CORVINUS ECONOMICS WORKING PAPERS

CORVINUS
UNIVERSITY of BUDAPEST
Faculty of Economics

CEWP 07/2018

How economic growth and energy consumption contribute to environmental degradation?

by
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26.11. 2018

Abstract

This paper explores the relationship between environmental degradation (measured by the ratio of carbon dioxide emissions), economic growth and energy consumption in case of Hungary over the period of 1990-2014 by annual data. To ascertain the integrating properties of the variables, the Zivot-Andrews unit root test was employed. The ARDL bounds testing approach and Gregory-Hansen structural break test have been adopted to test the relationship between the variables in the presence of structural break. Structural breaks occurred in the first half of the 2000s in the series of carbon dioxide emissions and energy consumption, while economic growth has a structural break in the middle of 1990s. My research shows that carbon dioxide emissions are influenced in several ways by the above-mentioned factors. The impact of energy consumption is time variant on carbon dioxide emissions and statistically significant in the short and long term. One-year delay, increasing in energy consumption results decline in carbon dioxide emissions while increasing in level of energy consumption is linked with increases in economic growth. The economic growth also has an important role in carbon dioxide emissions. Its increasing contributes to reduce carbon dioxide emissions in the short and long run. It is concluded that economic growth and energy consumption are in the background of the air quality and economic growth mitigates carbon dioxide emissions.

JEL-code: O04, O13, Q54, Q56,

Keywords: cointegration, energy, economic growth, ARDL bounds test

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1. Introduction

All the developments for the environment are costly, for example, the degradation of air and water qualities caused by energy-intensive production. These pollutants associated with economic growth may cause health problems which are paid by the society. This is why the analyzing of interaction between environmental degradation and economic growth became one of the most attractive fields of research in environmental economics.

At the center of the efforts to achieve sustainable development is the increasing emphasis on energy management. Nowadays it is often mentioned as a disadvantage of the neoclassical model in economics, that it treats energy as a neutral factor. Energy, according to many researchers (Aqeel, Butt 2001; Al-Iriani 2006; Chen et al. 2006; Shahbaz et al. 2010) acts as a dynamic engine of economic growth in an indirect way, and it is directly responsible for providing the basic conditions of the civilization for millions of households on a daily routine. The link between energy consumption and indicators of economic growth allows us to conclude that an expansionist policy towards energy may be harmonized with the country's economic growth goals.

Since the industrial revolution, increasing profitability with decreasing production costs become one of the most important factors of a country's competitiveness. One possible way to reduce this production cost is to use cheaper but polluting energy sources. Thus, for a long time industries have been using coal, later oil as primary energy sources. Even currently, production of energy mostly has been based on fossil fuels (Saidi and Mbarek 2017).

In the international literature, numerous researchers are currently investigating the challenges presented by economic growth, energy consumption, and carbon dioxide emissions and the effects these have on each other. However, there is no clear statement on the direction of causality among factors. This relationship is influenced by the countries' characteristics such as, different indigenous energy supplies, political and economic histories, cultures, and different institutional arrangements (Chen et al. 2007). The first focuses on the relationship between economic growth and energy consumption dating back to the pioneering work by Kraft and Kraft (1978) and leading to the use of Granger causality test approach as a tool for studying the relationship between energy consumption and economic growth in different countries.

The present study reveals the relationship between economic growth, energy consumption and carbon dioxide emissions in Hungary. The first step is to analyze the stationarity properties of the variables by using Augmented Dickey-Fuller and Zivot-Andrews unit root test. The second step of the research entailed the relationship between variables in the presence of structural break using Gregory-Hansen structural break cointegration test and ARDL bounds testing approach. The empirical models also analyzed by two of major diagnostic tests. To this end, VECM were used to examine causality between variables.

The connecting literature has a wide range of studies examining the mutual effects of energy consumption and economic growth. According to Shahbaz and Lean (2012), electricity consumption contributes to economic growth, and the bi-directional cause and effect relationship between the time series exists. Michieka et al. (2012) believes that there is no relationship between the two variables. Table 1 shows the summary of studies in connection with the (causality) analysis of economic growth (GDP), energy/electricity consumption and carbon dioxide emissions. The most often methodology for analysis are the VAR, VECM and the ARDL bounds testing approach for time series but some researcher used panel data analysis e.g. GMM. The results are inconclusive, there are largely dependent on the location, energy production and policy for the examined country.

Table 1
A brief summary of causality analysis literature by location

No	Study authors	Country	Time period	Methodology	Variables	Causality
			Evidence from international research			
1	Kraft and Kraft (1978)	USA	1947-1974	Granger causality	GNP, ENC	GNP-> ENC
2	Shahbaz and Lean (2012)	Tunisia	1971-2008	ARDL	GDP, EC, Fin.Dev., Ind., Urb.	Fin.Dev.-> EC
3	Solarin and Shahbaz (2013)	Angola	1971-2009	ARDL, VECM	GDP, EC, URB	EC-> Fin.Dev. URB-> EC GDP-> EC EC->GDP
4	Michieka-Fletcher (2013)	China	1971-2009	VAR	GDP, Coal prod. URB, EC	
5	Shahbaz et al (2014)	UAE	1975-2011	ARDL, VECM	GDP, EC, URB, CO2	CO2->EC
6	Belke et al (2011)	25 OECD countries	1981-2007	ARDL	GDP, ECN	GDP->ENC
7	Poumanyvong and Kaneko (2010)	99 countries	1975-2005	STIRPAT	URB, ENC, CO2	-
8	Kaid and Sami (2016)	58 countries	1990-2012	Panel data model	GDP, ENC, URB	-
			Evidence from European countries			
9	Dogan (2016)	EU	1980-2012	OLS	GDP, RES, CO2, TO	GDP->CO2 RES->CO2
10	Mazur et al (2009)	EU-28	1992-2010	FE-RE OLS panel data	GDP, CO2	-
11	Stolyarova (2010)	Eastern Europe	1960-2008	WITHIN, SYS GMM	GDP, CO2, POP, EC, Region	GDP->CO2
12	Ozturk-Acaravci (2010)	19 EU countries	1980-2006	ARDL, VECM	GDP, EC, ENC	GDP->ENC CO2->ENC
13	Syimelyte and Dudzeviciute (2017)	EU-28	1990-2012	Cobb-Douglas function	GDP, RES, TR, CAP, LABOUR	-
14	Shahbaz et al (2013)	Romania	1980-2010	ARDL	GDP, CO2, ENC	CO2->GDP

Source: Own's data collection

To measure the extent of environmental degradation, the most commonly added indicator to GDP and energy consumption is the carbon dioxide emissions. Acaravci and Ozturk (2010) investigated the causal relationship between carbon dioxide emissions, energy consumption, and economic growth by using ARDL bounds testing approach for 19 European countries. They concluded that a long-run relationship exists between only for Denmark, Germany, Greece, Iceland, Italy, Portugal and Switzerland. Positive long-run elasticity estimates of carbon emissions with respect to real GDP and the negative long-run elasticity estimates of carbon emissions with respect to the square of per capita real GDP at 1% significance level in Denmark and 5% significant level in Italy are also found.

For the European Union over the period 1980–2012 by using the dynamic ordinary least squares estimator, Dogan and Seker (2016) shows that renewable energy and trade mitigate carbon emissions while non-renewable energy increases carbon dioxide emissions. The Dumitrescu-Hurlin non-causality approach indicates that there is bidirectional causality between renewable energy and carbon emissions, and unidirectional causality is running from real income to carbon emissions, from carbon dioxide emissions to non-renewable energy, and from trade openness to carbon dioxide emissions.

Using panel data properties and Mazur et al (2009) studied the EKC Hypothesis for all 28 EU states. The empirical investigation for the 1992–2010 period, based on fixed and random effect estimations, does not provide strong evidence that a negative correlation of income is established with carbon dioxide emissions levels. Stolyarova article is about carbon dioxide emissions and economic growth for Eastern Europe countries, per capita emissions also depend on the lag of per capita GDP between 1960-2008 using panel dataset covering 93 countries all over the world.

Over the period of 1980-2006, Ozturk and Acaravci (2010b) analysis the relationship between energy use per capita and real GDP per capita variables using ARDL bounds testing and VECM in 19 EU countries. The findings demonstrate that there is a long-run relationship between energy use per capita and real GDP per capita as well as they found evidence of two-way (bidirectional) strong Granger causality between these variables.

Conservation hypothesis has been proved in case of Hungary. It means that energy consumption has a vital role in economic development in both directly and indirectly way. Thus, in this case, there is a unidirectional link from economic growth to consuming energy. According to Simelity and Dudzaviciute (2017), the most notable negative impact out of all EU countries, renewable energy would have on economic growth in Hungary, Ireland, Latvia and Slovenia, where 1% of decrease in consuming renewable energy would shrink economic growth by 0.417%, 0.431%, 0.331%, and 0.387% respectively. Moreover, the correlation coefficient indicates moderately strong links between renewable and real GDP per capita in these countries, in Hungary it is 0.703%.

2. Methodological framework

2.1 The data and modelling

Data on carbon dioxide emissions and energy consumption come from World Bank. Data for real GDP is obtained from Penn World Table (Groningen Growth and Development Centre). The study covers the time period of 1990-2014. Data periods may seem to be short. However, ARDL method using this study is suitable for especially shorter periods (Bildirici and Kayikci 2012).

All series have been calculated into per capita. The general form of the empirical equation as the following:

$$CO_{2t} = f(GDP_t, ENC_t) \quad (1)$$

where $CO2_t$ is the carbon dioxide emissions per capita, GDP_t is the real GDP per capita and ENC_t is the energy consumption per capita. All variables have been converted into their natural logarithm. The double linear specification provides better results compared to simple specification (Solarin and Shahbaz, 2013). A bulk amount of studies tested the nexus in logarithm form in this context, for instance, Wang et al. (2016), Liddle-Lung (2014) and Shahbaz et al. (2012).

The specification of the empirical equation as the following:

$$\ln CO2_t = \beta_0 + \beta_{GDP} \ln GDP_t + \beta_{CO2} \ln ENC_t + \varepsilon_t \quad (2)$$

where $\ln CO2_t$ is the natural log of carbon dioxide emissions per capita (metric tons), $\ln GDP_t$ is the natural log of real income per capita (in constant 2011 US million dollar) and $\ln EC_t$ is the natural log of energy consumption per capita (kt of oil equivalent and ε_t is the error term with normal conditions.

2.2 Unit root tests

The first step of the analysis is to test the stationarity for variables in the time series sample. There are so many unit root tests in literature to determine the integration order of variables. One of the most usual test called Dickey-Fuller test. The Dickey-Fuller test has been modified by Dickey and Fuller, Said and Dicky, Phillips as well as Phillips and Perron even so it can be applied when the error term is white noise. The Augmented Dickey-Fuller test covered these unit root tests. The null hypothesis of ADF test that unit root is present in the time series sample. According to the alternative hypothesis, the process (time series sample) is stationary. Critical values are used to indicate whether the null can be rejected.

There is plenty of evidence in the literature that the above mentioned traditional unit root tests are not reliable when structural break(s) occurs in the series. These tests do not allow for the possibility of a structural break, therefore, distort towards non-rejection of unit root (Perron, 1989). To overcome this problem, I employed Zivot and Andrews's test (1992) can be used for unit root analysis in the presence of not only one but also two unknown structural breaks.

The null hypothesis of three models that a unit root is present in the series with a drift and not having information structural break point, while the alternative hypothesis means that the series is a trend-stationary process with one-time break at an unknown point.

2.3 Cointegration tests

In this paper, the ARDL approach to cointegration involves two steps for estimating a long-run relationship. A different issue is that of testing for cointegration when regime shifts may be present in the data. In fact, in such cases conventional procedures to test for cointegration may lead to erroneous inferences.

This modelling approach involves estimating a dynamic model by incorporating the lags of the dependent variables as well as the lagged and contemporaneous values of the independent variables (Marbuah, 2013). The ARDL bounds testing to cointegration has several advantages compared other cointegration procedures. One of these is that it can relevantly be applied regardless of integrated order of the variables in time series. Pre-testing for the order of integration of the variables is not a pre-requisite but the integration order cannot exceed I(1) processes.

Shahbaz et al (2013) compared the usual cointegration tests in their article and concludes that the ARDL model uses a single reduced form equation while Engle and Granger (1987) requires a two-stage regression in which the generated error term form first stage will continue in the further stage. The Johansen cointegration test works well only large sample data and suffers from small sample bias while the ARDL model does not require large data. The empirical structure of the ARDL bounds test to cointegration is as follows:

$$\Delta CO2_t = \alpha_{0i} + \sum_{i=1}^{n} \alpha_i \Delta CO2_{t-1} + \sum_{i=1}^{n} \alpha_2 \Delta GDP_{t-1} + \sum_{i=1}^{n} \alpha_3 \Delta ENC_{t-1} + \varphi_1 CO2_{t-1} + \varphi_2 GDP_{t-1} + \varphi_3 ENC_{t-1} + \pi_t \quad (7)$$

$$\Delta GDP_t = \alpha_{0i} + \sum_{i=1}^{n} \alpha_i \Delta GDP_{t-1} + \sum_{i=1}^{n} \alpha_2 \Delta ENC_{t-1} + \sum_{i=1}^{n} \alpha_3 \Delta CO2_{t-1} + \varphi_1 GDP_{t-1} + \varphi_2 ENC_{t-1} + \varphi_3 CO2_{t-1} + \varepsilon_t \quad (8)$$

$$\Delta ENC_t = \alpha_{0i} + \sum_{i=1}^{n} \alpha_i \Delta EC_{t-1} + \sum_{i=1}^{n} \alpha_2 \Delta CO2_{t-1} + \sum_{i=1}^{n} \alpha_3 \Delta GDP_{t-1} + \varphi_1 ENC_{t-1} + \varphi_2 CO2_{t-1} + \varphi_3 GDP_{t-1} + \varepsilon_t \quad (9)$$

where Δ is the first difference operator, the variables appear in logarithmic form and ε_t, $\mu_t, \pi_t\ and\ \vartheta_t$ are assumed normally distributed and white noise.

The F statistic used in equation (7-9) is to examine the existing of a long run relationship between the variables by calculating critical values. The null hypothesis states that cointegration does not exist while the alternative hypothesis said that cointegration exists between variables. We decide rejecting of H_0 using an F-test. Two sets of critical values are constructed for ARDL testing by Pesaran (2001) depends on the value of F statistics: if the calculated F-statistic exceeds the upper critical bound at any significance level, then we can safely reject the null hypothesis of no cointegration. Conversely, if the calculated F-statistics less than the lower critical bound, we fail to reject the null of no cointegration. If the F-value is between the two critical values, our results are inconclusive.

3. Empirical results and discussions

3.1. Descriptive statistics

The most adapted methodology starts with descriptive statistics in which the basic features of the data can be seen. In Table 2, the Jarque-Bera test provides information that all the variables are normally distributed with having zero mean and finite covariance. The null hypothesis of normality is failed to reject if the calculated test statistic is below a critical value (4.62) from the χ^2 distribution. The values of Jarque-Bera test statistics for analyzed variables are from 1.83 to 9.34 leading us to the conclusion that variables follow a normal distribution.

Table 2
Descriptive statistics

	$lnCO_{2t}$	$lnGDP_t$	$lnENC_t$
Mean	8.750003	2.573684	3.206545
Median	8.685553	2.563014	3.207052
Maximum	9.049747	3.126883	3.311554
Minimum	8.356945	1.821820	2.998707
Std. Dev.	0.200037	0.337413	0.068749
Skewness	-0.118307	-0.303834	-0.956578
Kurtosis	1.991216	2.494503	4.344800
Jarque-Bera	1.834119	1.067344	9.342278
Probability	0.399693	0.586448	0.01362
Sum	358.7501	105.5210	131.4684
Sum Sq. Dev.	1.600598	4.553891	0.189058
Observations	25	25	25

3.2. Unit root tests

Variables properties have to be known to effectively apply further tests. The present study uses the ARDL bounds test approach, the first step is to ascertain that all the variables meet the requirements of the bounds test.

One of the assumptions of the ARDL bounds testing is that the integration order of time series should be I(0) or I(1) or any kind of combination of these. The integration order cannot exceed I(1) otherwise the critical bounds provided by Pesaran (2001) and Narayan (2005) are not valid (Ozturk and Acaravci 2011; Shahbaz et al. 2011). Therefore at the beginning of the analysis we have to check the order of integration of variables because I(2) process are excluded from bounds testing. In order to correctly evaluate the stationary of the variables, this paper employs two different unit root tests including Augmented Dickey-Fuller test and Zivot-Andrews test with single unknown break.

Table 2
ADF and Zivot-Andrews unit root test

Variables	Augmented Dickey-Fuller test		Zivot-Andrews test			
	Level	First diff.	Level		First diff.	
			T-stat	Time break	T stat.	Time break
$lnCO2_t$	-2.539 [0]	-6.405***[0]	-3.0688	2001	-6.404***[0]	2005
$lnGDP_t$	-4.315***[1]	-4.249 ***[0]	-2.314	1996	-5.572** [1]	1995
$lnENC_t$	-2.706 [0]	-5.563*** [0]	-3.359	2007	-7,503***[2]	2005

Note: *,**,*** denote significance at 10%, 5% and 1% levels, respectively. The [] contains the appropriate lags of the variables.

Table 3 inform us about the result of two unit root tests. It indicates that carbon dioxide emissions ($lnCO2_t$) and energy consumption ($lnENC_t$) are not found to be stationary at level with constant and trend but integrated at I(1). Traditional unit root tests may not provide appropriate information in the presence of a structural break in connection with integrating order of the variables. To overcome this issue, I have used Zivot-Andrews test. The statistics significantly confirm that the level values of all series are non-stationary and all variables are stationary at I(1) in the presence of structural breakpoints. Time break points occurs in carbon dioxide emissions, economic growth, and energy consumption in 2005, 1995 and 2005 respectively.

Many aspects of such structural changes will depend upon the government's policy response (Rumelt, 2006). The real information about structural break dates may contribute for policymakers to make appropriate and sustainable plans for energy and economic policy.

3.2. Cointegration

After establishing the integration order for all variables, now the cointegration test can be applied for investigating the long-run relationship between the variables. Three models were analyzed not only from the point of view whether cointegration exists between the variables but also how these models perform the diagnostic test.

Table 3
Critical value Bounds

Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

The ARDL test requires to choose the correct lag length. Optimal lag order is determined by Akaike Information Criteria (AIC). The F-statistic values reveal that the null hypothesis of no cointegration can be rejected at 5% and 10% level of significance in case of F_{CO2} and F_{ENC}. The calculated F-statistics are 4.8196 and 8.7921, respectively, which are above the critical values. The results in Table 5 suggest that the models should involve two cointegration vectors.

Table 5

ARDL Bounds test

Dependent variable	**Test Statistic**	**Value**	**k**
$CO2_t$	F-stat.	4.8196*	2
GDP_t	F-stat.	2.0887	2
ENC_t	F-stat.	8.7921***	2

Note: *** denote the significance at 1% level.

The diagnostics tests are Breusch-Godfrey LM test for serial correlation and White test for heteroscedasticity. The empirical models also perform two of major diagnostic tests. The diagnostic tests indicate that the error term is free from serial correlation and homoscedasticity exists. The findings for ARDL bounds testing approach demonstrate the existence of cointegration for long-run relationship between carbon dioxide emissions, economic growth, and energy consumption in Hungary over the period of 1990-2014.

3.3. Short and long-run analysis

The next step to reveal the impact of independent variables on dependent variable separated by short and long run. Bildirici and Kaicki (2013) found that there is a long run equilibrium relationship between energy consumption and economic growth for the emerging countries of Europe. I came to the same conclusion as Bildirici and Kaicki (2013) in connection with economic growth (GDP) and electricity consumption for Hungary in the long run.

Table 5 contains short run and long-run analysis

Table 6
Short run and long-run analysis

$CO2_t$ is the dependent variable							
Short run				Long run			
Variables	Coefficient	T-stat.	Prob.	**Variables**	Coefficient	T-stat.	Prob.
$CO2_t$(-1)	0.5578*	5.2225	0.0874	**Constant**	6.2901**	11.586	0.0461
GDP_t	-0.7200**	0.0545	0.0564	**D(GDP_t)**	-0.2200**	-4.035	0.0412
ENC_t	1.2851**	11.0654	0.0020	**D(ENCt)**	1.2851**	11.065	0.0487
ENC_t(-1)	-0.777**	0.1360	0.0397	**F-stat.**	4.1257		
ECM(-1)	-0.1787**			**R^2**	0.5176		
F-stat.	459.70						
R^2	0.9881						

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

According to my calculations, the impact of energy consumption is time variant on carbon dioxide emission and statistically significant at 5% level in the short term. It means that a 0.17% increase in economic growth is linked with 1% decrease in lag of energy consumption. It may refer to energy efficiency change because using less energy to produce the same value.

The negative and statistically significant impact of GDP on carbon dioxide emissions is found. To reach higher GDP, more products and services are produced which processes are less polluting the environment. It does not necessarily mean that more energy is needed. The production is also affected by the applied technology and energy structure.

The error correction term is -0,1787 which is negative and significant meaning that there is a long run causality running from independent variables (energy consumption, carbon dioxide emissions) to dependent variable (economic growth). It can also be said that the speed of adjustment towards long-run equilibrium is 17.87% percent annually. Therefore, the system corrects its disequilibrium from the previous period by 17.87% to the next period to creates equilibrium again.

Bildirici and Kaicki (2013) also calculated the error correction term for Hungary with similar results. In their study, ECT coefficient range from -0.13 to -0.19 for Hungary, Czech Republic, Romania and Slovakia which indicates that the speed of adjustment is rather slow (5 to 7 years).

In the long run, we can see a similar relationship between variables as previously described. The impact of energy consumption is negative on GDP and statistically significant at 5% level and the impact of energy consumption is positive on carbon dioxide emissions keeping other things constant. However, the links between energy consumption and carbon dioxide emissions differ in the short and long run.

3.4 Stability tests

To check the stability of the model, a visual examination of the recursive parameter estimates is available. The CUSUM test provides to show the null hypothesis of model stability.

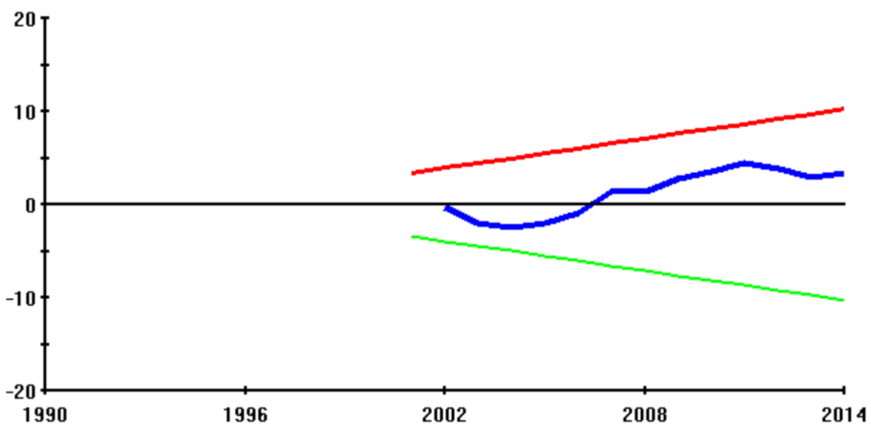

Figure 1
Plot of the cumulative sum of recursive residuals
Note: The straight lines represent critical bounds at 5% significance level

Under the null hypothesis of coefficient constancy, the values of the sequence outside of an expected range suggest a structural change in the model over time (Mathworks.com, 2017).

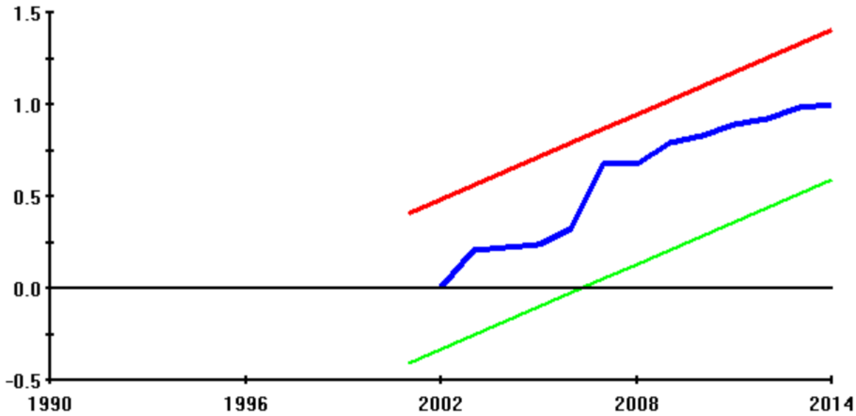

Figure 2
Plot of the cumulative sum of squares of recursive residuals
Note: The straight lines represent critical bounds at 5% significance level

Figure 2. and Figure 3. illustrates the stability results. As we can see, both plots are moving inside the critical bounds. So far all in comparison it concludes that there are cointegration vectors between variables. Solarin-Shahbaz (2013) identify that in the presence of structural break, the ARDL bounds testing may become unreliable. This problem is eliminated by using Gregory-Hansen structural break cointegration test to investigate cointegration.

3.5 Gregory-Hansen structural break test

Table 7 presents the results of Gregory-Hansen test.

Table 7
Gregory-Hansen structural break cointegration test

Estimated models	ADF test	Time Break
$F_{CO2}(CO2_t \| GDP_t, EC_t)$	-3,35**	2004
$F_{GDP}(GDP_t \| EC_t, CO2_t)$	-5,07*	1996
F_{EC} $(EC_t \| GDP_t, CO2_t)$	-5,81**	2005

Note: *, **, and ***show significance at 1%, 5%, and 10% respectively. Critical values for ADF test are - 5,77, - 5,28, and -5,02. Lag lengths are decided by evaluating Akaike Information Criterion (up to maximum 4 lag length).

As we can see, the null hypothesis of no long-run relationship is rejected according to carbon dioxide emissions, economic growth, and energy consumption as dependent variables. The structural breaks occurred in the first half of the 2000s in the series of carbon dioxide emissions and energy consumption while in case of economic growth the structural break year can be found in the middle of 1990s.

4. Conclusion and future directions

The present study investigates causality between carbon dioxide emissions, economic growth, and energy consumption, in case of Hungary over the period of 1990-2014 by annual data.

I tested the stationarity properties by using the Zivot-Andrews unit root test. I assumed structural break in the time series therefore also Gregory-Hansen structural break cointegration test, and ARDL bounds testing approach has been applied to analyze the relationship between variables in the presence of structural break. The structural breaks occurred in the first half of the 2000s in the series of carbon dioxide emissions and energy consumption while in case of economic growth the structural break year can be found at the middle of 1990s.

The results suggest that two models should be involved cointegration vectors. The diagnostic tests indicate that the error term is free from serial correlation and homoscedasticity exists. The findings for ARDL bounds testing approach demonstrate the existence of cointegration for long-run relationship between carbon dioxide emissions, economic growth and energy consumption.

The impact of energy consumption is time variant on carbon dioxide emissions and statistically significant in the short and long term. The relationship between carbon dioxide emissions and energy consumption differs in the short run. With lags, increasing in energy consumption results decline in carbon dioxide emissions while in level increasing in energy consumption is linked with increases in economic growth. The economic growth also has an important role in carbon dioxide emissions over the period of 1990-2014 in Hungary. Its increasing supports to mitigate carbon dioxide emissions in the short and long run.

The conclusion is that economic growth and energy consumption have an important role in the forecast of carbon dioxide emissions. The economic growth of the country can contribute to the reduction of the carbon dioxide emissions rates in the short and long run. Therefore, the growth-oriented policy is recommended in the future. These findings may contribute to widen literature sources and policymakers to plan energy management and growth policies. In the following research, I would like to support forecasts by testing a causal relationship between carbon dioxide emissions, economic growth, and energy consumption.

References

1. Acaravci, A., Ozturk, I. (2010): On the Relationship between Energy Consumption, CO2 Emissions and Economic Growth in Europe. Energy, 35(12), 5412-5420. http://www.sciencedirect.com/science/article/pii/S0360544210003737
2. Acaravci, A., Ozturk, I. (2010b): The causal relationship between energy consumption and GDP in Albania, Bulgaria, Hungary and Romania: Evidence from ARDL bound testing approach. Applied Energy, Volume 87, Issue 6. Pages 1938-1943 http://www.sciencedirect.com/science/article/pii/S0306261909004383
3. Al-Iriani, M. (2006): Energy–GDP relationship revisited: an example from GCC countries using panel causality. Energy Policy. 34 (17), pp. 3342–3350. DOI: 10.1016/j.enpol.2005.07.005
4. Aqeel, A.- Butt, M.S. (2001): The relationship between energy consumption and economic growth in Pakistan. Asia Pac. Dev. J. 8(2). pp. 101–110. http://www.sciencedirect.com/science/refhub/S2352-4847(15)00013-X/sbref9
5. Belke, A. – Dobnik, F. - Dreger, C. (2011): Energy consumption and economic growth: New insights into the cointegration relationship. Energy Economics. http://faculty.smu.edu/millimet/classes/eco6375/papers/belke%20et%20al%202011.pdf
6. Bildirici, M.E.- Kayikci, F. (2012): Economic growth and electricity consumption in emerging countries of Europe: An ARDL analysis.
7. Chen, S.-T., Kuo, H.-I., Chen, C.-C., (2007). “The relationship between GDP and electricity consumption in 10 Asian Countries”. Energy Policy 35, 2611–2621. https://www.sciencedirect.com/science/article/pii/S0301421506003685
8. Liddle, B.- Lung, S. (2014): Might electricity consumption cause urbanization instead? Evidence from heterogeneous panel long-run causality tests. Global Environmental Change 24, 42–51. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2237749
9. Chen, X. L.- Zhao, H. M.- Li, P. X.- Yin, Z. Y. (2006): Remote sensing image-based analysis of the relationship between urban heat island and land use/cover changes. Remote Sensing of Environment 104 (2). pp. 133–146. DOI: 10.1016/j.rse.2005.11.016
10. Dogan, E. –Seker, F. (2014): Determinants of CO2 emissions in the European Union: The role of renewable and non-renewable energy. https://sociorepec.org/publication.xml?h=repec:eee:renene:v:94:y:2016:i:c:p:429-439&l=en
11. Engle, R.F., Granger, C.J., (1987): Cointegration and error-correction: representation, estimation and testing. Econometrica 55, 251–278.
12. Groningen Growth an d Development Centre (2018): The database.
13. Kraft, J; Kraft, A., (1978): On the Relationship between Energy and GNP. Journal of Energy and Development 3, 401-403. http://www.sciepub.com/reference/68265
14. Liddle, B- Lung, S. (2014): Might electricity consumption cause urbanization instead? Evidence from heterogeneous panel long-run causality tests. Global Environmental Change. Volume 24, January 2014, Pages 42-51. http://www.sciencedirect.com/science/article/pii/S0959378013002215
15. MATHWORKS.COM (2017): Econometrics toolbox. https://www.mathworks.com/help/econ/cusumtest.html,%20http://www.sciencedirect.com/science/article/pii/S0165176508000293)
16. Marbuah, G. (2013): Understanding Crude Oil Import Demand Behaviour in Ghana. http://encuentros.alde.es/anteriores/xviieea/trabajos/m/pdf/35.pdf
17. Mazur, A.- Phutkaradze, Z.- Phutkaradze. J. (2017): Economic Growth and Environmental Quality in the European Union Countries – Is there Evidence for the Environmental Kuznets Curve?.. International Journal of Management and Economics

No. 45, January–March 2015, pp. 108–126; http://www.sgh.waw.pl/ijme/ https://www.degruyter.com/downloadpdf/j/ijme.2015.45.issue-1/ijme-2015-0018/ijme-2015-0018.pdf
18. Michieka, Ny.M.- Fletcher, J.J. (2013): An investigation of the role of China's urban population on coal consumption. Energy Policy. Volume 48. pp. 668–676. DOI: 10.1016/j.enpol.2012.05.080
19. Narayan, P.K. (2005): The saving and investment nexus for China: evidence from cointegration tests. Appl. Econ.37,1979–1990.
20. Öztürk, Ý.- Acaravci, A. 2010. The causal relationship between electricity consumption and GDP in Albania, Bulgaria, Hungary and Romania: evidence from ARDL bound testing approach. Applied Energy 87:1938-43.
21. Perron, P., 1989. The great crash, the oil price shock, and the unit root hypothesis. Econometrica.
22. Pesaran, M.H., Shin, Y., Smith, R. (2001): Bounds testing approaches to the analysis oflevel relationships. J. Appl. Econom. 16, 289–326. 57 (6), 1361–1401.
23. Poumanyvong, P.- S. Kaneko (2010): Does urbanization lead to less energy use and lower CO2 emissions? A cross-country analysis. Ecological Economics. 70(7). pp. 434-444. DOI: 10.1016/j.ecolecon.2010.09.029
24. Saidi, K – Mbarek, MB (2017): The impact of income, trade, urbanization, and financial development on CO2 emissions in 19 emerging economies. Environ Sci Pollut Res Int. 2017 May;24(14):12748-12757. https://www.ncbi.nlm.nih.gov/pubmed/26903128
25. Shahbaz, M.- Shamim, S.M.A.- Aamir, N. (2010): Macroeconomic environment and financial sector's performance: econometric evidence from three traditional approaches. Journal of Financial Economics (8). pp. 103–123. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1610029
26. Shahbaz, M.- Lean, H.H. (2012): Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia Energy Policy. Volume 40. pp. 473–479. DOI: 10.1016/j.enpol.2011.10.050
27. Shahbaz, M.- Solarin, S.A.- Mahmood, H.- Arouri, M. (2013): Does financial development reduce CO 2 emissions in Malaysian economy? A time series analysis . Economic Modelling (35). pp. 145-152. DOI: 10.1016/j.econmod.2013.06.037
28. Stolyarova (2013): Carbon Dioxide Emissions, economic growth and energy mix: empirical evidence from 93 countries. http://econpapers.repec.org/paper/ekd004912/5433.html
29. Simelyte, A.- Ducedziciuté, G. (2017): Consumption of Renewable Energy and Economic Growth. CONTEMPORARY ISSUES IN BUSINESS, MANAGEMENT AND EDUCATION'2017. http://cbme.vgtu.lt/index.php/verslas/2017/paper/viewFile/48/90
30. Wang, Y. – Hayashi, Y. – Chen, J. – Li, Q. (2014): Changing Urban Form and Transport CO_2 Emissions: An Empirical Analysis of Beijing, China. *Sustainability*, Volume *6*, pp. 4558-4579. http://www.mdpi.com/2071-1050/6/7/4558
31. World Bank (2018): CO2 emissions in kt in Hungary. Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States. https://data.worldbank.org/indicator/EN.ATM.CO2E.KT?locations=HU
32. World Bank (2018): Energy use in Hungary. https://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE?end=2015&locations=HU&start=1974

33. Zivot, E., Andrews, D. (1992): Further evidence of great crash, the oil price shock andunit root hypothesis. J. Bus. Econ. Stat. 10, 251–270.