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Economic growth and energy consumption: comparative analysis of V4 and the "old" EU countries

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Abstract. Our paper uses the panel data approach to investigate the relationship between energy consumption and economic growth for V4 countries and for the 14 EU "old" Member States from 1995 to 2012. We define the differences between the estimated results for these two groups of countries. We assume that there is a positive relationship between energy use and economic growth. Our results reveal that in the countries in question energy consumption is not neutral to economic growth. The estimation of GDP equation indicates that that energy consumption is positively related to economic growth. Energy consumption is a pro-growth variable which means that the increase in energy consumption causes the increase of economic growth. Moreover, the energy consumption in relation to GDP growth in the V4 countries seems to be more efficient than in the "old" EU countries. Furthermore, our results point at the individual growth rate effect of GDP for every country that was not captured by the estimated model.

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INTRODUCTION

Energy plays a crucial role in economic growth in developing countries. Therefore, it is very important to understand the relationship between energy consumption and economic growth. Relationship between energy consumption and economic growth is a popular area of research in economics literature in the past years. The first research in this area was conducted by Kraft and Kraft (1978) for the United States covering the period of 1947-1974. Thereafter, numerous studies (Erol and Yu, 1987; Asafu-Adjaye, 2000; Ghali and El-Sakka, 2004; Soytas and Sari, 2006; Climent and Pardo, 2007; Sari and Soytas, 2007; or Tsani, 2010;)

have investigated the relationship between energy consumption and economic growth in different countries using various methods. Many studies have mainly focused on small sample group of countries or single country only using time series analysis. The major problem in applying time series techniques are the available datasets that are relatively short, which reduces the power of the unit root and statistical tests. To overcome such problems by modeling in time series methods, the panel data approach can be used. Panel data sets reduce the colinearity among explanatory variables and enhance the degrees of freedom, this together improve the efficiency of econometric estimations (Hsiao, 1986). Some empirical studies have investigated the relation between energy consumption and economic growth using panel data analysis (see for example, Narayan *et al.*, 2007; Lee *et al.*, 2008; Narayan and Smyth, 2008; Lee and Lee, 2010; Hamit-Haggar, 2012; Ozturk *et al.*, 2010; Eggoh *et al.*, 2011; Kahsai *et al.*, 2012; Balitskiy *et al.*).

In this study, we use the panel data approach to investigate the relationship between energy consumption and economic growth for V4 countries and 14 old EU members from 1995 to 2012. We made an attempt to define the differences between the estimated results for these two groups of countries. Understanding the relationship between energy consumption and economy (measured as GDP) is a very important task to ensure a stable economic development. The hypothesis of the study is: there is a positive relationship between energy consumption and economic growth. So, energy consumption is a significant explanatory variable in GDP equation. The GDP growth of the V4 countries depends more on energy consumption then GDP growth in the analyzed old EU countries.

The remainder of the paper is organized as follows. Section 2 presents the literature review. Section 3 presents the data used in our model. Section 4 describes the model and the econometric methodology used in the analysis. Section 5 reports the empirical results for the unit root testing. Section 6 reports the panel estimation results. Finally, conclusions are made in Section 7.

LITERATURE REVIEW

The literature on the relationship between energy consumption and economic growth dates back to the late seventies. The article on this topic was published by Kraft and Kraft (1978). Their analysis, made using U.S. data from 1947–1974, pointed out that GNP leads energy consumption, they found evidence of causality running from GNP to energy consumption. Erol and Yu in 1987 went one step further to test the neutrality hypothesis of energy consumption and found a neutrality relation between the two variables. Asafu-Adjaye (2000) tested for Granger causality between energy consumption and income for four Asian developing countries, including price as a third variable. From the test results he concluded that unidirectional Granger causality runs from energy to income for India and Indonesia, while bidirectional Granger causality runs from energy to income for Thailand and the Philippines. In the long run, he found unidirectional Granger causality running from energy and prices to income for India and Indonesia. The study results do not support the view that energy and income are neutral with respect to each other. Ghali and El-Sakka (2004) attempted to analyze the causal relationship between energy use and output growth in Canada. Based on the neo-classical one sector aggregate production technology, they developed a VEC model after testing for multivariate cointegration between output, capital, labor and energy use. They found causality running in both directions between output growth and energy use. The results significantly reject the neo-classical assumption that energy is neutral to growth, they conclude that energy is a limiting factor to output growth in Canada. Soytas and Sari (2006) investigated the relationship between energy consumption and income in a production function framework utilizing annual data from G-7 countries and uncovered long run causality between energy use and income in all G-7 countries. In four countries (Canada, Italy, Japan and UK) causality runs in both directions, in two of them (US and France) from energy use to income, and in one (Germany) from income to energy consumption. Climent and Pardo (2007) studied the Spanish energy–output linkage, they found that a long-run equilibrium relationship does not exist between the variables. However, after taking into account the effects of the oil price, they detected a short-run causality from energy consumption to economic growth and bidirectional causality in the long-run. Sari and Soytas (2007) studied the relationship between income and energy consumption in a multivariate framework in six developing countries. Their empirical evidence indicates that energy may be relatively more important input than labor. Tsani (2010) investigated the causal relationship between energy consumption and economic growth for Greece for the period 1960– 2006. The empirical findings suggest the existence of a uni-directional causal relationship running from total energy consumption to real GDP. Narayan and Smyth (2008) examined the relationship between capital formation, energy consumption and real GDP in a panel cointegration and Granger causality framework and found cointegration after allowing for structural breaks in the data. The results in this study are consistent with the energy-dependent hypothesis, suggesting that energy consumption is a major factor influencing economic growth. Eggoh, Bangake and Rault (2011) investigated the relationship between energy consumption, economic growth and auxiliaries' variables for 21 African countries over the period from 1970 to 2006. The obtained results reveal that there is a long-run equilibrium relationship between real GDP, energy consumption, consumer price index, labor and capital. Kahsai, Nondo, Schaeffer and Gebremedhin (2012) tested for Granger causality between energy consumption, price level (CPI), and GDP for 40 SSA countries. The results provide evidence of a long-run permanent relationship between GDP and energy consumption and bidirectional causality between energy consumption and GDP. Ozturk, Aslan and Kalyoncu (2010) used the panel data of energy consumption and GDP for 51 countries to investigate if there is relationship between energy consumption and real GDP. The results of the study show that energy consumption and GDP are cointegrated and there is a long-run Granger causality running from GDP to energy consumption for low income countries and bidirectional Granger causality between energy consumption and GDP for the lower middle and upper middle income countries. Taking into consideration the literature, there is a visible lack of analysis of the economies of Visegrad countries. The existing ones like Zimmermannova, et. al. (2015), Balcerzak (2015), Urbaniec (2015) concern only a part of the subject or only one country.

THE DATA

The data for calculation was taken from Eurostat databases. The financial data was adapted to reality with the use of Eurostat price indices. Then data were converted to their logarithms which allowed us to present the relationships between variables in an additive equation. The research covers the period from the 1995 to 2012 for the V4 countries (Czech Republic, Hungary, Poland, Slovakia) and for 14 countries of the "old" European Union member countries (Belgium, Denmark, Germany, Ireland, Spain, France, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, United Kingdom). In case of Greece there are missing observations in the statistics, so it was excluded from the study. In total, we are working with 324 observations in two panels which ensures the statistical validity of our results and enables us to draw conclusions and policy implications.

EMPIRICAL MODEL

In the presented study, we use the panel data approach to investigate the dependence of economic growth on energy consumption. We propose a framework based on the conventional neo-classical one-sector aggregate production function, where we treat Energy Consumption (E), Capital (K) and Total Employment (L), as separate inputs in GDP equation. That is:

$$GDP = f(K, L, E) \quad (1)$$

$$GDP_{i,t} = \beta_0 + \sum_{j=0}^{n} \beta_{1j} K_{i,t-j} + \sum_{j=0}^{n} \beta_{2j} L_{i,t-j} + \sum_{j=0}^{n} \beta_{3j} E_{i,t-j} + \mu_{i,t} \quad (2)$$

where:

GDP – log of Gross Domestic Product
K – log of Gross Fixed Capital
E – log of Total Energy Consumption
L – log of Total Employment

The panel estimation methodology adopted in this study uses a two-step procedure. First, panel unit root tests are applied to test the degree of integration of economic growth and energy consumption. Second, panel least squares method is applied to determine the dependence between energy consumption and GDP. The empirical study was made using EViews software. EViews provides convenient tools for computing panel unit root tests. We computed the following tests: Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003), Fisher-type tests using ADF and PP tests—Maddala and Wu (1999), Choi (2001). Moreover, to adjust the obtained results the causality analysis using Granger test was made

TESTING FOR THE EXISTENCE OF UNIT ROOT

Before conducting any further analysis, the applied time series were examined by unit root tests. The tests are needed because the applied panel least squares method assumes the stationarity of the analyzed time series. Table 1 reports the results of testing for unit roots in the level variables as well as in their difference.

Table 1

Test results for panel unit roots

	Variable		Method			
			Levin, Lin & Chu t*	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square
V4	GDP	Statistic	-1.85354***	0.73319	4.25658	3.59501
	ΔGDP	Statistic	-3.47871***	-2.12042***	16.5357***	15.4653***
	E	Statistic	0.60805	0.34013	5.17927	4.85107
	ΔE	Statistic	-6.36207***	-6.34654***	46.7672***	46.9352***
	K	Statistic	-1.74307***	-0.73670	9.90548	10.5925
	ΔK	Statistic	-3.23544***	-2.52179***	20.2548***	26.8323***
	L	Statistic	-1.82719***	-1.31578	13.0932	4.70081
	ΔL	Statistic	-1.53419	-1.39468	12.4285	12.4406
	ΔΔL	Statistic	-6.57240***	-4.90729***	36.0111***	41.1078***
EU	GDP	Statistic	0.66083	5.17750	8.05612	4.38070
	ΔGDP	Statistic	-6.87134***	-4.09941***	63.7074***	71.7271***
	E	Statistic	-0.45122	1.49325	31.6991	45.8331
	ΔE	Statistic	-11.8213***	-10.2298***	152.214***	431.713***
	K	Statistic	-1.16015	0.21900	36.8236	16.4038
	ΔK	Statistic	-5.85515***	-4.93830***	75.0724***	80.7743***
	L	Statistic	3.46841	2.89875	26.9147	10.4067
	ΔL	Statistic	-4.48102***	-5.35772***	83.2143***	68.0070***

*** denotes that we can aknowledge the stationarity for 5% significance level

Source: Own calculation.

In the case of the level of variables the null hypothesis that variables assume common and individual unit root process cannot be rejected. However, after applying the first difference, almost all of the variables meet the requirements of the study. So, we can acknowledge their stationarity for the 95% confidence interval. Only in the case of Total Employment (L) in V4 Countries is there no confidence about the lack of unit root, which results in applying the second difference. After applying the second difference we can acknowledge the stationarity for Total Employment in V4 Countries, but the economic interpretation of the two times differenced variable is problematic.

PANEL LEAST SQUARES ESTIMATION RESULTS

In studying the GDP energy consumption dependence we applied panel least squares method. There were estimated equations of GDP, taking into consideration one way models with fixed or random cross-section effects. The final form of estimated equation for V4 Countries is as follows:

$$\Delta GDP_{i,t} = \beta_0 + \sum_{j=0}^{n} \beta_{1j}\Delta K_{i,t-j} + \sum_{j=0}^{n} \beta_{2j}\Delta\Delta L_{i,t-j} + \sum_{j=0}^{n} \beta_{3j}\Delta E_{i,t-j} + \mu_{i,t} \quad (3)$$

The results of modeling the V4 GDP equation are reported in Table 2, which presents the econometrical tests of the estimated models as well. Results were obtained using EViews software.

Table 2

ΔGDP equation of V4 countries

One Way Fixed - Panel Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.025795	0.002391	10.78672	0.0000
ΔE	0.190110	0.073977	2.569835	0.0128
ΔK	0.241291	0.030244	7.978201	0.0000
ΔΔL	-0.001564	0.151623	-0.010318	0.9918
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.662776	Mean dependent var		0.031019
Adjusted R-squared	0.627279	S.D. dependent var		0.029281
S.E. of regression	0.017876	Akaike info criterion		-5.107776
Sum squared resid	0.018215	Schwarz criterion		-4.871648
Log likelihood	170.4488	Hannan-Quinn criter.		-5.014753
F-statistic	18.67117	Durbin-Watson stat		1.518236
Prob(F-statistic)	0.000000			
Test cross-section fixed effects				
Effects Test		Statistic	d.f.	Prob.
Cross-section F		2.834006	-3,57	0.0462
Cross-section Chi-square		8.897901	3	0.0307
Normality Test of Residuals		Statistic		Prob.
Jarque-Bera		4.051950		0.131865
Autocorrelation Test of Residuals	AC	PAC	Q-Stat	Prob
1 Lag	0.231	0.231	3.5794	0.059
2 Lag	-0.096	-0.157	4.2012	0.122
3 Lag	-0.149	-0.095	5.7434	0.125
4 Lag	-0.019	0.031	5.7677	0.217

Source: Own calculation.

The results of the estimation of V4 GDP equation allow to state, that the cross-section effects should be treated as fixed effects. Notice that there are two sets of tests made by modeling. The first set consists of two tests - Cross-section F and Cross-section Chi-square - that evaluate the joint significance of the cross-section effects using sums-of-squares (F-test) and the likelihood function (Chi-square test). The two statistic values (2.834006 and 8.897901) and the associated p-values allow us to reject the null hypothesis that the cross-section effects are redundant. The second test was Hausman test for random effects. A central assumption in case of random effects estimation is the assumption that the random effects are uncorrelated with the explanatory variables. One common method for testing this assumption is to employ a test to compare the fixed and random effects estimates of coefficients (Hausman, 1978). The statistic provides evidence that there is no reason to accept the null hypothesis that there is no misspecification, so the random effects are not significant. The adjusted R-squared of the estimated model is 0.627, so it fits the actual data quite well. The estimated DW test statistic is 1.518, so we can state that the residuals are uncorrelated and the heteroscedasticity of residuals is not present. Furthermore, the residual PAC correlogram was made taking 4 quarters lag into account, the analysis confirms that the residuals are uncorrelated. The Jarque-Bera statistic does not reject the hypothesis of normal distribution, so it indicates that there is no reason to reject the null hypothesis and allows us to accept the normality of residuals.

The next step was to establish the dependences between energy consumption and GDP in EU countries. The final form of estimated equation for EU14 countries is as follows:

$$\Delta GDP_{i,t} = \beta_0 + \sum_{j=0}^{n} \beta_{1j} \Delta K_{i,t-j} + \sum_{j=0}^{n} \beta_{2j} \Delta L_{i,t-j} + \sum_{j=0}^{n} \beta_{3j} \Delta E_{i,t-j} + \mu_{i,t} \quad (4)$$

The results of modeling the EU14 GDP equation are reported in Table 3, which presents the econometrical tests of the estimated models as well.

Table 3

ΔGDP modeling of EU14 countries

One Way Fixed - Panel EGLS (Cross-section weights)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.014719	0.000755	19.50429	0.0000
ΔE	0.066527	0.020696	3.214440	0.0015
ΔK	0.307928	0.016814	18.31347	0.0000
ΔL	0.011390	0.054266	0.209899	0.8339
	Effects Specification			
Cross-section fixed (dummy variables)				
	Weighted Statistics			
R-squared	0.823898	Mean dependent var		0.023377
Adjusted R-squared	0.811149	S.D. dependent var		0.030251
S.E. of regression	0.013335	Sum squared resid		0.039297
F-statistic	64.62234	Durbin-Watson stat		2.059023
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.767298	Mean dependent var		0.020716
Sum squared resid	0.041567	Durbin-Watson stat		1.946492
Test cross-section fixed effects				
Effects Test		Statistic	d.f.	Prob.
Cross-section F		4.754833	-13,221	0.0000
Normality Test of Residuals		Statistic		Prob.
Jarque-Bera		0.842985		0.656067
Autocorrelation Test of Residuals	AC	PAC	Q-Stat	Prob
1 Lag	0.024	0.024	0.1447	0.704
2 Lags	-0.025	-0.026	0.2994	0.861
3 Lags	-0.030	-0.029	0.5214	0.914
4 Lags	-0.019	-0.018	0.6060	0.962

Source: Own calculation.

The results of the estimation of EU14 GDP equation appear to be a little confusing. The Cross-section Fixed effects test and Cross-section Chi-square test - that evaluate the joint significance of the cross-section effects strongly reject the null hypothesis that the cross-section effects are redundant. On the other hand the next test was Hausman test for random effects. The statistic provides evidence that there is no reason to reject the null hypothesis that there is no misspecification, so the cross-section effects can be random. The testing established that we have a situation when the cross-section effects could be treated as fixed effects as well as random effects. Taking the statistics of evaluated models into account, it becomes obvious that both of estimated equations of GDP do not meet the requirements of proper estimation - the Jarque-Bera statistics rejects the hypothesis of residuals normal distribution.

Thence, we have recalculated the one way fixed effects equation using panel EGLS (Cross-section weights) to meet the assumptions of regression. The estimated DW test statistic for the model is 2.059, so we can assume that the residuals are uncorrelated and the heteroscedasticity of residuals is not present. Furthermore, the residual PAC correlogram was made taking 4 quarters lag into consideration and the results confirm that the residuals are uncorrelated. We conducted a test for the normality of residuals as well. This time the Jarque-Bera statistic does not reject the hypothesis of normal distribution. The p-value is 0.656, so it indicates that there is no reason to reject the null hypothesis and allows us to accept the normality of residuals.

The modeling we carried out meets all the requirements of a proper estimation. The residuals of the models have normal distribution with the expected value 0. In addition, we used stationary variables for the estimation of the equations. The estimated models of V4 and EU14 economic growth with the application of energy consumption as one of the explanatory variables meets all the conditions of proper estimation, so it undoubtedly has reliable economic interpretation.

Taking the coefficients of estimated equations under consideration (Table 4) indicates that the energy consumption is positive related to the economic growth. The final GDP equations exclude Total Employment, what stands in line with the previous studies in the subject (Kasperowicz, 2013; Kasperowicz, 2014). The evaluated regression model includes growth rates of Energy Consumption and growth rates of Gross Fixed Capital in real prices.

Table 4

Coefficients of estimated models

	V4 equation		EU14 equation	
Variable	Coefficient	Prob.	Coefficient	Prob.
C	0.025795	0.0000	0.014719	0.0000
ΔE	0.190110	0.0128	0.066527	0.0015
ΔK	0.241291	0.0000	0.307928	0.0000
ΔΔL, ΔL	-0.001564	0.9918	0.011390	0.8339

Source: Own calculation.

The analysis let us to state that in the analyzed countries energy consumption is not neutral to economic growth. The Energy Consumption is a pro-growth variable, which means that the increase of the energy consumption causes the increase of economic growth. And what interesting about this - the energy consumption in relation to the GDP growth in the V4 countries seems to be more efficient then in EU countries. The energy consumption increase of 1% causes the GDP growth increase of 0,19% in the V4 countries and the GDP growth increase of 0,066% in the EU14 countries. Differently looks the growth capacity when we take the capital under consideration. The fixed capital increase of 1% causes the GDP growth increase of 0,241% in the V4 countries and the GDP growth increase of 0,307% in the EU14 countries. So the capital works better in the EU old member countries. To provide additional information about the estimated dependences between energy consumption and GDP the Granger causality test was made, the results are reported in Table 5.

Table 5

Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
V4 E does not Granger Cause V4 GDP	68	8.12037	0.0059
EU14 E does not Granger Cause EU14 GDP	238	13.7297	0.0003

Source: Own calculation.

The results show that in case of energy consumption as the explanatory variable the Granger's test H0 can be rejected. It means that the selected data show the econometric causality against dependent variable, so the energy consumption can be a reason of GDP growth.

The explanatory variables make up regression equation V4 GDP, which explains about 63% of the variability of the economic growth in the Visegrad Group countries, and regression equation EU14 GDP, which explains about 81% of the variability of the economic growth in 14 countries of "old" EU members. The applied panel modeling with cross-section fixed effects let to point the individual effect for every country that was not captured by the estimated model (the effects are given in table 6).

Table 6

Individual effects

V4	Czech Republic	CZ	-0.004713
	Hungary	HU	-0.007432
	Poland	PL	0.002944
	Slovakia	SK	0.009201
EU	Belgium	BE	-0.003385
	Denmark	DK	-0.007902
	Germany	DE	-0.003370
	Ireland	IE	0.024424
	Spain	ES	0.001883
	France	FR	-0.005889
	Italy	IT	-0.009082
	Luxembourg	LU	0.002877
	Netherlands	NL	-0.000601
	Austria	AT	0.000815
	Portugal	PT	0.000242
	Finland	FI	-8.30E-05
	Sweden	SE	-0.000819
	United Kingdom	UK	0.000891

Source: Own calculation.

The individual effects show the part of growth rate of economic growth of a country that is not calibrated in the estimated model. So we have here some other information about the results. For example - the characteristics of Polish economy that was not included in the model affected the Polish economic growth rate so that the Polish economic growth rate was about 0.003 (0.002944) higher than the average economic growth rate in analyzed V4 countries, the characteristics of German economy that was not included in the model affected the German economic growth rate so that the German economic growth rate was about 0.003 (0.003370) lower than the average economic growth rate in analyzed EU14 countries. Analogously can be interpreted fixed effects for other countries.

CONCLUSIONS

Our paper analyzed the relationships between energy consumption and economic growth for V4 countries and 14 countries of old EU members. The analysis was based on panel least squares modeling. The estimation of GDP equation indicated that that the energy consumption is positive related to the economic growth, what stays in line with the founding of previous study of Streimikiene and Kasperowicz (2016). The final GDP equations, in both cases, excludes Total Employment – the finding stands in line with the results obtained by Sari and Soytas (2007). The evaluated regression models include growth rates of Energy Consumption and growth rates of Gross Fixed Capital in real prices. The analysis let us to state that in the analyzed countries energy consumption is not neutral to economic growth. The Energy Consumption is a pro-growth variable, which means that the increase of the energy consumption causes the increase of economic growth. Furthermore, the energy consumption in relation to the GDP growth in the V4 countries seems to be more efficient then in EU countries. Our empirical results suggest that energy is an essential factor for economic growth in developing countries. This implies that the relation between energy consumption and economic growth are an integral part of development process. The energy consumption increase of 1% causes the GDP growth increase of 0,19% in the V4 countries versus GDP growth increase of 0,066% in the EU14 countries. So, the GDP growth in the V4 countries is more energydependent. The estimated dependences were confirmed by the Granger causality analysis. Different looks the growth capacity when we take the capital under consideration. The fixed capital increase causes lower GDP growth in the V4 countries then in the EU14 countries. So the capital is more effective in the EU old member countries.

To sum up, the empirical results of the study show that the economic growth of analyzed European countries is energy-dependent, so one can state that energy consumption is a limiting factor to economic growth. The empirical results of this study provide policymakers a better understanding of energy consumption–economic growth nexus to formulate energy policies in these countries. The ongoing political situation shows that the first place to secure a stable economic growth is to ensure stable and secure energy supply. Security of energy supply hit again the top of the EU agenda. The diversification of sources (away from Russian), origin and transport routes of energy become the most important factors of economic growth in European Union.

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APPENDIX

A1

ΔGDP modeling of V4 countries

One Way Random - Panel EGLS (Cross-section random effects)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.025644	0.002386	10.74687	0.0000
ΔE	0.190046	0.073558	2.583617	0.0122
ΔK	0.247620	0.029608	8.363256	0.0000
ΔΔL	-0.017684	0.150920	-0.117172	0.9071
Effects Specification				
			S.D.	Rho
Cross-section random			1.19E-09	0.0000
Idiosyncratic random			0.017876	1.0000
Weighted Statistics				
R-squared	0.612476	Mean dependent var		0.031019
Adjusted R-squared	0.593100	S.D. dependent var		0.029281
S.E. of regression	0.018678	Sum squared resid		0.020932
F-statistic	31.60972	Durbin-Watson stat		1.334001
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.612476	Mean dependent var		0.031019
Sum squared resid	0.020932	Durbin-Watson stat		1.334001
Correlated Random Effects - Hausman Test				
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random		8.502019	3	0.0367

Source: Own calculation.

A2

ΔGDP modeling of EU14 countries

One Way Fixed - Panel Least Squares				
1	2	3	4	5
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.014152	0.001013	13.96742	0.0000
ΔE	0.112436	0.025188	4.463958	0.0000
ΔK	0.283042	0.018582	15.23206	0.0000
ΔL	0.090221	0.065687	1.373498	0.1710
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.772337	Mean dependent var		0.020716
Adjusted R-squared	0.755854	S.D. dependent var		0.027454
S.E. of regression	0.013565	Akaike info criterion		-5.693868

1	2	3	4	5
Sum squared resid	0.040667	Schwarz criterion		-5.445849
Log likelihood	694.5703	Hannan-Quinn criter.		-5.593912
F-statistic	46.85826	Durbin-Watson stat		1.941554
Prob(F-statistic)	0.000000			
Test cross-section fixed effects				
Effects Test		Statistic	d.f.	Prob.
Cross-section F		4.783668	-13,221	0.0000
Cross-section Chi-square		59.011421	13	0.0000
Normality Test of Residuals		Statistic		Prob.
Jarque-Bera		157.7954		0.000000
One Way Random - Panel EGLS (Cross-section random effects)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013928	0.001865	7.468205	0.0000
ΔE	0.116686	0.025074	4.653749	0.0000
ΔK	0.276572	0.018335	15.08435	0.0000
ΔL	0.121814	0.064283	1.894969	0.0593
Effects Specification				
			S.D.	Rho
Cross-section random			0.005870	0.1577
Idiosyncratic random			0.013565	0.8423
Weighted Statistics				
R-squared	0.733436	Mean dependent var		0.010129
Adjusted R-squared	0.730019	S.D. dependent var		0.026252
S.E. of regression	0.013640	Sum squared resid		0.043538
F-statistic	214.6130	Durbin-Watson stat		1.810369
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.705983	Mean dependent var		0.020716
Sum squared resid	0.052520	Durbin-Watson stat		1.500753
Correlated Random Effects - Hausman Test				
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random		5.599875	3	0.1328
Normality Test of Residuals		Statistic		Prob.
Jarque-Bera		163.5620		0.000000
Autocorrelation Test of Residuals	AC	PAC	Q-Stat	Prob
1 Lag	0.243	0.243	14.251	0.000
2 Lags	0.188	0.137	22.822	0.000
3 Lags	0.151	0.085	28.361	0.000
4 Lags	0.111	0.042	31.374	0.000

Source: Own calculation.