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THE NEXUS OF BETWEEN CO2 EMISSION, ENERGY AND POPULATION: EVIDENCE FROM A PANEL OF G7 COUNTRIES

Absract

The present report is the main initiative of the G7 countries to investigate the linkages between renewable energy, population and CO2 emissions per capita between 1990 and 2014 with GDP and non-renewable power. The variables used according to the panel unit root test applied in the study are stationary at the first level. According to Pedroni cointegration test to investigate co-integration between variables, there is co-integration between variables. According to the Panel OLS, FMOLS and DOLS tests we use to determine the long-term coefficients of the variables, renewable energy consumption and energy production from renewable sources play a negative role in carbon absorption. It is observed that energy production and consumption, GDP and urban population have a positive effect on carbon emission. According to the results of the tests carried out in the study, it is seen that the increase of carbon in these countries is increasing in the GDP variable which is one of the indicators of the advanced levels of the countries. For all these reasons, G7 country managers should be the pioneers in using renewable energy, to move the whole world to the era of renewable energy and to minimize the environmental factors.

Keywords: Carbon emissions, Energy, G7, Panel Data

1. Introduction

The health's of the world, the environment and the well-being of the nations have been threatened with the increasing impact of today's intensifying air pollution. For these reason, it is necessary for man to take serious steps to protect nature. This reason underlining that global warming and climate change issues become the focus of our day's work. (Bilgili, Koçak, &

Bulut, 2016, s. 838-845). Along with increased carbon emissions, marine, oceans, all living and non-living assets are at risk. Carbon emissions caused by humans are also accompanied by climate changes. Both to avoid these changes and to reduce carbon emissions, either reducing carbon emissions or increasing the world's carbon absorption capacity (Ashfaq, Tariq Iqbal Khan, & Ali, 2018, pp. 437-451).

Environmental change is responsible for the welfare loss of people, the destruction of our resources, the shrinking of forests and agriculture (Shahbaz, Tiwari, & Nasir, 2013, s. 1452-1459). The increase in carbon emissions in the last thirty years has prompted people around the world to take precautions. The first priority of all countries on the planet is to protect the planet from environmental disaster. Consequently, it was aimed to control the carbon emissions of industrialized countries within the framework of treaties such as the United Nations Framework Convention, the Kyoto Protocol, the Marrakesh Treaties, the Bali Road Map, the Doha Amendment for the Kyoto Protocol and the Paris Convention (Ross, et al., 2016, pp. 363-370). Thus, many developed countries have started research and development work by allocating funds in order to increase the renewable energy resources.

Whether developed or emerging, energy has been shown to be one of the main actors of economic growth. However, the energy production of most countries is derived from traditional energy sources including oil, coal and gas. Consumption of these resources for energy production has also caused the greenhouse gas to spread to the atmosphere during the last ten years, in enormous amounts that could cause climate change and global warming. Although agreements have been made to keep carbon emissions under control, it has not been possible to fully pass conventional fuels in the face of low prices and easy acquisition of industrial countries. In other words, it is understood that countries ignore carbon emissions at the cost of strong growth (Cai, Sam, & Chang, 2018, s. 1001-1011).

Given that CO2 emissions are very closely in connection with human actions, the relationship between urbanization, economic growth, energy consumption, and Carbon dioxide emissions has received significant attention from scholars working across the environment sciences (Wang, Fang, & Wang, 2016, s. 505-515), (Wang, Zhou, Li, & Feng, 2016, s. 184-195). An expanding body of literature has employed a range of quantitative ways to find out the nature on the link involving growth and emissions In addition, recent a number of usually associated reviews (or just empirical studies including an internal literature review) in addition investigated these kind of intricate interactions among urbanization, economic growth, energy consumption as well as Carbon dioxide emissions (Wang, Li, & Fang, 2018, s. 2144-2159).

Considerable approach effects exist for research in which is targeted on the connection amongst urbanization, economic development, energy consumption, and Carbon dioxide emissions. Growth (via both speedy urbanization and economic development) is often a vital goal with regard to governments throughout the world and, examining the link among development and emissions is essential regarding policy and selection. Simply by looking at the links between these kinds of parameters, research workers could probably help with pinpointing whether it be in fact urbanization or economic development in which comprises the serious driver of energy usage and Carbon dioxide emissions accelerates around the world. If advancement leads to minimization in emissions for high-income countries, chasing urbanization development is going to have the effective side effects of mitigating global warming. in addition, if improvement enhances emission degrees in low-incomes nations, after that growth policy might give force for decrease in CO_2 emissions and alternate ways might be of interest, such as producing an eco-friendly and a circular economy to deal with these kinds of environment influences. If growth has tiny impact regarding emission levels, subsequently reduction of CO_2 pollution levels will probably be productive only if unique policies are designed in combination with those that boost improvement (Wang, Li, & Fang, 2018, s. 2144-2159).

Panel data analysis and time series analyzes are also used in existing studies in the literature. In these studies, the main theme of exploring the effects of renewable energy consumption, urbanization, population growth, agricultural value added and economic growth on carbon emissions through various econometric methods is brought to the fore. Cai et al. (2018) investigated the effects of renewable energy consumption and economic growth on carbon emissions in their work for the G7 countries. They have conducted causality and cointegration analysis using the data of G7 countries. They have come to the conclusion that efficient energy use strategies are used as policy to reduce carbon emissions. In another study, Liua et al. (2017) examined the effects of per capita renewable energy, agriculture and non-renewable energy factors on carbon emissions. Panel unit root tests and cointegration tests using the data of BRICS countries. As a result of the work, the increase of renewable energy sources and the strengthening of agricultural management have resulted. In another study, Ashfaq et al. (2018) tested Toda Yamamoto's approach to the impact of agriculture's added value on carbon emissions from coal-derived electricity, hydropower, renewable energy, forestry and vegetable fields. As a result of their work, all other factors, except for the coal-derived electricity variant, have come to the conclusion that carbon emissions can be reduced.

Despite the large number of studies still in progress in the literature, economists still do not find consistently correlations of macroeconomic variables and cointegration and causality of data in this area. For this reason, panel data analysis is used in many studies in order to make relations more stable (Cai, Sam, & Chang, 2018, s. 1001-1011). Few studies have been conducted on the relationship between agriculture land, renewable energy consumption, electric power consumption (kWh per capita), electricity production from oil, gas and coal sources, electricity production from renewable sources and on CO_2 emissions in G7 countries. To this end, the present document is to want to discover the link between urban population, renewable energy consumption, electric power consumption (kWh per capita), electricity production from oil, gas and coal sources, electricity production from renewable sources and CO_2 emissions in a panel of G7 countries from 1990 to 2014.Beyond the current literature, the article adds the following new contributions.

To our knowledge, this is the first time that urban population, renewable energy consumption, electric power consumption (kWh per capita), electricity production from oil, gas and coal sources, electricity production from renewable sources variables are used together. Other studies in the literature have used variables such as GDP, energy consumption and agricultural value added. Our primary goal in this work for the G7 countries is to influence carbon emissions in the above variables, as well as GDP and energy consumption. Thus, it is aimed to contribute to the investigation of the relationship between these variables and carbon release in the literature. Secondly, one more reason, in which conducts researchers to concentrate on the connect amongst power consumption and economic progress, could be the vision of sustainable improvement. The reality that lots of nations decided on preserving strength and cutting down CO2 emissions has amplified the attractiveness of energy usage associated research. For this reason, it is desired to investigate which variables in the G7 countries affect CO2 emissions between 1990 and 2014. The reason for the selection of G7 countries is that the world has the most CO2 emissions countries.

As the third, using these variables, Panel unit root test, Panel cointegration test (VECM) Granger causality and long-term forecasts will be made for G7 countries for the first time.The paper's rest will continue following the sequence. In section 2, the literature will be investigated in detail to assess the effects of variables such as urban population, renewable energy consumption, electric power consumption (kWh per capita), electricity production from oil, gas and coal sources, and electricity production from renewable sources, which are thought to be effective on carbon emissions. In section 3, information about the models, methods and data to be used in the study will be given. Section 4 discusses the experimental results and economic results of the study. In the last part, the article will be finished with the policy suggestion and discussion questions from the data obtained from the study.

2. Literature review on related topics

In latest decades, many econometrical studies have looked at the connections in between the carbon dioxide emissions and some other variables, like economic growth, energy (nonrenewable and renewable energy) consumption, capital, labor force, trade openness, foreign direct investment, and urbanization. According to the result of literature survey, the studies about the subject are shown in table 1 according to the date order. There are authors, variables, method, countries, time interval and results of the study in relation to studies in the table. This table also includes the work done with the G7 countries in the literature.

Table 1 A summary of picked literature.

Writer(s)	Factors	Process	Countries	Time	Conclusion
(Soytas & Sari, 2003)	EC, GDP[3]	VEC, Granger Causality	10 emerging market and G7	1950-1992	It has been found causality running from GDP to energy consumption
(Soytas & Sarı , 2006)	K, L, E[2]	Johansen and Juselius cointegration, Engle and Granger	G7	1960-2004	Granger causality was found between energy consumption and GDP in all G7 countries.
(Narayan, Smyth, & Prasad, 2007)	EC, Y, EP, RP[1]	OLS, DOLS, FMOLS	G7	1978-2003	The long-run residential demand for electricity is selling price elastic and revenue inelastic.
(Narayan, Narayan, & Prasad, 2008A)	EC, GDP[3]	SVAR	G7	1970-2002	It has been found that Electricity utilization has a statistically major positive influence on real GDP above short term.
(Narayan & Smyth, 2008B)	CAP, GDP[4]	OLS, DOLS, FMOLS, VAR	G7	1972-2002	It's been found that capital formation, electricity use, and genuine GDP are cointegrated which capital formation and energy usage Granger result in real output GDP positively inside the long term.
(Sadorsky, 2009)	RE, Y, CO2, ROP[5]	DOLS, FMOLS, SUR	G7	1980-2005	According to the results of the study, the increase in long term per capita GDP and per capita carbon emissions leads to an increase in per capita renewable energy consumption.

(Tugcu, Özturk, & Aslan, 2012)	Y, I, L, RD, HC, E[6]	ARDL, Causality analysis by Hatemi	G7	1980-2009	In the long run, renewable and non-renewable energy consumption has been found to be an important influence on economic growth.
(Chu & Chang, 2012)	NEC, OILC, RGDP, TWH[7]	Bootstrap-corrected causality	G6	1971-2010	The result of the study was found to be causality between nuclear energy consumption and GDP.
(Ajmi, Montasser, & Nguyen, 2013)	Y, E[8]	Hiemstra–Jones's nonlinear causality test, Kyrtsou–Labys tests.	G7	1960-2010	In the study, there is a causality from energy consumption to GDP for the UK, while for Canada, France, Japan and the United States, a bi-directional causality between these two variables has been determined.
Writer(s)	**Factors**	**Process**	**Countries**	**Time**	**Conclusion**
(Bilgili & Ozturk, 2015)	Y, K, L, Biomass[9]	Panel unit root analyses panel cointegration analyses, Conventional OLS and dynamic OLS analyses	G7	1980-2009	The conclusions show that the long-term elasticities of panel true GDP facts with regards to panel capital stock, panel human capital index and panel biomass usage are substantial and beneficial.
(Chang, Gupta, Lotz, & Kengne, 2015)	GDP and Renewable energy	Granger Causality	G7	1990-2013	In the study, causality was found among the variables.
(Chang M.-C. , 2015)	GDP, CO2	The environmental Kuznets curve hypothesis	G7 and BRICS countries	2000-2010	In this study Energy intensity level, emission severity, and carbonization amount do not satisfy the environmentally Kuznets curve theory.
(Ajmi, Hammoudeh, Nguyen, & Sato, 2015)	GDP, CO2	VAR, Granger Causality	G7	1960-2010	In this paper, were proposed a new method for estimating the time-varying values of the variables.
(Mutascu, 2016)	EC, GDP[1]	Bootstrap panel Granger causality	G7	1970-2012	In this study, Canada, Japan and the US have found a two-way causality relationship between GDP and energy use. In France and Germany have found that GDP causes energy consumption.
(Bildirici & Gökmenoğlu, 2017)	HEC, CE, Y[10]	Markov Switching-Vector Autoregressive (MS-VAR) and MS-Granger Causality	G7	1961-2013	According to analysis results, it was found that there was a bidirectional Granger causality between carbon dioxide emissions and economic growth in the regime
(Shahbaz, Shafiullah, Papavassiliou, & Hammoudeh, 2017)	GDP, CO2	Local Linear regression analysis and the environmental Kuznets curve	G7	Very Long Data	In this study, validate the existence of the environmental Kuznets curve in six of the G7 countries.
(Cai, Sam, & Chang, 2018)	RPGDP, CO2, CEC[11]	Bootstrap ARDL bounds test	G7	1965-2015	No cointegration between GDP, renewable energy and Co2 was found.

EC: Electric consumption per capita, Y: Real income per capita, EP: Real residential electricity price, RP: Real price of gas[1]

K: Capital stock, L: Total labor, E: Energy consumption, Y: Real output[2]

EC: Industrial electricity consumption, GDP: Real output[3]

CAP: Real gross fixed capital formation per capita, GDP: Real output[4]

RE: Renewable energy consumption per capita, Y: Real Gdp per capita, CO2: CO2 emissions per capita, ROP: Real oil Prices[5]
Y: Real income, I: Physical capital, L: Labor, RD: Research and development, HC: Human capital, E: Indicator of Energy consumption[6]
NEC: Nuclear Energy consumption, OILC: Oil consumption, RGDP: Real GDP, TW H: Terawatt hours[7]
Y: GDP, E: energy consumption[8]
Y: Reel GDP, K: Capital stock, L: Labor, BIOMASS: Country's biomass consumption[9]
HEC: Hydropower energy consumption, CE: The carbon dioxide emissions, Y: Real GDP[10]
RPGDP: Real GDP, CEC: Consuming Clean Enegy[11]

In addition to the work for the G7 countries given in the table above, there are studies in different countries or cities in the literature. For example; (Jaunky, 2011, s. 1228-1240), in the study, he tries to examine the Environment Kuznets Curve (EKC) theory for thirty-six high-income countries around the world for the time period 1980-2005.The exam was based on the recommendation of Narayan and Narayan (2010). A variety of panel data unit root and co-integration studies are usually employed. CO2 (Carbon dioxide) pollution levels and Gross domestic product variety are designed of order just one and co-integrated, specially following controlling for cross-sectional dependency. At the same time, the Blundell- bond process generalized techniques of moments (GMM) is used to conduct a panel causality test in a vector error-correction procedure (VECM) setting. Unidirectional causality running through real per capita GDP to per capita Carbon dioxide emissions is discovered in both the short-run and the long-run. In another study, in the (Baek, 2015, s. 133-138)'s article, data from 1980 to 2009 are used. The 12 countries' CO2 emissions, income, nuclear energy and energy consumption variables have been analyzed. In the study Panel analyzed cointegration and showed that nuclear energy production tended to reduce carbon emissions (BenJebli & Youssef, 2017, s. 295-301). In another study (BenJebli & Youssef, 2017, s. 295-301), he conducted Panel work using the data of 5 North African countries between 1980 and 2011. According to the results of the study, short-term Granger causality between CO2 emissions and agriculture has emerged. In addition, a one-way causality from agriculture to GDP and from GDP to renewable energy consumption has been found. Finally, one of the most up-to-date studies we found (Liu, Zhang, & Bae, 2017, s. 489-496), in study, the cointegration was found between 1992-2013 according to panel cointegration in the study using data from BRICS countries. Long-term per capita production and edible energy have been found to have a negative effect on CO2 emissions according to the elasticity interpretations. In the long run, no correct causality relationship has been found for CO2 emissions.

3. **Model, Methodology and Data**

Annual data from 1990 to 2014 were used in this study. All data used for the G7 (United States, UK, Japan, Italy, Germany, France and Canada) countries are taken from the World Bank. Analyze the effect of electric power consumption (kWh per capita), electricity production from oil, gas and coal sources, electricity production from renewable sources (excluding hydroelectric) as well as GDP and urban population on CO2 in the G7 countries the long-run multivariable equation can be constructed as follows:

$$CO2_{jn} = f\left(GDP_{jn}, REWEC_{jn}, EPC_{jn}, EPCOG_{jn}, EPREW_{jn}, URPOP_{jn,}\right) \quad (1)$$

All the variables are changed into logarithmic types, and then equation can be defined as follows:

$$lnco2_{jn} = \sigma_j + \theta_j n + \beta_{1j} lngdp_{jn} + \beta_{2j} lnrewec_{jn} + \beta_{3j} lnepc_{jn} + \beta_{4j} lnepcog_{jn} + \beta_{5j} lneprew_{jn} + \beta_{6j} lnurpop_{jn} + \varepsilon_{jn} \quad (2)$$

where co2 is CO2 emissions (metric tons per capita), gdp is real output, rewec and epc donate renewable energy consumption (% of total final energy consumption) and electric power consumption (kWh per capita), epcog is electricity production from oil, gas and coal sources (% of total), eprew is electricity production from renewable sources (excluding hydroelectric, % of total) and urpop is urban population (% of total).The definition and provenance of the chosen factors in the model are shown in the chart 2 below.

Table 2 The definition and provenance of chosen factors in the model.

Variables	Symbol	Unit	Definition measuring method	Data source
Carbon dioxide emissions	CO2	metric tons per capita	Carbon dioxide emissions are all those stemming through the burning of fossil fuels and the manufacture of cement. They include things like carbon dioxide made throughout usage of solid, liquid, and gasoline fuels and gas flaring.	World Development Indicators
Real output	GDP	Constant 2010 US$	Real GDP (Constant US$ 2010)	
Renewable energy consumption	REWEC	(% of total final energy consumption)	Renewable electrical power consumptions are classified as the share of renewables ability in full final electrical power consumption.	
Electric power consumption	EPC	kWh per capita	Electric power expenditure dimensions the production of power facility and linked heat and power facility minus transportation, dispersion, and complete change losses and own use by heat and power facility.	
Electricity production from oil, gas and coal sources	EPCOG	% of total	Resource of electricity term the entry used to produce electricity.	
Electricity production from renewable sources	EPREW	excluding hydroelectric, % of total	Electricity generation from renewable resource, not including hydroelectric, contain geothermal, solar, flux and reflux, flatus, biomass, and biofuels.	
Urban population	URPOP	(% of total)	City populace impute of men and women living in city spots as described by national statistical offices.	

3.1 . Panel Unit Root Test

In the unit root test known as the Augmented Dickey Filler (ADF), the series of short data sets are likely to reject the stationary hypotheses. Therefore; panel stationarity tests on this type of short data set provides us with more accurate results in terms of unit root test (Al-Iriani, 2006). For this reason, the variables that are used in the study will be tested by unit root test and at what level they are stationary. Panel unit root tests involving Levin-Li-Chu (LLC) (Levin , Lin , & Chu , 2002, s. 1-24), Im-Pesaran-Shin (IPS) W-statistics (Im , Pesaran , & Shin , 2003,

s. 53-57), Augmented Dickeye Fuller (ADF) and Phillips-Perron (PP) (Maddala & Wu, 1999, s. 631-652) tests will be applied in this study. The null hypothesis of the panel unit root tests that we will apply in the study is that the series is not stationary and unit root is present whereas the alternative hypothesis is the opposite and the series are stationary and unit root free. The LLC and panel-based ADF test assumes that the autoregressive (AR) process for all panel series is homogeneous. Axis assumes heterogeneous kernels between series groups. The ADF and PP tests we call Fisher type are based on parametric methods. This test assumes heterogeneity between the panel series and accepts the asymptotic chi-square distribution. Note that these two test delays are more sensitive to IPS selection than the length.

3.2 . Panel Co-integration Tests and Long-run Estimates

Many tests have been developed to use in panel data sets. In this study we will use the panel cointegration test to see if there is a long cyclic relationship between the series in our data set. First of all, we have to check each data for stability. The linear combination of stationarity-controlled series is not integrated or not. We use the panel cointegration test to measure long-run relationships of the series in which we are working to see it. We will use that a two-stage Engle-Granger (Engle & Granger, 1987, s. 251-276) basis and Kao residual co-integration test (Kao, 1999) put forward by Pedroni (Pedroni, 2000, s. 93-130).

Since we use heterogeneous panel data, we use the (Pedroni, 1999, s. 653-670) method to test cointegration in equation 2. (Pedroni, 1999, s. 653-670) residue co-integration is a two-stage test statistic. These are intra-dimension and inter-dimension statistics. First, the assumption of heterogeneity in each series is valid. This test gives us the results of panel V-statistics, panel p-statistics, panel pp-statistics and panel ADF statistics, which allows the collection of AR coefficients for each data set for cumulative root tests on the residues. The second test is p-statistic, group PP statistic and group ADF statistics. These seven statistics are constructed from the autoregressive coefficients of each country. We can estimate the homogeneous cointegration relation through pooled regression which allows constant effects using the Kao cointegration test to ensure accuracy and reliability. Assuming that the null hypotheses of both Pedroni and Kao cointegration tests are not cointegration between time series in the long run, alternative hypotheses assume that the series are cointegrated.

These seven tests in this method follow the regression given below:

$$\mathbf{y_{nt} = a_n + \partial_{nt} + \sum_j^k \gamma_{jn} x_{jnt} + \varepsilon_{nt}} \qquad (3)$$

where by t denotes time, and k signifies the amount of regressors. To check the approximated residuals, it can be required to run the following regression for each group:

$$\mathbf{e_{nt} = \rho_n e_{nt-1} + \mu_{nt}} \qquad (4)$$

Underneath the null hypothesis, all seven assessments haven't any cointegration $H_0: \rho_n = 1;\ \forall\ n$, we used while the alternative hypothesis is specified $H_1: \rho_n < 1;\ \forall\ n$.

In our work, we can test the cointegration of the series with the panel cointegration tests. However, we cannot estimate the long-term coefficients of these series. For this reason, we need to find the long-term values of the coefficients of the variables we used in Eq 2. We need to make FMOLS and DOLS regression estimates in order to obtain these coefficients in the study and to confirm long-run cointegration. These methods can correct prejudiced and unbalanced results of the least squares method (OLS). FMOLS and DOLS techniques can be used to eliminate possible internal and long-run correlations among the participants. These three methods are used for consistency and accuracy of the run.

3.3 VECM Granger Causality

We need to use the VECM Granger causality test to determine whether there is a cointegration between the panel time series data and the cointegration between these series and the causality between the variables used in the study. This causality approach is based on Engel and Granger (Engle & Granger, 1987), which investigate the causality of two time periods, the short and long term of the time series data used in the study. We will use this method when conducting the long-run analysis of the equation of the equation used in our study. We will examine the short-term causality using the dynamic VECM test based on the Wald test.

The VECM empirical equation we use in our study is as follows:

$$\begin{bmatrix} \Delta co2_{jn} \\ \Delta gdp_{jn} \\ \Delta rewec_{jn} \\ \Delta epc_{jn} \\ \Delta epcog_{jn} \\ \Delta eprew_{jn} \\ \Delta urpop_{jn} \end{bmatrix} = \begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \sigma_4 \\ \sigma_5 \\ \sigma_6 \\ \sigma_7 \end{bmatrix} + \sum_{p-1}^{q} \begin{bmatrix} \beta_{11p}\beta_{12p}\beta_{13p}\beta_{14p}\beta_{15p}\beta_{16p}\beta_{17p} \\ \beta_{21p}\beta_{22p}\beta_{23p}\beta_{24p}\beta_{25p}\beta_{26p}\beta_{27p} \\ \beta_{31p}\beta_{32p}\beta_{33p}\beta_{34p}\beta_{35p}\beta_{36p}\beta_{37p} \\ \beta_{41p}\beta_{42p}\beta_{43p}\beta_{44p}\beta_{45p}\beta_{46p}\beta_{47p} \\ \beta_{51p}\beta_{52p}\beta_{53p}\beta_{54p}\beta_{55p}\beta_{56p}\beta_{57p} \\ \beta_{61p}\beta_{62p}\beta_{63p}\beta_{64p}\beta_{65p}\beta_{66p}\beta_{67p} \\ \beta_{71p}\beta_{72p}\beta_{73p}\beta_{74p}\beta_{75p}\beta_{76p}\beta_{77p} \end{bmatrix} \begin{bmatrix} \Delta co2_{jn-1} \\ \Delta gdp_{jn-1} \\ \Delta rewec_{jn-1} \\ \Delta epc_{jn-1} \\ \Delta epcog_{jn-1} \\ \Delta eprew_{jn-1} \\ \Delta urpop_{jn-1} \end{bmatrix} + \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \\ \varphi_4 \\ \varphi_5 \\ \varphi_6 \\ \varphi_7 \end{bmatrix} ECT_{jn-1} + \begin{bmatrix} \mu_{1jn} \\ \mu_{2jn} \\ \mu_{3jn} \\ \mu_{4jn} \\ \mu_{5jn} \\ \mu_{6jn} \\ \mu_{7jn} \end{bmatrix} \quad (5)$$

Where $\Delta, p, ECT\ and\ \mu$ the respective markings are: 1. difference operator, delay length, error term and random error term. The q sign in the equation indicates the number of VAR delays. The coefficients $\sigma, \beta\ and\ \varphi$ indicate the fixed country effect, the short-term causality coefficient on the dependent variable, and the long-term corrected coefficient, respectively. The coefficient of ECT_{jn-1} is negative and this coefficient must be statistically significant. Thus, we can say that the equation has a long-run causality to the dependent variables from the three independent variables. While we use t statistics in long-run causality, we need to use F statistics in short-term causalities.

3.4 Details along with illustrative statistics

The data from 1990 to 2014, are preferred for electric power consumption (kWh per capita), electricity production from oil, gas and coal sources, electricity production from renewable sources (excluding hydroelectric), GDP, urban population and CO2 in the G7 countries. Definition and method to obtain preferred parameters in the model are listed in Table 2. The data for each country from 1990 to 2014 are defined in the following Table 3.

Table 3. The sum up statistics of G7 countries (before logarithm) from 1990 to 2014

Country	Variables	Mean	Median	Maximum	Minimum	Std, Dev,	Skewness	Kurtois	Jaque-Bera	Probability
France	CO2	5,89E+06	6,01E+06	6,67E+06	5,06E+06	4,25E-01	-5,99E-01	2,75E+06	1,50E+06	4,73E-01
	GDP	2,35E+12	2,41E+12	2,72E+12	1,91E+12	2,94E+11	-2,10E-01	1,50E+06	2,41E+06	2,99E-01
	URPOP	7,64E+06	7,63E+06	7,91E+06	7,41E+06	1,58E+06	1,74E-01	1,73E+06	1,72E+06	4,22E-01
	REWEC	1,03E+06	1,05E+06	1,34E+06	8,50E+06	1,26E+06	5,17E-01	2,88E+06	1,08E+06	5,82E-01
	EPC	7,11E+06	7,27E+06	7,73E+06	5,94E+06	4,92E+06	-7,29E-01	2,53E+06	2,35E+06	3,09E-01
	EPCOG	9,36E+06	9,36E+06	1,34E+06	7,03E+06	1,44E+06	6,48E-01	3,72E+06	2,19E+06	3,34E-01
	EPREW	7,06E+09	3,64E+09	2,60E+10	1,91E+09	7,26E+09	1,55E+06	4,13E+06	1,09E+06	4,21E-03
Germany	CO2	1,01E+06	1,00E+06	1,16E+06	8,82E+06	7,49E-01	1,83E-01	2,23E+06	7,57E-01	6,85E-01
	GDP	3,14E+12	3,18E+12	3,65E+12	2,57E+12	3,13E+11	-7,39E-02	1,88E+06	1,33E+06	5,14E-01
	URPOP	7,36E+06	7,33E+06	7,51E+06	7,31E+06	6,18E-01	1,21E+06	3,09E+06	6,06E+06	4,83E-02
	REWEC	5,94E+06	4,41E+06	1,34E+06	1,99E+06	3,84E+06	5,69E-01	1,84E+06	2,74E+06	2,54E-01
	EPC	6,82E+06	6,82E+06	7,28E+06	6,24E+06	3,64E+06	-1,00E-01	1,46E+06	2,50E+06	2,87E-01
	EPCOG	6,30E+06	6,28E+06	6,86E+06	5,67E+06	2,90E+06	-5,14E-02	2,53E+06	2,44E-01	8,85E-01
	EPREW	4,21E+10	2,14E+10	1,43E+11	1,67E+09	4,53E+10	9,22E-01	2,54E+06	3,76E+06	1,52E-01
Canada	CO2	1,62E+06	1,62E+06	1,75E+06	1,47E+06	8,28E-01	-1,28E-01	1,79E+06	1,60E+06	4,50E-01
	GDP	1,37E+12	1,41E+12	1,78E+12	9,93E+11	2,58E+11	-1,19E-01	1,63E+06	2,02E+06	3,64E-01
	URPOP	7,94E+06	7,99E+06	8,17E+06	7,66E+06	1,61E+06	-4,05E-01	1,86E+06	2,03E+06	3,63E-01
	REWEC	2,20E+06	2,19E+06	2,31E+06	2,10E+06	5,45E-01	4,40E-01	2,58E+06	9,96E-01	6,08E-01
	EPC	1,63E+04	1,64E+04	1,72E+04	1,53E+04	5,75E+06	-3,48E-01	2,15E+06	1,26E+06	5,33E-01
	EPCOG	2,38E+06	2,33E+06	2,90E+06	2,02E+06	2,67E+06	3,97E-01	1,93E+06	1,84E+06	3,98E-01
	EPREW	1,00E+10	8,46E+09	2,96E+10	3,95E+09	6,21E+09	1,81E+06	5,87E+06	2,23E+06	1,40E-05
Italy	CO2	7,37E+06	7,57E+06	8,22E+06	5,27E+06	7,55E-01	-1,29E+00	4,10E+06	8,18E+06	1,68E-02
	GDP	2,01E+12	2,06E+12	2,23E+12	1,75E+12	1,51E+11	-4,32E-01	1,90E+06	2,04E+06	3,61E-01
	URPOP	6,76E+06	6,74E+06	6,88E+06	6,67E+06	6,77E-01	4,22E-01	1,86E+06	2,10E+06	3,50E-01
	REWEC	7,77E+06	5,60E+06	1,71E+06	3,78E+06	4,07E+06	1,08E+06	2,75E+06	4,89E+06	8,69E-02
	EPC	5,13E+06	5,30E+06	5,83E+06	4,14E+06	5,50E+06	-4,32E-01	1,83E+06	2,20E+06	3,33E-01
	EPCOG	7,77E+06	8,05E+06	8,36E+06	5,55E+06	7,15E+06	-1,94E+06	5,98E+06	2,50E+06	4,00E-06
	EPREW	1,59E+10	8,80E+09	6,21E+10	3,28E+09	1,76E+10	1,65E+06	4,47E+06	1,37E+06	1,07E-03
Country	Variables	Mean	Median	Maximum	Minimum	Std, Dev,	Skewness	Kurtois	Jaque-Bera	Probability
Japan	CO2	9,41E+06	9,46E+06	9,91E+06	8,62E+06	3,33E-01	-7,41E-01	2,66E+06	2,41E+06	3,00E-01

	GDP	5,39E+12	5,38E+12	5,91E+12	4,68E+12	3,67E+11	-2,97E-01	1,94E+06	1,54E+06	4,64E-01
	URPOP	8,35E+06	8,16E+06	9,30E+06	7,73E+06	5,81E+06	3,79E-01	1,51E+06	2,92E+06	2,33E-01
	REWEC	4,17E+06	4,04E+06	5,53E+06	3,57E+06	4,66E-01	1,10E+06	3,93E+06	5,97E+06	5,04E-02
	EPC	7,96E+06	8,02E+06	8,71E+06	6,81E+06	5,17E+06	-8,23E-01	2,86E+06	2,85E+06	2,41E-01
	EPCOG	6,69E+06	6,45E+06	8,70E+06	5,83E+06	8,32E+06	1,59E+06	4,22E+06	1,21E+06	2,40E-03
	EPREW	2,16E+10	1,50E+10	6,35E+10	1,13E+10	1,40E+10	1,73E+06	4,90E+06	1,63E+06	2,96E-04
England	CO2	8,72E+06	9,04E+06	9,87E+06	6,50E+06	9,23E-01	-1,01E+06	2,87E+06	4,23E+06	1,20E-01
	GDP	2,15E+12	2,20E+12	2,64E+12	1,62E+12	3,44E+11	-2,58E-01	1,58E+06	2,37E+06	3,06E-01
	URPOP	7,96E+06	7,90E+06	8,23E+06	7,81E+06	1,42E+06	6,04E-01	1,90E+06	2,78E+06	2,49E-01
	REWEC	2,02E+06	1,03E+06	7,29E+06	6,08E-01	1,82E+06	1,59E+06	4,46E+06	1,28E+06	1,65E-03
	EPC	5,78E+06	5,82E+06	6,27E+06	5,13E+06	3,40E+06	-1,12E-01	1,62E+06	2,03E+06	3,63E-01
	EPCOG	7,27E+06	7,35E+06	8,02E+06	6,08E+06	4,25E+06	-8,15E-01	4,03E+06	3,88E+06	1,44E-01
	EPREW	1,31E+10	6,34E+09	5,94E+10	6,04E+08	1,56E+10	1,66E+06	4,98E+06	1,56E+06	4,15E-04
Usa	CO2	1,88E+06	1,93E+06	2,02E+06	1,63E+06	1,21E+06	-1,11E+06	2,68E+06	5,28E+06	7,15E-02
	GDP	1,28E+13	1,31E+13	1,62E+13	9,06E+12	2,35E+12	-2,88E-01	1,68E+06	2,17E+06	3,38E-01
	URPOP	7,90E+06	7,94E+06	8,14E+06	7,53E+06	1,85E+06	-5,31E-01	2,10E+06	2,02E+06	3,64E-01
	REWEC	5,86E+06	5,43E+06	8,93E+06	4,09E+06	1,55E+06	7,67E-01	2,27E+06	3,00E+06	2,23E-01
	EPC	1,30E+04	1,30E+04	1,37E+04	1,17E+04	5,47E+06	-7,53E-01	2,79E+06	2,41E+06	3,00E-01
	EPCOG	7,02E+06	7,03E+06	7,22E+06	6,75E+06	1,40E+06	-2,87E-01	1,89E+06	1,62E+06	4,44E-01
	EPREW	1,17E+11	8,18E+10	2,98E+11	6,19E+10	6,82E+10	1,49E+06	3,97E+06	1,03E+06	5,88E-03

Ahead of the empirical examination, it truly is necessary discover the normality in variable series through the use of dissimilar indicators (skewness, kurtosis and Jarque-Bera stats). The worth of Jarque-Bera chance was better than 5% in every single case which approved the normality in just about every variable collection. Soon after the affirmation of normality (Table 3), it is actually vital that we forecast the pairwise correlation coefficients. An optimistic coefficient show off the move of variables from the very identical aspect whilst the way is reverse for adverse coefficient of correlation. Table 3 displays which the multicollinearity wasn't a difficulty for chosen variables

Table 4 provides correlations for the panel info after transforming into logarithms. The per capita CO_2 emissions are most correlated with electric product consumption, followed by GDP, while GDP is most correlated with electric production from renewable positively. Renewable energy consumption has negative correlation with GDP, urban population and electric production from coil, oil and gas.

Table 4 After receiving the log of data, the panel verified correlation results.

	CO2	GDP	URPOP	REWEC	EPC	EPCOG	EPREW
CO2	1.000.000	0.387407	0.313277	0.120944	0.816964	0.293542	0.378435
GDP	0.387407	1.000.000	0.338983	-0.191739	0.235485	0.372331	0.724398
URPOP	0.313277	0.338983	1.000.000	-0.047096	0.481263	-0.089412	0.271137
REWEC	0.120944	-0.191739	-0.047096	1.000.000	0.532066	-0.561738	0.245894
EPC	0.816964	0.235485	0.481263	0.532066	1.000.000	-0.234680	0.349882
EPCOG	0.293542	0.372331	-0.089412	-0.561738	-0.234680	1.000.000	0.323687
EPREW	0.378435	0.724398	0.271137	0.245894	0.349882	0.323687	1.000.000

4. Empiric conclusions and analysis

The analysis conclusions of four panel unit root tests are introduced in Table 5. The lag length depends on automatic selection of Schwarz info criterion (SIC). The 4 panel tests all of the recognize the null hypothesis in the level part; when within the initial big difference section, all the p values under the 1% signification level claim that the seven-time series don't have stationary unit roots. That is, the series admit the alternate hypothesis of no unit roots within I (1).

Table 5 Panel unit root tests.

Variables	LLC		IPS		Fisher-Adf		Fisher-PP	
	Level	1st difference	Level	1st difference	Level	1st difference	Level	1st difference
Co2	4.7432 (1.000)	-6.10109 (0.000)***	5.52456 (1.000)	-9.02586 (0.000)***	5.80946 (0.9711)	96.7470 (0.000)***	5.57555 (0.9761)	120.284 (0.000)***
Gdp	-2.52534 (0.0058)	-7.06536 (0.000)***	0.47895 (0.6840)	-7.18800 (0.000)***	9.14627 (0.8216)	72.7355 (0.000)***	11.7006 (0.6303)	99.7088 (0.000)***
Urpop	0.85609 (0.8040)	-1.77841 (0.000)***	2.51177 (0.9940)	-1.04454 (0.000)***	9.39100 (0.8052)	17.7699 (0.000)***	26.5512 (0.0220)**	16.1554 (0.000)***
Rewec	3.32862 (0.9996)	-11.1268 (0.000)***	5.32714 (1.000)	-11.1498 (0.000)***	1.98335 (0.999)	116.449 (0.000)***	2.42574 (0.9997)	119.884 (0.000)***
Epc	-1.77995 (0.0375)	-7.95162 (0.000)***	-0.50042 (0.3084)	-6.89576 (0.000)***	14.6980 (0.3991)	79.3078 (0.000)***	22.1255 (0.0761)	100.548 (0.000)***
Epcog	4.21663 (1.000)	-4.20390 (0.000)***	3.53040 (09998)	-5.65953 (0.000)***	6.20444 (0.9611)	72.9165 (0.000)***	3.23957 (0.9986)	97.7971 (0.000)***
Eprew	1.52848 (0.9368)	-3.11051 (0.000)***	6.36664 (1.000)	-4.39564 (0.000)***	1.60573 (1.000)	48.2147 (0.000)***	1.63041 (1.000)	67.8095 (0.000)***

Information: The optimum lag length choice is based upon SIC automatically. P-values are shown in parentheses.

*** At the 1% significant level. ** At the 5% significant level.

All variables used in our study are stationary at I (1) level as a result of unit root tests. CO2 emissions, GDP, urban population, renewable energy consumption, electricity production consumption, coal, oil and gas electricity generation, energy production from renewable sources of energy, the cointegration relation between the variables can be passed through the examination phase. The results of panel cointegration tests are shown in table 6 below.

Table 6 Panel co-integration tests.

Pedroni residual co-integration test

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-1.780196	0.9625	-2.415976	0.9922
Panel rho-Statistic	-0.733689	0.2316	0.224839	0.5889
Panel PP-Statistic	-10.60743*	0.0000	-10.94030*	0.0000
Panel ADF-Statistic	-9.027454*	0.0000	-7.713096*	0.0000

	Statistic	Prob.
Group rho-Statistic	0.763376	0.7774
Group PP-Statistic	-13.63433***	0.0000
Group ADF-Statistic	-9.670696***	0.0000

Kao residual co-integration test

	t-Statistic	Prob.
ADF	-9.641818*	0.0000

Information: The optimum lag length selection is based upon SIC automatically. P-values are shown in parentheses.

* At the 1% significant level.

The Pedroni cointegration test we apply to our data allows us to reach a conclusion that when we look at the results given to us by the regression on residuals using least squares (OLS) supervision, 4 of the 7 cointegration tests are meaningful at 5% level. Thus, the rejection of the null hypothesis implies that we accept the hypothesis that the alternative is the cointegration. In addition, the Kao cointegration test results in us supporting the results of Pedroni cointegration at the 1% significance level. As a result, both the Pedroni and Kao cointegration tests present proof of cointegration between the time series of the G7 countries that we use to study us.

Table 7 Panel OLS, FMOLS, and DOLS (Dependent variable: CO_2 emissions).

Variables	Gdp	Urpop	Rewec	Epc	Epcog	Eprew	R^2	Adj. R^2	JB	SSR
OLS	0.319509 (0.0007)	0.540385 (0.0005)	-0.062256 (0.0001)	0.654810 (0.000)	0.14352 (0.000)	-0.007603 (0.4945)	0.63	0.61	0.9167 (0.6323)	0.013571
FMOLS	0.338029 (0.003)	0.969944 (0.0570)	-0.076727 (0.000)	0.673914 (0.000)	0.160630 (0.000)	-0.007264 (0.5886)	0.64	0.61	4.759121 (0.092591)	0.012778
DOLS	0.298129 (0.000)	0.393728 (0.4647)	-0.073309 (0.000)	0.670882 (0.000)	0.117225 (0.000)	-0.0066512 (0.5108)	0.64	0.61	0.9184 (0.632742)	0.013202

Information: SSR; Sum Squared Residual, which is small, can be regarded as a sign of the success of the models. The Jarque-Bera normality test examines the degree of normal distribution ownership of the error series. The value in parentheses is the probability value for the JB test. When this value is greater than 0.05, it is given that the series of error terms have normal distribution and that the t test and R square values are reliable. Variance and autocorrelation in the DOLS and FMOLS model's problems have been tried to be solved by Newey-West method.

We predicted the long-term effects of other variables with OLS, FMOLS, and DOLS methods by selecting CO2 as a dependent variable, intentionally, as a cointegration between the groups with the Pedroni and Kao cointegration tests above. The long-run estimation results we have obtained are shown in table 7 above**.** The R squares of the models estimated by OLS, FMOLS and DOLS were 63%, 63% and 64%, respectively. This result shows us that the dependent variable explanation ratio of each variable in the model is close to each other in all three models. All three models have normal distribution and the F statistics of the models are meaningful at the 1% significance level. When we look at the long-term flexibility we assume, an increase of 1% EPC according to OLS regression results in an increase of 65% in CO2 emissions. This ratio is 67% for the FMOLS regression and 67% for the DOLS regression. When the long-run estimation coefficients are examined, it is seen that the variable that increases the CO2 emissions among the variables is the urban population. A 1% increase in urban population increases carbon emissions by about 97%. In addition, there is an inverse relationship between consumption of renewable energy sources and carbon emissions in all three models in line with economic expectations. The use of renewable energy sources will decrease by 0.06% for the OLS regression, 0.07% for the FMOLS regression, and 0.07% for the DOLS regression. It can be said that declining values are derived from consumption of renewable energy resources which are not fire-fired in the world.

We will use the VECM Granger causality analysis to determine the direction of causality among the series that we use in our study after short and long-term cointegration analyzes. For this, the first thing we need to do is determine the delay length.

Table 8 VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
1	2428.316	NA	8.34e-28*	-42.48778*	-41.29844*	-42.00523*
2	2462.984	60.66896	1.09e-27	-42.23185	-39.85317	-41.26674
3	2500.569	61.07596	1.36e-27	-42.02802	-38.45999	-40.58035
4	2538.905	57.50472	1.72e-27	-41.83760	-37.08022	-39.90738
5	2589.263	69.24199*	1.81e-27	-41.86184	-35.91513	-39.44907
6	2626.443	46.47533	2.52e-27	-41.65078	-34.51472	-38.75545
7	2675.774	55.49699	2.98e-27	-41.65668	-33.33128	-38.27880
8	2732.521	56.74718	3.32e-27	-41.79502	-32.28028	-37.93459

* indicates lag order selected by the criterion

Table eight experiences the outcomes of a few vector auto-regression (VAR) lag buy choice criteria, such as likelihood ratio statistic (LR), final prediction error (FPE), AIC, Schwarz information criterion (SC), and Hannan-Quinn info criterion (HQ). The recommendation from Table 7 is to decide on 1 for that optimum lag length. Whilst getting proof of co-integration relationship amid the selected variables, the chances of short and long-run Granger causality is often confirmed by panel VECM.

Table 9 Panel VECM Granger causality tests.

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	Short Run							Long-Run
Dependent Variables	DCO2	DGDP	DURPOP	DEPC	DEPCOG	DEPREW	DREWEC	ECT
DCO2	-	0.039824	-0.003796	0.261183	-0.702239	0.643728	0.311899	-1.269215
		(0.08726)*	(0.00542)***	(0.10905)	(0.33307)	(0.43614)	(0.37370)	[-5.96482]
DGDP	-0.079437	-	0.010804	-0.235640	0.329439	-0.892234	-0.538697	-0.248886
	(0.15610)		(0.00612)***	(0.12325)	(0.37644)	(0.49294)	(0.42237)	[-2.57911]
DURPOP	0.192917	0.078096	-	0.041038	0.130331	2.647066	-0.058998	-0.169333
	(1.99151)	(1.25826)		(1.57247)	(4.80264)	(6.28890)	(5.38863)	[-0.42001]
DEPC	-0.154265	0.009935	-0.000836	-	-0.132884	-0.007915	-0.064195	-0.275089
	(0.12285)	(0.07762)*	(0.00482)***		(0.29627)	(0.38795)	(0.33241)	[-3.01300]

DEPCOG	-0.082059	-0.005909	-0.000256	-0.032451	-	-0.216488	-0.015652	-0.251886
	(0.04238)**	(0.02678)*	(0.00166)***	(0.03346)**		(0.13383)	(0.11467)	[-8.58315]
DEPREW	0.068394	0.017927	-0.000959	0.016381	0.167493	-	0.040595	0.030682
	(0.02353)**	(0.01487)***	(0.00092)***	(0.01858)**	(0.05675)*		(0.06367)*	[1.98626]
DREWEC	0.041993	0.009188	0.000181	0.040234	-0.088109	-0.002279	-	0.076095
	(0.02580)**	(0.01630)	(0.00101)***	(0.02037)**	(0.06221)*	(0.08146)*		[3.39843]

Notes: P-values are presented in parentheses, while t-statistics are shown in bracket.

*** At the 1% significant level.

** At the 5% significant level.

* At the 10% significant level.

In Table 9, there is a causality relation between per capita emissions and short and long-term tests between coal, oil and gas produced energy. In other words, the use of coal, oil, and gas-generated energy increases carbon emissions, and this is the opposite. At the beginning of the main that increase carbon emissions today is to get energy from these fossil-derived fuels. Even in the developed seven countries of the world, even if measures are taken to reduce carbon emissions, these fuels, which are still cheap and easy sources of energy production, cannot be abandoned.

5. **Conclusion**

This panel cointegration and VECM Granger causality tests are used to test the short-term and long-term effects of CO2 emissions, GDP, urban population, coal, oil and gas power generation, energy consumption, renewable energy consumption and production variables in the G7 countries for the first time in the 1990s and 2014 .When we look at the results of long-term forecasts (OLS, FMOLS and DOLS), the increase in carbon emissions shows that GDP, urban population, energy consumption and coal oil and gas energy production have a positive effect. Again, according to the coefficient results of these tests, renewable energy production and consumption have an effect in reducing carbon emissions.

This econometric analysis backup the next ramifications. Crosscheck with the favorable effect of non-renewable energy on CO2 emission, the unfavorable effect of renewable energy usage on emissions is very low in these panel in G7 which recommended G7's politicians should speed up renewable energy usage in both individual and general activities and develop the status of renewable energy. These seven countries, which are the most industrialized industries in the world, need to focus more on renewable energy sources to reduce this negative impact on carbon emissions. The results of the study show that the consumption of non-renewable energy resources is the biggest threat. In addition, renewable energy consumption, which has a high carbon emission with increasing urban population, poses an environmental threat.

As a result, when the results of the study are taken into consideration, we see that G7 countries take the first place in terms of energy production and consumption in the world. However, the fact that the production of energy is cheaper than the non-renewable sources makes these countries the first in terms of carbon emission. They can use renewable energy sources in order to meet their great energy consumption with their R & D work. The cost of these R & D activities in the short term will reveal the decrease in carbon emission in the long term. Thus, a more livable environment can be created in cities with population density and elsewhere in the world. In developing countries that follow these developed countries, the trend towards renewable energy can be increased. Thus, G7 countries will be countries that are aware of who they are in the world for their carbon emissions, and who have become authentic leaders who are sensitive and transparent about carbon emissions. (Özdemir, Erkutlu, & Elden, 2018)

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