^{th} cross-section at time t is;

$$y_{it} = (1-\phi_i)\mu_i + \phi_i y_{i,t-1} + u_{it}, \quad i = 1, \dots. N; t = 1, \dots., T \quad (4)$$

$$\mu_{it} = \gamma_i f_t + \varepsilon_{it} \quad (5)$$

Here, f_t is the unobserved common effect and ε_{it} is the individual specific error. The two equations given above and unit root hypotheses can be written as follows:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \gamma_i f_t + \varepsilon_{it} \quad (6)$$

$\alpha_i = (1-\phi_i)\mu_i, \quad \beta_i = -(1-\phi_i) \quad$ and $\quad \Delta y_{it} = y_{it} - y_{i,t-1}$
$\phi_i = 1$ then $H_0 = \beta_i = 0$ for all i (7)

and the alternative hypothesis is as follows:

$$H_1 = \beta_i < 0, i = 1,2, \dots, N_1, \beta_i = 0, i = N_1 + 1, N_1 + 2, \dots, N \quad (8)$$

Here, the fraction of the stationary individuals is $N_1/N \rightarrow k$ such that $0 < \delta \leq 1$ as $N \rightarrow \infty$.

Standard IPS test may lead to spurious inferences due to spillovers or common shocks. For this reason, the cross-sectionally augmented IPS test proposed by Pesaran (2007) is employed. This test is designed by augmenting the ADF regression with the cross-sectional averages of lagged levels and first differences of the individual series (Herzer 2014). Accordingly, the cross-sectionally augmented ADF (CADF) regression is given by

$$\Delta x_{it} = z_{it}'\gamma + \rho_i x_{it-1} + \sum_{j=1}^{k_i} \phi_{ij} \Delta x_{it-j} + \alpha_i \bar{x}_{t-1} + \sum_{j=0}^{k_i} \eta_{ij} \Delta \bar{x}_{t-j} + \nu_{it} \quad (9)$$

where $\bar{x}_t$ is the cross-section mean of x_{it} and $\bar{x}_t = N^{-1} \sum_{i=1}^{n} x_{it}$. By taking the simple average of the individual CADF statistics calculated for each cross-section, the presence of a unit root in the panel is checked.

$$CIPS = t - bar = N^{-1} \sum_{i=1}^{N_i} t_i. \quad (10)$$

where t_i, is the OLS t-ratio of ρ_i in Equation 9. Critical values are tabulated by using the table values in Pesaran (2007).

3.3 Durbin-Hausman panel cointegration test

In the present study, the cointegration relationship between the series was analyzed by using the Durbin-Hausman (Durbin-H) panel cointegration test developed by Westerlund (2008). Durbin-H test takes the common factors into account and makes it possible to conduct cointegration analysis in case the independent variables are I(1) or I(0) on condition that the dependent variable is I(1) (Westerlund 2008).

In Durbin-H method, Westerlund (2008) examined the existence of a cointegration relationship by using two different tests. The first of these tests is Durbin-H panel test and the second is Durbin-H group test. In Durbin-H group test, Westerlund (2008) allows the autoregressive parameter to differ between cross-sections. In this test, H_0 hypothesis indicates that there is no cointegration, and the alternative hypothesis indicates that there is cointegration relationship for at least some cross-sections. In Westerlund's (2008) Durbin-H panel test, the autoregressive parameter is considered to be the same for all cross-sections. Panel data model is specified as follows:

$$y_{it} = \alpha_i + \beta_i x_{it} + z_{it} \quad (11)$$

$$x_{it} = \delta x_{it-1} + w_{it} \tag{12}$$

It is assumed that the disturbance z_{it} obeys the following set of equations that allow for cross-section dependence through the use of common factors.

$$z_{it} = \lambda_i' F_t + e_{it} \tag{13}$$

$$F_{jt} = p_j F_{jt-1} + u_{jt} \tag{14}$$

$$e_{it} = \phi_i e_{it-1} + v_{it} \tag{15}$$

For each j, $p_j < 1$.

Where F_t is a k-dimensional vector of common factors F_{jt}(j=1…k). λ_i is a conformable vector of factor loadings.

To construct Durbin-H test, we take the first difference of Equation 13.

$$\Delta z_{it} = \lambda_i' \Delta F_t + \Delta e_{it} \tag{16}$$

If $\Delta z_{it}$was known, then λ_i and ΔF_tcould be estimated. However, Δz_{it} is not known. For this reason, it is necessary to apply principal components to its OLS estimate instead, which can be written as follows:

$$\Delta \hat{z}_{it} = \Delta y_{it} - \hat{\beta}_i \Delta x_{it} \tag{17}$$

The principal components estimator ΔF_t of F_t is obtained by computing $\sqrt{T-1}$ times the eigenvectors corresponding to the K largest eigenvalues of the (T-1)x(T-1) matrix $\Delta\hat{z}\Delta\hat{z}'$. Here, $\hat{\lambda}$ is calculated with $\hat{\lambda} = \frac{\Delta\hat{F}'\Delta z}{\mathrm{T-1}}$.

The first difference of the residuals can be stated as follows:

After calculating $\widehat{\Delta F}$ and $\hat{\lambda}_i$, the difference of the residuals is calculated as:

$$\Delta \hat{e}_{it} = \Delta \hat{z}_{it} - \lambda_i' \Delta \hat{F}_t \tag{18}$$
$$\hat{e}_{it} = \sum_{j=2}^{t} \Delta \hat{e}_{ij}$$

Testing the null hypothesis of no cointegration is asymptotically equivalent to testing whether $\phi_i = 1$.

$$\hat{e}_{it} = \phi_i \hat{e}_{it-1} + error \tag{19}$$

Another estimator needed for constructing the Durbin-H test is the kernel estimator. The kernel estimator can be defined as:

$$\widehat{\omega}_i^2 = \frac{1}{T-1}\sum_{j=M_i}^{M_i}\left(1-\frac{j}{M_i+1}\right)\sum_{t=j+1}^{T}\hat{\mu}_{it}\hat{\mu}_{it-1} \quad (20)$$

where $\hat{\mu}_{it}$ is the OLS residual obtained from Equation (19). M_i is a bandwidth parameter. The value of $\widehat{\omega}_i^2$ is a consistent estimate of $\widehat{\omega}_i^2$, the long-run variance of $\hat{\mu}_{it}$. The corresponding contemporaneous variance estimate can be denoted by $\hat{\sigma}_i^2$. After these estimates, the two variance ratios can be calculated:

$$\hat{S}_i = \frac{w_i^2}{\sigma_i^4} \text{ and } \hat{S}_n = \frac{w_n^2}{(\sigma_n^2)^2} \quad (21)$$

where

$$\widehat{\omega}_i^2 = \frac{1}{n}\sum_{i=1}^{n}\widehat{\omega}_i^2 \text{ and } \hat{\sigma}_i^2 = \frac{1}{n}\sum_{i=1}^{n}\hat{\sigma}_i^2. \quad (22)$$

After these calculations, the Durbin–Hausman test statistics can now be obtained as:

$$DH_G = \sum_{i=1}^{n}\hat{S}_i\left(\tilde{\phi}_i - \hat{\phi}_i\right)^2\sum_{t=2}^{T}e_{it-1}^2; \quad (23)$$

$$DH_p = \hat{S}_n\left(\tilde{\phi}_i - \hat{\phi}_i\right)^2\sum_{i=1}^{n}\sum_{t=2}^{T}e_{it-1}^2. \quad (24)$$

3.4 Testing the homogeneity of cointegration coefficients

In his study, Swamy (1970) determined whether the slope coefficients in the cointegration equation were homogeneous. Pesaran and Yamagata (2008) contributed to the literature by further developing the Swamy test. In this test, it is tested whether β_i slope coefficients are homogeneous across cross-sections with a general cointegration equation as follows:

$$Y_{it} = \alpha + \beta_i X_{it} + \varepsilon_{it} \quad (25)$$

The hypotheses of the test are:
$H_0: \beta_i = \beta$ Slope coefficients are homogeneous.
$H_1: \beta_i \neq \beta$ Slope coefficients are not homogeneous.

The necessary test statistics are constructed through estimations firstly by panel OLS and then by the Weighted Fixed Effects model. Pesaran and Yamagata (2008) developed two different test statistics to test the hypothesis:

For large samples: $\tilde{\Delta} = \sqrt{N}\frac{N^{-1}\tilde{S}-k}{\sqrt{2k}}$ (26)

For small samples: $\tilde{\Delta}_{adj} = \sqrt{N}\frac{N^{-1}\tilde{S}-k}{\sqrt{Var(t,k)}}$ (27)

where N is the number of cross-sections, S is the Swamy test statistics, k is the number of explanatory variables, and Var(t,k) is the standard error. If the obtained probability values are smaller than 0.05, H_0 hypothesis is rejected at a significance level of 5%, and H_1 hypothesis is accepted. In this way the homogeneity of the cointegration coefficients is determined (Pesaran and Yamagata 2008).

3.5 Estimation of long term cointegration coefficients

In this part of the study, following the detection of cointegration between the series, long term individual cointegration coefficients were estimated by using the Common Correlated Effects (CCE) method developed by Pesaran (2006). CCE takes cross-section dependence into consideration and it is an estimator that can produce consistent results that show asymptotic normal distribution even when time dimension is smaller or greater than cross-section dimension (Pesaran 2006). The stages of this test are as follows:

$$y_{it} = \alpha_i' d_t + \beta_i' x_{it} + e_{it}, \qquad i = 1,2,\dots,N;\ t = 1,2,\dots,N \quad (28)$$

Based on Equation 28, which belongs to the linear heterogeneous panel data model;

$$e_{it} = \gamma_i' f_t + \varepsilon_{it} \quad (29)$$

where d_t refers to observed common effects and f_t refers to unobserved common effects.

The model is maintained through the following transformation:

$$x_{it} = A_i' d_t + \Gamma_i' f_t + v_{it} \quad (30)$$

The advantage of CCE is that it provides a cointegration coefficient for each cross-section. With the coefficients found for each cross-section, it is possible to make respective interpretations for each country.

4 ECONOMETRIC ANALYSIS

4.1 Model and dataset

The model used in the present study is as follows:

$$GDP_t = \alpha_0 + \alpha_1 ELC_t + \varepsilon_t \tag{31}$$

In Equation 31, GDP_t represents real GDP in USD in 2005 prices, and ELC_t represents electricity consumption (billion kWh). Real GDP data was obtained from the World Bank and electricity consumption data was taken from the U. S. Energy Information Administration. The logarithms of all the variables were taken and used in the model estimation. In the study, 28 OECD countries were included in the analysis. Annual data for the period between 1980 and 2012 were used in the model.

4.2 Testing cross-section dependence

The results of the cross-section dependence tests for OECD countries are presented in Table 1. Since the p-value was smaller than 0.05, H_0 hypothesis was rejected and the alternative hypothesis stating that there is cross-section dependence was accepted. Thus, it was concluded that there is cross-section dependence among the countries constituting the panel.

Table 1: cross-section dependence test results for OECD countries

Variables	***lnGDP***	***lnELC***	***Cointegration Equation***
Tests	***Test statistics and p-value***		
LM1 (Breusch and Pagan 1980)	687.958 (0.000)	551.354 (0.000)	2909.283 (0.000)
CDLM2 (Pesaran 2004)	11.273 (0.000)	6.305 (0.000)	92.062 (0.000)

Source: own elaboration.

In case of the presence of cross-section dependence, the unit root tests and cointegration tests to be used need to be those that take cross-section dependence into account. For this reason, second generation panel unit root test and cointegration test were used in the present study.

Table 2: CADF and CIPS Unit Root Test Results for OECD Countries

COUNTRIES	CONSTANT								CONSTANT AND TREND							
	lnGDP		*ΔlnGDP*		*lnELC*		*ΔlnELC*		*lnGDP*		*ΔlnGDP*		*lnELC*		*ΔlnELC*	
	p	*CADF stats*	*p*	*CADF stats*	*p*	*CADF stats*	*p*	*CADF stats*	*p*	*CADF stats*	*p*	*CADF stats*	*p*	*CADF stats*	*p*	*CADF stats*
Australia	1	-0.971	1	-4.989***	1	-2.260	1	-3.570**	1	-2.662	1	-5.718***	1	-2.563	1	-3.267
Austria	1	-2.786	1	-4.044**	2	-2.740	1	-5.885***	1	-2.737	2	-1.501	1	-3.538	2	-4.031
Belgium	1	-2.016	1	-2.564	1	-1.070	1	-4.218***	1	-1.931	1	-2.938	3	-1.508	1	-4.165
Canada	1	-2.058	1	-4.087**	1	-2.990	1	-3.359**	1	-2.291	1	-3.680	1	-2.221	3	-2.123
Chile	1	-2.693	1	-4.646***	1	-2.510	1	-3.197	1	-2.797	1	-4.358**	1	-2.831	1	-3.380
Denmark	1	-3.076	1	-3.113	1	-1.520	1	-5.534***	1	-3.474	1	-3.104	1	-3.061	1	-5.501***
Finland	1	-2.059	1	-3.708**	3	-2.450	3	-3.144	1	-2.026	1	-4.112**	3	-2.410	3	-3.028
France	1	-3.195	1	-3.621**	3	-2.10	3	-3.630**	1	-3.485	1	-3.388	3	-2.507	1	-4.329**
Germany	1	-2.416	1	-2.177	2	-2.40	2	-2.211	1	-2.370	1	-1.925	2	-2.501	2	-2.152
Greece	1	-0.975	1	-2.541	1	-2.780	1	-5.260***	1	-1.030	1	-2.349	1	-2.599	1	-5.027***
Iceland	1	-0.717	1	-3.212	1	-0.930	1	-2.631	1	-0.862	1	-3.736	1	-2.631	1	-3.198
Ireland	1	-1.809	1	-1.828	1	-1.960	1	-3.973**	1	-1.928	1	-1.940	2	-1.660	1	-4.406**
Israel	1	-1.948	1	-3.274	1	-2.640	1	-3.794**	1	-2.112	1	-3.206	1	-2.484	1	-3.711
Italy	1	-1.189	1	-2.587	2	-1.740	2	-3.049	1	-2.128	1	-3.844	2	-2.733	2	-3.128
Japan	1	-2.091	2	-1.694	1	-0.764	1	-3.607**	1	-1.942	1	-1.372	1	-1.160	1	-4.618**
Korea, South	1	-1.369	1	-2.612	1	-1.730	1	-3.421**	1	-1.331	1	-4.416**	1	-1.750	1	-3.770
Luxembourg	1	-1.819	1	-2.821	1	-2.110	1	-5.355***	1	-2.080	1	-2.849	1	-2.112	1	-5.343***
Mexico	1	-2.738	1	-3.769**	1	-1.630	3	-1.855	1	-2.942	1	-4.273**	1	-3.707	3	-1.690
Netherlands	1	-2.110	1	-3.169	1	-2.460	1	-3.591**	1	-2.750	1	-3.026	1	-4.030**	1	-3.084
New Zealand	1	-1.740	1	-1.967	1	-3.540	1	-5.252***	1	-1.779	1	-1.782	1	-3.466	1	-6.019***
Norway	1	-3.532**	1	-3.088	1	-3.170	1	-4.639***	1	-3.354	1	-3.351	1	-2.790	1	-4.798***
Poland	1	-1.592	2	-3.018	2	-1.050	3	-1.391	1	-2.748	1	-3.966**	3	-0.321	3	-2.081
Spain	1	-1.237	1	-2.858	2	-1.150	2	-0.877	1	-1.573	1	-2.800	2	-0.699	2	-2.214
Sweden	2	-0.865	1	-2.761	3	-5.250	1	-1.633	1	-0.866	1	-3.475	3	-5.110***	1	-2.249
Switzerland	1	-0.401	1	-2.188	1	-1.940	1	-2.656	1	-0.972	1	-2.420	1	-1.904	1	-2.682
Turkey	1	-1.425	1	-4.310***	2	-0.676	2	-2.488	1	-2.934	1	-4.223**	1	-2.113	2	-2.491
United Kingdom	1	-3.236	1	-3.559**	1	-1.470	1	-5.022***	1	-3.197	1	-3.512	1	-4.377**	1	-4.889***
United States	1	-2.369	1	-3.401**	1	-2.110	1	-4.974***	1	-1.960	1	-4.061**	1	-2.257	1	-4.445**
CIPS		**-1.944**		**-3.129*****		**-2.110**		**-3.579*****		**-2.224**		**-3.262*****		**-2.537**		**-3.636*****

Notes: The null hypothesis is that the panel has a unit root. Critical values are tabulated by Pesaran (2007). Table I (b–c) and Table II (b-c), we report the ones for T = 33 and N = 28. *** and ** indicates significance of the test at 1% and 5% level respectively.
Source: own elaboration.

4.3 CADF unit root test results

In the present study, due to the presence of cross-section dependence among the countries, the stationarity of the series was checked using the CADF unit root test, which is one of the second generation panel unit root tests. The test results are presented in Table 2.

According to the results of the unit root test that were calculated with constant for OECD countries, since CIPS statistics were lower than table values at the level, H_0 hypothesis was accepted. Thus, it was concluded that the entire panel had a unit root (Table 2). According to the results of the unit root test that was conducted after taking the differences of the series, H_0 hypothesis was rejected and the alternative hypothesis was accepted. The findings led to the conclusion that the series were stationary I(1).

After finding out that the series had a unit root at the level and the test carried out after taking the differences showed that the series were stationary, Westerlund Durbin-Hausman (2008) cointegration test was implemented.

4.4 Durbin-Hausman cointegration test results

In panel data analysis, the existence of cointegration between the series was tested using Durbin-H Cointegration Test developed by Westerlund (2008), which takes cross-section dependence and the heterogeneity of cross-section slope parameters into consideration.

Table 3: Durbin-Hausman Cointegration Test Results for OECD Countries

Tests	***Test statistics***	***Probability value***
Durbin-H Group Statistic	5.859	0.000
Durbin-H Panel Statistic	1.397	0.081

Source: own elaboration.

Durbin-H Cointegration Test consists of two analyses. These are Durbin-H Group Statistics and Durbin-H Panel Statistics. In both tests, H_0 hypothesis indicates that there is no cointegration. According to the results given in Table 3, probability values were found to be 0 and 0.081 in these tests. In this case, H_0 hypothesis is rejected and the alternative hypothesis stating that there is cointegration in the country groups and throughout the panel is accepted.

4.5 Test results for the homogeneity of the cointegration coefficients

The results of the homogeneity test are given in Table 4.

According to the results given in Table 4, since the probability values of the tests were smaller than 0.05, H_0 hypothesis was rejected and H_1 hypothesis was accepted. The variables of the empirical model were not homogeneous. In this case, the cointegration interpretations for the entire panel were reliable (Pesaranand Yamagata, 2008).

Table 4: Homogeneity test results for OECD Countries

Tests	***Test statistics***	***Probability value***
$\tilde{\Delta}$	60.183	0.000
$\tilde{\Delta}_{adj}$	63.028	0.000

Source: own elaboration.

4.6 Estimation of long term cointegration coefficients

After the cointegration relationship between the series was detected, the long term cointegration coefficients of the series were estimated using the CCE method. The findings are presented in Table 5.

The long term effect of energy consumption on economic growth in OECD countries was calculated by using the CCE method. According to the results in Table 5, the increase in electricity consumption has a positive effect on economic growth and is significant in Australia, Austria, Chile, Finland, Greece, Iceland, Ireland, Israel, Italy, Japan, South Korea, Netherlands, New Zealand, Poland, Spain, Sweden, Switzerland and Turkey. The results are consistent with our expectations and with the studies conducted by Ciarreta and Zarraga (2010), Gurgul and Lach (2012), Acaravci and Ozturk (2012), and Hossain and Saeki (2012).

Table 5: Long term cointegration coefficients for OECD countries

Countries	*Cointegration coefficients*	*t-statistics*
Australia	0.481***	3.364
Austria	0.090***	4.500
Belgium	0.032	0.390
Canada	0.235*	1.284
Chile	0.695***	3.203
Denmark	0.100	0.649
Finland	0.345***	2.363
France	-0.025	-0.253
Germany	-0.332***	-4.882
Greece	2.244***	5.088
Iceland	0.089**	1.745
Ireland	1.339***	4.978
Israel	0.952***	5.770
Italy	0.522**	2.310
Japan	0.598***	3.602
Korea, South	0.369***	3.265
Luxembourg	-0.180	-1.000
Mexico	0.169	1.119
Netherlands	0.417***	3.363
New Zealand	0.512**	1.932
Norway	0.116	0.847
Poland	0.558***	3.282
Spain	0.284**	2.272
Sweden	0.381***	7.620
Switzerland	0.742***	6.235
Turkey	0.719***	4.858
United Kingdom	0.152*	1.448
United States	0.010	0.057
PANEL	**0.415*****	**4.366**

Notes: ***, ** and * refer to stationarity at significance levels of 1%, 5% and 10%, respectively. t value is significant at a level of 1% if greater than 2.32, at a level of 5% if greater than 1.65 and at a level of 10% if greater than 1.28.
Source: own elaboration.

5 CONCLUSION

In the present study, the relationship between electricity consumption and economic growth in 28 OECD countries was investigated for the period between 1980 and 2012 using panel cointegration and panel causality tests under cross-section dependence.

Breusch-Pagan (1980) LM_1 test, Pesaran et al. (2004) CD_{LM2} test, and Pesaran et al. (2004) CD_{LM} test were used for testing cross-section dependence between the countries. The results showed existence of cross-section dependence between the countries. Therefore, tests that take cross-section dependence into consideration were used in the following stages of the study. Since it was found that there was cross-section dependence between the countries, it is inferred that a shock that occurs in one country may also affect other countries. It is necessary for policy makers not to ignore the changes in other countries when taking decisions.

The stationarity of the series was tested using the CADF unit root test. The series, which were not stationary at the level, were made stationary by taking the differences. In this way, it can be seen that the effects of economic shocks do not pass quickly.

The cointegration relationship between the series was analyzed by using the Durbin-Hausman Cointegration Test developed by Westerlund (2008), which takes cross-section dependence into account. Cointegration was detected between the series. The series move together in the long term. Thus, electricity consumption and economic growth are coherent in the long term.

Long term individual cointegration coefficients were estimated by using the CCE (Common Correlated Effects) model**.** According to the obtained estimation results, as expected, energy consumption has a long-term relation with economic growth in OECD countries throughout the panel. In the long run they have common fluctuations.

It has been concluded that the increase in electricity consumption has a positive effect on economic growth – the more electricity is consumed the more product is generated. Because of this relationship between electricity consumption and economic growth, economic policies should be compatible with electricity policies.

REFERENCES:

1. ACARAVCI, A. – OZTURK, I. (2012): Electricity Consumption and Economic Growth Nexus: A Multivariate Analysis for Turkey. In *Amfiteatru Economic Journal*, 2012, Vol. 14, No. 31, pp. 246-257.
2. ADOM, P. K. et al. (2012): Modelling Aggregate Domestic Electricity Demand in Ghana: An Autoregressive Distributed Lag Bounds Cointegration Approach. In *Energy Policy*, 2012, Vol. 42, pp. 530-537.
3. AL-MULALI, U. et al. (2014): Electricity Consumption from Renewable and Non-Renewable Sources and Economic Growth: Evidence From Latin American Countries. In *Renewable and Sustainable Energy Reviews*, 2014, Vol. 30, pp. 290-298.

4. BÉLAÏD, F. – ABDERRAHMANI, F. (2013): Electricity Consumption and Economic Growth in Algeria: A Multivariate Causality Analysis in The Presence of Structural Change. In *Energy Policy*, 2013, Vol. 55, pp. 286-295.
5. BREUSCH, T. S. – PAGAN, A. R. (1980): The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics. In *The Review of Economic Studies*, 1980, Vol. 47, No. 1, pp. 239-253.
6. CHEN, S.T. et al. (2007): The Relationship between GDP and Electricity Consumption in 10 Asian Countries. In *Energy Policy*, 2007, Vol. 35, No. 4, pp. 2611-2621.
7. CIARRETA, A. – ZARRAGA, A. (2010): Economic Growth-Electricity Consumption Causality in 12 European Countries: A Dynamic Panel Data Approach. In *Energy Policy*, 2010, Vol. 38, No. 7, pp. 3790-3796.
8. GAO, J. – ZHANG, L. (2014): Electricity Consumption–Economic Growth–CO_2 Emissions Nexus in Sub-Saharan Africa: Evidence From Panel Cointegration. In *African Development Review*, 2014, Vol. 26, No. 2, pp. 359-371.
9. GRANGER, C. W. (1969): Investigating Causal Relations by Econometric Models and Cross-Spectral Methods. In *Econometrica: Journal of the Econometric Society*, 1969, Vol. 37, No. 3, pp. 424-438.
10. GURGUL, H. – LACH, Ł. (2012): The Electricity Consumption Versus Economic Growth of The Polish Economy. In: *Energy Economics*, 2012, Vol. 34, No. 2, pp. 500-510.
11. HERZER, D. (2014): Unions And Income Inequality: A Heterogeneous Panel Cointegration and Causality Analysis. In *Diskussionspapier, Helmut-Schmidt-Universität, Fächergruppe Volkswirtschaftslehre*, 2014, no. 146, pp. 1-50.
12. HOLTZ-EAKIN, D. et al. (1988): Estimating Vector Autoregressions with Panel Data. In *Econometrica: Journal of the Econometric Society*, 1988, Vol. 56, No. 6, pp. 1371-1395.
13. HOSSAIN, M. S. – SAEKI, C. (2012): A Dynamic Causality Study between Electricity Consumption and Economic Growth for Global Panel: Evidence from 76 countries. In *Asian Economic and Financial Review*, 2012, Vol. 2, No. 1, pp. 1-13.
14. IM, K. S. et al. (2003): Testing For Unit Roots in Heterogeneous Panels. In *Journal of Econometrics*, 2003, Vol. 115, No. 1, pp. 53-74.
15. JUMBE, C. B. (2004): Cointegration and Causality Between Electricity Consumption and GDP: Empirical Evidence From Malawi. In *Energy Economics*, 2004, Vol. 26, No. 1, pp. 61-68.
16. KARAGOL, E. et al. (2011): Economic Growth and Electricity Consumption in Turkey: A Bound Test Approach. In *Doğuş Üniversitesi Dergisi*, 2011, Vol. 8, No. 1, pp. 72-80.

17. KRAFT, J. – KRAFT, A. (1978): On the Relationship between Energy and GNP. In *Journal of Energy and Development*, 1978, Vol. 3, No. 2, pp. 401-403.
18. LORDE, T. et al. (2010): The Importance of Electrical Energy for Economic Growth in Barbados. In *Energy Economics*, 2010, Vol. 32, No. 6, pp. 1411-1420.
19. NIU, S. et al. (2013): Electricity Consumption and Human Development Level: A Comparative Analysis Based on Panel Data for 50 Countries. In *International Journal of Electrical Power & Energy Systems*, 2013, Vol. 53, No. 1, pp. 338-347.
20. OZTURK, I. – ACARAVCI, A. (2011): Electricity Consumption and Real GDP Causality Nexus: Evidence from ARDL Bounds Testing Approach for 11 Mena Countries. In *Applied Energy*, 2011, Vol. 88, No. 8, pp. 2885-2892.
21. PESARAN, M. H. (2004): General Diagnostic Tests for Cross-Section Dependence in Panels. In *IZA Discussion Papers*, 2004, No. 1240.
22. PESARAN, M. H. (2006): Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure. In *Econometrica*, 2006, Vol. 74, No. 4, pp. 967-1012.
23. PESARAN, M. H. (2007): A Simple Panel Unit Root Test in The Presence of Cross-Section Dependence. In *Journal of Applied Econometrics*, 2007, Vol. 22, No. 2, pp. 265-312.
24. SHAHBAZ, M.et al. (2012): Revisiting the Relationship Between Electricity Consumption, Capital and Economic Growth: Cointegration And Causality Analysis in Romania. In *Romanian Journal of Economic Forecasting*, 2012, Vol. 2012, No. 3, pp. 97-120.
25. SHAHBAZ, M. – LEAN, H. H. (2012): The Dynamics of Electricity Consumption and Economic Growth: A Revisit Study of Their Causality in Pakistan. In *Energy*, 2012, Vol. 39, No. 1, pp. 146-153.
26. STERN, D. I. – CLEVELAND, C. J. (2004): Energy and Economic Growth. In *Encyclopedia of Energy*, 2004, pp. 35-51.
27. WESTERLUND, J. (2008): Panel Cointegration Tests of the Fisher Effect. In *Journal of Applied Econometrics*, 2008, Vol. 23, No. 2, pp. 193-233.
28. YOO, S. H. – KWAK, S. Y. (2010): Electricity Consumption and Economic Growth in Seven South American Countries. In *Energy Policy*, 2010, Vol. 38, No. 1, pp. 181-188.