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Does Renewable Energy Increase Growth? Evidence from EU-19 Countries

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ABSTRACT

The relationship between renewable energy consumption (REC) and economic growth has constituted a substantial field of research. Particularly, examining the significance of causality direction between the two variables is of high significance, since it may provide valuable insights for policy-makers. In this study the causality between REC and economic growth was investigated for 19 EU countries by using Rolling Windows Granger Causality Test for the 1994–2015 periods. Empirical findings show that REC Granger caused economic growth at 2001, 2002, 2003 and 2014 years. Economic growth Granger cause REC at 2004, 2005 and 2007 years. As can be understood from the results, the direction of the causality relationship between variables changes in different time periods. Empirical results have important policy implications for EU-19 Countries.

Keywords: Economic Growth, Renewable Energy Consumption, Europe Union
JEL Classifications: O47, O13, O52

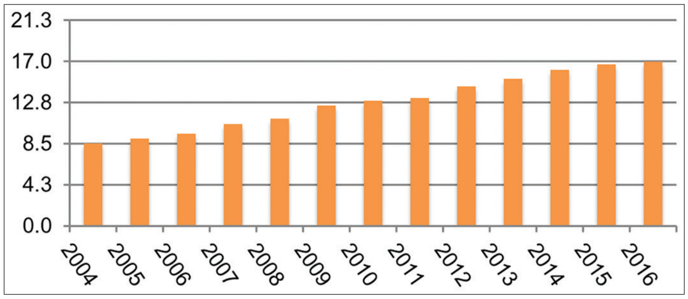
1. INTRODUCTION

In recent years, with the key role of energy in industrialization whole of World is witnessing a wave of development and rise of economies that have experienced a rapid increase in trade, income and energy consumption (Hassine and Harrathi, 2017). The raising of energy consumption in the developed and developing countries lead to two major problems: First problem is the reduction of the most easily accessible energy resources and the other problem is global warming which is caused by the rapidly increasing emissions of greenhouse gases. These problems require that renewable energy resources be appropriately managed and used.

Renewable energy is commonly defined as energy generated from solar, wind, geothermal, tide and wave, wood, waste, and biomass. With this aspect, these energy sources are clear, safe and inexhaustible contrarily to conventional energy (Apergis and Danuletiu, 2014). These properties of renewable energy sources are causing increase the countries' investments in this sector. According to Eurostat Statistics (2018); EU countries agreed in 2014 on a new renewable energy target which is aim the increasing the renewable energy consumption (REC) share in total consumption at least 27% by 2030. Europe Union member 28 countries were product 211 toe renewable energy in 2016. The renewable energy supply increased to 5.3% average per year between 2006 and 2016, the total increase is 66.6% for this period (Eurostat, 2018).

EU countries have steadily increased the share of renewable energy in gross final energy consumption from 2004 to 2016 (Figure 1). Renewable energy investments play a major role at this increase. According to the Global Trends in Renewable Energy Investment Report (2018), Europe accounted for 45% of global total renewable energy investments in 2011, but in 2017 this share decreased to 15%. The investments of the countries on renewable energy sources cause providing the development of alternative resources. Thus, income increase is achieved by

Figure 1: The share of renewable energy in gross final energy consumption % for EU-28



Source: Eurostat Statistics 2018 (https://ec.europa.eu/)

decreasing energy costs which is an important input for the product. Therefore, the relationship between REC and economic growth is remarkable to investigate.

2. REVIEW OF LITERATURE

In many studies which were investigated the relationship between REC and economic growth, it was concluded that there is a relationship between the variables. Sadorsky (2009) has estimated two empirical models of REC and GDP for emerging economies. Empirical results show that increases in GDP have a positive and statistically significant impact on REC. In the long term, a 1% increase in real income per capita increases the consumption of renewable energy per capita in emerging economies by approximately 3.5%. The findings show for long run that the renewable energy per capita consumption price elasticity estimates are approximately equal to −0.70. Apergis et al. (2010) have investigated the causal relationship between CO_2 emissions, nuclear energy consumption, REC, and economic growth for 19 developed and developing countries for the period 1984–2007 using a panel error correction model. The long-run estimates indicate that there is a statistically significant positive relationship between emissions and REC. According to the authors, this may be due to the lack of satisfactory storage technology to overcome irregular supply problems.

Apergis and Danuletiu (2014) have investigated long-run causality between renewable energy and economic Growth for 80 countries with Canning and Pedroni (2008) long-run causality test. According to the empirical findings; there is strong evidence that there is bidirectional causality between REC and economic growth. Beside this renewable energy has a key role on economic growth; on the other hand, economic growth increases the use of renewable energy sources. Sebri and BenSalha (2014) used ARDL and Granger causality tests for examined to relationship renewable energy and Economic Growth for BRICS members. Their findings are shown that bidirectional causality between variables. Bakırtas and Cetin (2016) have investigated the relationship between renewable energy and economic growth for G20 countries for the period of 1992–2010. Authors have used Panel cointegration tests and estimators. Empirical findings are shown there is a long run cointegration between renewable energy and economic growth. And there is causality from Economic Growth to Renewable Energy for the period of 1992–2010.

Bhattacharya et al. (2016) have used panel cointegration, panel DOLS, FMOLS estimator and panel causality tests for investigating effects of REC on the economic growth of major renewable energy consuming countries in the World. According to findings are that there is evidence of long-run dynamics between economic growth, and traditional and energy-related inputs. Therewithal findings for long-run output elasticities indicate that REC has a positive impact on the economic output.

Özşahin et al. (2016) try to determine the relationship between REC and economic development for BRICS countries and Turkey in the period of 2000-2013 in their study. According to the study, there is a positive long-run relationship between REC and economic development. Inglesi-Lotz (2016) has investigated the impact of the REC to economic growth for 34 countries-members of OECD. Findings show that there is a statistically significant positive effect of REC to economic growth. Menyah and Wolde-Rufael (2010) explore the causal relationship between carbon dioxide (CO_2) emissions, renewable and nuclear energy consumption and real GDP for the US for the period 1960–2007. Using a modified version of the Granger causality test, findings show that there is causality from growth to REC. Tugcu et al. (2012) have investigated the long-run and causal relationships between renewable and non- REC and economic growth for G7 countries at 1980–2009 period. Findings are show that both renewable or non- REC is important for economic growth.

Lin and Moubarak (2014) have examined the relationship between REC and economic growth in China for the period 1977–2011. The results show that there is a bi-directional long term causality between REC and economic growth. According to authors, this finding implies that the growing economy in China is propitious for the development of the renewable energy sector which in turn helps to boost economic growth. Ocal and Aslan (2013) have researched the REC –economic growth causality for Turkey using the ARDL and Toda–Yamamoto causality tests. The findings of ARDL approach show that REC has a negative impact on economic growth, and according to Toda–Yamamoto causality tests, there is unidirectional causality from economic growth to REC. Ntanos et al. (2018) have examined the relationship between REC and growth for 25 EU countries for the period from 2007 to 2016 by using descriptive statistics, cluster analysis, and ARDL methods. The results show that a correlation between GDP and both renewable energy sources and non- renewable energy sources energy consumption. Shahbaz et al. (2015) have investigated the relationship between REC and economic growth for Pakistan. In this study, the ARDL model and rolling window approach were used for the period 1972Q1–2011Q4 with quarterly data. According to results that long-run relationship between the variables. The causality analysis shows that there is bidirectional causality between economic growth and REC.

3. DATA AND MODEL

3.1. Data

Annual data from 1994 to 2015 were obtained from the World Bank Development Indicators, for 19 EU countries are included in the analysis[1]. This study has investigated, the relationship between the income per capita (constant 2011 US$) and REC which is the share of renewables energy in total final energy consumption with annual data. To see the correlation between variables and descriptive statistics of variables look at the Appendix Tables 1 and 2. The natural logarithm of the variables which is seen in Table 1 was used in model.

3.2. Model

In this study, empirical model have investigated for long-run as follows (denoted by the small letters);

$$lnGDP_{it} = \alpha_i + \beta_{1i} + ln\ REC_{it} + \varepsilon_{it}$$

Where GDP is the gross domestic product per capita (constant 2011 US$) and REC is the share of REC to total energy consumption, β_0, β_1, represent the slope coefficients, *i* represent cross section (EU-19 countries), *t* is the time period (1994–2015) and ε is the error term.

4. EMPIRICAL RESULTS

It is necessary to apply some preliminary tests for the panel before starting the econometric analyzes to determine the causality relationship between variables. For this reason, primarily the cross section dependency tests developed by Pesaran (2004) CD_{LM}, Breusch and Pagan (1980) CD_{LM1}, Pesaran (2004) CD_{LM2} were used for cross section dependency; and the homogeneity test developed by Pesaran and Yamagata (2008) were used to test whether the slope coefficients are homogeneously distributed for the EU-19 countries in the panel.

According to the homogeneity test results developed by Pesaran and Yamagata (2008), slope coefficients are heterogeneously distributed. And it seems interdependency between countries by cross section dependency tests developed by Pesaran (2004) CD_{lm}, Breusch and Pagan (1980) CD_{lm1}, Pesaran (2004) CD_{lm2} (Table 2).

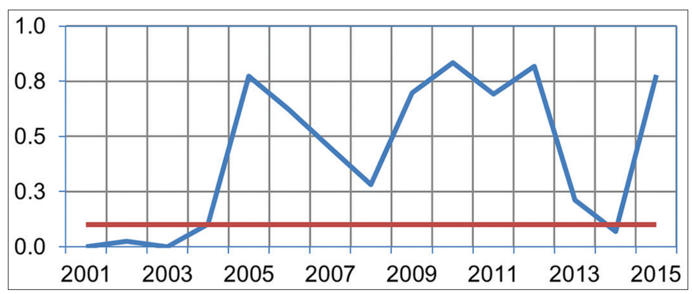
Through the assumption of the cross section dependency, which is also assigned to the mutually interdependent among the countries, the stationarity of the variables will be investigated by 2nd generation unit root tests. The CADF test within the 2nd generation unit root tests allows for stability testing both for all panel and also for each country in the panel separately. On the other hand, the CADF test is that it can be used in both when the time dimension bigger than cross section dimension (T>N) and the cross section dimension bigger than time dimension (N>T). The CADF test hypothesis is as follows;

H_0: Serial has a unit root, so it is not stationary.
H_1: Serial, has not got a unit root, so it is stationary.

According to CADF tests results (Table 3) for GDP variable, it seems that Austria, Czech Republic, Germany, Netherlands, Portugal, and UK have unit root at constant. On the other hand, Bulgaria and Netherlands have unit root at the constant and trend. And according to CIPS statistics which is the average of the CADF, all panel has unit root at constant. For REC variables Belgium, Romania and UK have unit root at constant. Czech Republic, Denmark and Spain have unit root at constant, and trend model.

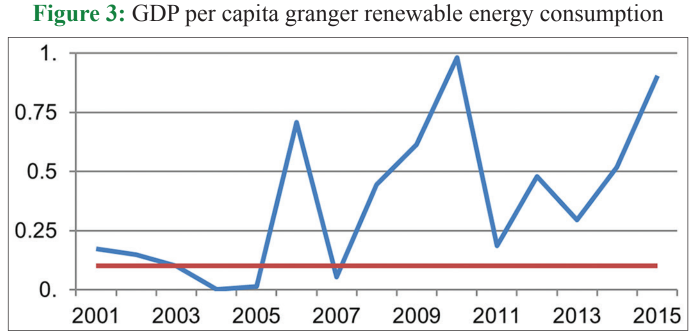
Structural changes can be pre-defined and included in the estimation using a variety of techniques, such as using of dummy variables. However, these techniques bring about the disadvantage of pre-test bias (Ming-Hsien and Chih-She, 2015). Two important reasons verify the use of the rolling estimation. First, the rolling window regressions accept that the causal relationship between variables changes over time. Secondly, the rolling estimation can observe instability across different sub-samples due to the presence of structural changes (Yang and Wu, 2015). The final step of the studied relationship between REC and GDP was investigated by Rolling Windows Granger Causality Test. In this approach initially, Granger causality is conducted using first sub-sample of T observations where T is the size of rolling window. Then the first observation is deleted from the sub-sample, and a new time

Figure 2: Renewable energy consumption granger GDP per capita



Source: Prepared by author

Figure 3: GDP per capita granger renewable energy consumption



Source: Prepared by author

1 EU-28 members Croatia, Cyprus, Estonia, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta and Slovenia are not included in the analysis due to lack of data.

Table 1: Variables used in study

Variable name	Acronym	Calculation	Database	Period
Income per capita	GDP	GDP/population	World Bank	1994–2015
REC	REC	Renewables energy consumption/ total final energy consumption	World Bank	1994–2015

Table 2: Cross-section dependency and homogeneity tests

Regresyon modeli	Statistic	P value
$lnGDP_{it} = \alpha_i+\beta_{1i}+ln\ REC_{it}+\varepsilon_{it}$		
Cross-section dependency tests		
LM (BP, 1980)	786.276	0.000
CD_{lm} (Pesaran, 2004)	33.270	0.000
CD (Pesaran, 2004)	17.580	0.000
LM_{adj} (PUY, 2008)	22.932	0.000
Homogeneity tests		
$\tilde{\Delta}$	22.223	0.000
$\tilde{\Delta}_{adj}$	24.451	0.000

Table 3: CADF tests results for GDP and rec variables

GDP	Constant		Constant and trend	
	Lags	CADF-stat	Lags	CADF-stat
Austria	1.000	−3.658**	1.000	−3.218
Belgium	1.000	−1.143	1.000	−1.178
Bulgaria	4.000	−7.758	4.000	−10.672***
Czech Republic	2.000	−3.211*	4.000	−1.453
Denmark	2.000	−2.272	2.000	−2.046
Finland	1.000	−0.564	1.000	−2.712
France	1.000	−2.748	4.000	−3.466
Germany	1.000	−3.276*	1.000	−3.447
Greece	3.000	−1.421	4.000	−0.072
Italy	2.000	−1.203	4.000	0.374
Netherlands	1.000	−4.419***	1.000	−4.125**
Norway	4.000	−0.366	4.000	−0.475
Poland	1.000	−1.106	1.000	−2.165
Portugal	2.000	−3.381**	2.000	−2.376
Romania	4.000	−2.021	4.000	−0.580
Slovak Republic	4.000	−2.093	4.000	−0.288
Spain	4.000	−2.789	4.000	0.612
Sweden	2.000	−0.972	2.000	−0.909
United Kingdom	1.000	−3.463**	1.000	−3.224
	CIPS-stat = −2.519**		CIPS-stat = −2.180	
REC				
Austria	2.000	−1.737	1.000	−3.028
Belgium	1.000	−3.681**	1.000	−2.366
Bulgaria	1.000	−2.426	1.000	0.038
Czech Republic	2.000	−2.612	1.000	−5.700***
Denmark	1.000	−0.846	3.000	−3.631*
Finland	1.000	−1.853	1.000	−1.828
France	1.000	−0.577	1.000	−2.874
Germany	1.000	0.299	1.000	−3.190
Greece	2.000	−0.922	2.000	−2.556
Italy	1.000	−2.507	1.000	−2.098
Netherlands	1.000	0.129	1.000	−1.056
Norway	1.000	−2.953	2.000	−2.225
Poland	1.000	−2.163	1.000	−2.100
Portugal	1.000	−1.734	3.000	−2.154
Romania	1.000	−6.335***	1.000	−5.834
Slovak Republic	4.000	−1.807	1.000	−2.972
Spain	1.000	−0.752	1.000	−3.720*
Sweden	1.000	−2.647	1.000	−2.554
United Kingdom	1.000	−3.047*	1.000	−3.390
	CIPS-stat = −2.009		CIPS-stat = −2.802*	

observation is added to the end of the observations, and the Granger causality test is repeated with the new sub-sample. Obviously, the size of the sub-sample is fixed over time, and this rolling regression procedure will continue until the last observation is used (Tang and Abosedra, 2016). In this study, the first seven observations were used for Rolling Windows approach. Then, unit root test was performed for each data according to the same procedure and the Granger causality test was applied.

Figure 2 presents the rolling bootstrap P values of LR-statistics estimated using subsamples data. The alternative hypothesis that REC causes economic growth can be accepted at 10 percent significance level for EU-19 countries at 2001, 2002, 2003 and 2014 years. According to Rolling Windows Granger Causality Tests; the causality between variables are changing over time (Appendix Table 3).

Figure 3 represents the rolling bootstrap p-values of LR-statistics estimated using subsamples data. The null hypothesis that REC doesn't cause economic growth was rejected at 10 percent significance level for EU-19 countries at 2004, 2005 and 2007 years. These results are shown by graphic above. For this reason, P > 0.1 (part above the red line) are ignored (Appendix Table 3).

5. CONCLUSION AND POLICY IMPLICATIONS

The European Union is trying to create policies for its concerns such as energy imports dependence, resource security, climate change caused by people and the threat of abduction of the future global technology market. The Council of Europe and its Parliament therefore adopted the White Paper (White Paper for a Community Strategy and Action Plan) in December 1997. In this paper, concrete targets identified which were promoted renewable energy production. 3 years after the White Paper, Green Paper (Towards a European Strategy for the Security of Energy Supply) was adopted in 2000. In the final report of the Green Paper in 2002, it was concluded that renewable energy sources have an important potential for resource security in Europe, but it would require considerable political and economic efforts to increase its use (Altuntaşoğlu, 2005). Due to the European Union's efforts in this respect, the causal relationship between renewable energy and economic growth has been the main motivation of this study. In this context, this study was investigated the causal relationship between REC and economic growth for 19 EU countries by Rolling Windows Granger Causality Test for the period of 2001–2015.

The rolling-window technique uses a fixed-length moving window sequentially from the beginning to the end of the sample by adding one observation from ahead and dropping one from behind, where each rolling-window subsample includes l observations. In each step, the causality test to each sub-sample was applied, providing a (T−l) sequence of causality tests, as opposed to just one. Two important reasons justify the use of the rolling-window estimation. First, the rolling window adopts the view that the relationship between variables changes through time. Second, we observe instability across different sub-samples due to structural change and the rolling-window estimation captures this process (Nyakabawo et al., 2015). In this study, the Rolling Window's size is set to seven. According to the results, REC Granger cause economic growth at 2001, 2002, 2003 and 2014 years. Economic growth Granger cause REC at 2004, 2005 and 2007 years. Our empirical results have important policy implications for EU-19 Countries. Full sample granger causality test shows that there is causality from REC to economic growth at 5% significance level (Appendix Table 4).

Renewable energy has an important role in terms of reducing the energy dependency on energy exporting countries by meeting the energy demands with own domestic resources and minimizing the harm to the environment as a result of energy consumption. Therefore, the EU member states, which are energy importers, have initiated the ALTENER program, in 1992, to prevent global warming and to reduce dependence on foreign countries. In 2030, EU countries aim to increase the share of renewable energy resources in total energy consumption by 34%, with the latest updates. For this reason, EU countries need to develop environmentally friendly vehicles (green vehicles) that can be used especially in the transportation sector in order to meet the 2030 targets. The renewable energy sector, which will become an important economic sector in the future will guide EU policies by creating new technologies and employment.

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APPENDIX

Appendix Table 1: Descriptive statistics of variables

Statistics	GDP	REC	CS
Mean	4.484.050	1.075.568	1.354.031
Median	4.535.495	1.060.361	1.356.494
Maximum	4.813.469	1.781.029	1.567.894
Minimum	3.912.482	−0.027070	−0.522517
SD	0.195488	0.390076	0.119374
Skewness	−0.906088	−0.346364	−9.541.143
Kurtosis	3.370.282	2.856.880	1.481.048
Jarque-Bera	5.958.400	8.714.539	373057.1
Probability	0.000000	0.012813	0.000000

Appendix Table 2: Correlations between variables

Correlations			
	GDP	REC	CS
GDP	-	0.288256	
REC		-	0.065049
CS	0.114369		-

Appendix Table 3: Rolling windows granger causality tests results (Figures 2 and 3)

Date	Lag	REC≠>GDP		GDP ≠> REC	
		F-statistic	P value	F-statistic	P value
2001	1	22.2795	7.E-06***	0.87641	0.1735
2002	1	5.09828	0.0259**	2.12163	0.1481
2003	1	17.8429	4.E-05***	2.74346	0.1001
2004	1	2.71307	0.1019	11.7835	0.0008***
2005	1	0.08478	0.7714	6.12363	0.0146**
2006	1	0.24958	0.6182	0.14065	0.7083
2007	1	0.57365	0.4504	3.77700	0.0545*
2008	1	1.16717	0.2823	0.58984	0.4441
2009	1	0.15124	0.6980	0.25599	0.6137
2010	1	0.04394	0.8343	0.00055	0.9814
2011	1	0.15634	0.6932	1.77201	0.1855
2012	1	0.05339	0.8176	0.50442	0.4788
2013	1	1.56786	0.2128	1.10287	0.2956
2014	1	3.33315	0.0702*	0.41764	0.5193
2015	1	0.07880	0.7794	0.01474	0.9036

Appendix Table 4: Full sample granger causality tests results

Null hypothesis	Obs	F-statistic	P
REC does not granger cause GDP	380	4.94693	0.0267
GDP does not granger cause REC		2.08675	0.1494