Yayın Geliş Tarihi (Submitted): Mart/March-2019 | Yayın Kabul Tarihi (Accepted): Aralık/December-2020

Population Density, Economic Growth, Energy Consumption and CO_2 Emissions: Empirical Evidence from Asia-Pacific Countries

Nüfus Yoğunluğu, Ekonomik Büyüme, Enerji Tüketimi ve CO_2 Emisyonu: Asya-Pasifik Ülkelerinden Ampirik Kanıtlar

Doç. Dr. Tuncer GÖVDELİ[1]

Abstract

Energy is the main source of CO_2 emissions, which is the key factor of the environmental pollution increasing everywhere around the world. The connection between energy consumption, economic growth, population density and CO_2 emissions are an issue that needs to be analyzed in a multidisciplinary and scholarly manner. In this study, the connection between energy consumption, economic growth, population density and CO_2 emissions were analyzed empirically on the basis of 14 Asian-Pacific countries. A series of panel data models and a balanced panel data set were used in the study which covered the period between 1971 and 2017. The results of the cointegration test for the panel showed that there was a cointegration relationship between the variables. According to the results of the Panel VECM granger causality test, there is evidence of a two-way causality relationship between CO_2 emissions and economic growth, and between energy consumption and economic growth. In addition, population density is the causality of energy consumption, and population density is the causality of economic growth. According to the results, countries need to turn to cleaner energy sources to reduce CO_2 emissions.

Keywords: Population density, economic growth, CO_2 emissions, energy consumption, Asia-Pacific countries

Paper Type: Research

Öz

Dünya genelinde artan çevresel kirlenmenin ana faktörü olan CO_2 emisyonlarının ana kaynağı enerjidir. Enerji tüketimi, ekonomik büyüme, nüfus yoğunluğu ile CO_2 emisyonu arasındaki bağlantı, çok disiplinli (multidisciplinary scholarly) ve bilim olarak incelenmesi gereken bir konudur. Bu çalışmada 14 Asya-Pasifik ülkesi ele alınarak enerji tüketimi, ekonomik büyüme, nüfus yoğunluğu ile CO_2 emisyonu arasındaki bağ ampirik olarak analiz edilmiştir. 1971 ile 2017 dönemini dikkate alan çalışmada bir dizi panel veri modeli ve dengeli panel veri seti kullanılmıştır. Panel eşbütünleşme testi sonucu değişkenler arasında eşbütünleşme ilişkisisin olduğunu ortaya koydu. Panel VECM granger nedensellik testi sonucuna göre, CO_2 emisyonu ile ekonomik büyüme arasında ve enerji tüketimi ile ekonomik büyüme arasında çift yönlü nedensellik ilişkisine dair kanıtlar vardır. Ayrıca nüfus yoğunluğu enerji tüketiminin nedenseli ve nüfus yoğunluğu ekonomik büyümenin nedenselidir. Elde edilen sonuçlara göre, ülkelerin, CO_2 emisyonunu azaltabilmek için daha temiz enerjiye yönelmesi gerekmektedir.

Anahtar Kelimeler: Nüfus yoğunluğu, ekonomik büyüme, CO_2 emisyonu, enerji tüketimi, Asya-Pasifik ülkeleri

Makale Türü: Araştırma

[1] Atatürk Üniversitesi, Beşeri ve Sosyal Bilimler Fakültesi, tgovdeli@gmail.com.

Atıf için (*to cite*): Gövdeli, T. (2020). Population density, economic growth, energy consumption and CO_2 emissions: Empirical evidence from Asia-Pacific countries. *Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi, 22*(4), 934-944.

Introduction

Increasing environmental pollutants (CO_2 emissions) have been a source of concern over the last few decades due to their detrimental effects. CO_2 emissions are greenhouse gases which are the main cause of global warming and climate change. Examined closely by economists, this problem also attracts the attention of policy makers. CO_2 emissions are on the rise all around the world due to economic development, increasing population and urbanization, and industrialization (Rahman, 2017). As a result of increasing CO_2 emissions, climate change will have many positive and negative effects. While climate change can lead to positive changes such as more moderate climates and longer climates in some regions, it can also bring negative changes affecting much more of the world's population. The melting of glaciers, as a result of climate change, increased the world's sea level by about 3 mm. A one-meter rise in the sea level of Bangladesh would mean that around 17.5% of the country's land would be submerged (Nasa, 2018). In the last two decades, climate-related and geophysical disasters caused 1.3 million people to die and 4.4 billion to be injured, lose their homes and become displaced. From an economic point of view, this damage was identified to be $2.9 trillion (United Nation Office for Disaster Risk Reduction, 2018).

Although energy consumption plays a critical role for economic development and prosperity, it is the key element for environmental degradation. Energy is an indispensable element of the economy as the production and consumption activities are directly related to energy. Since the industrial revolution, fossil fuels have been the primary source of energy consumption. Excessive consumption of fossil fuels has triggered the pollution of the environment. Human life is also negatively affected by environmental pollution. (Muhammad and Fatima, 2013; Ozturk and Acaravci, 2010). Stern et al. (2006) states that the concentration of greenhouse gases in the atmosphere will be doubled by 2035, unless the necessary actions to reduce CO2 emissions are taken. This will lead to serious drawbacks by increasing the average global temperature by 2°C. In the long term, it is estimated that the average global temperature will increase by more than 5°C. This change can cause countries to encounter serious threats, both socially and economically (Tiwari, 2011). According to Worldbank data, the 14 Asia-Pacific countries used in the study accounted for 32.02% of the global GDP in 2017. In addition, these countries contain 50.37% of the world's population. According to BP data, 14 Asia-Pacific countries were responsible for 46.21% of the global CO_2 emissions in 2017. In addition, these countries consume 39.96% of the Primary Energy in the world.

In the literature, it is possible to classify the studies that examine the relationship between economic growth and environmental pollutants under four research groups. The first group economic growth increases, environmental pollution increases as well and after the country reaches a certain level of development, environmental pollution decreases as economic growth increases. The second group focuses on the connection between economic growth and energy consumption (Govdeli, 2018). The third group is a unified approach of these two methods which examine the dynamic relationships between economic growth, environmental pollutants and energy consumption (Magazzino, 2014; Wang et al., 2016). The fourth group consists of studies that examine economic growth, environmental pollutants, energy consumption and population density (Ohlan, 2015; Rahman, 2017).

The purpose of this study is to contribute to the environmental economics literature both contextually and empirically. Conducted for the first time under structural breaks through panel data analysis for 14 Asia-Pacific countries, this study explores the dynamic relationship between CO_2 emissions, economic growth, energy consumption and population density. In the methodology section, the model's cointegration relationship was analyzed under structural breaks after the cross-sectional dependency and stability of the main variables were identified. In addition, the causality relationships of the variables used in the study were identified and interpreted. The second section consists of a literature review. In the third section, the data set and methodology are explained. In the fourth section, the empirical results are interpreted. The fifth and final section is where conclusions and political suggestions are provided.

1. Literature Review

In recent years, many empirical studies were undertaken regarding the relationship between CO_2 emissions and economic growth, or between CO_2 emissions and energy consumption for developed and developing countries. However, studies investigating the relationship between CO_2, GDP, population density and energy consumption are limited.

Meng and Han (2018) examined the largest and most developed state of China, Shanghai for the period between 1989 and 2014. Transport infrastructure, GDP, population density and CO_2 were used in the study. In that research a cointegration relationship in the model where the CO_2 were dependent variables was found. They also concluded that an increase in population density would reduce CO_2 per capita. There is a one-way causality from GDP to CO_2 and from GDP to population density. A two-way causality between CO_2 and population density was also identified. Ohlan (2015) examined India during the period of 1970 - 2013. In the study where the ARDL test and the VECM Granger causality test are used, the CO_2 was selected as the dependent variable. A cointegration relationship was identified based on the results of the empirical analysis. In addition, the findings of the study revealed a two-way causality between GDP and population density in the long run.

Rahman (2017) researched 11 Asian countries for the period between 1960 and 2014. Granger causality test in the study used the CO_2, energy consumption, GDP, population density and export variables. A cointegration relationship was identified in the study in which CO_2 were a dependent variable. Energy consumption, export and population density increase CO_2 in the long run. In addition, there is a one-way causality relationship from energy consumption to GDP and from the CO_2 to GDP in the short term. A two-way causality between population density and GDP was also identified. Abdouli et al. (2018) examined the BRICST countries for the period between 1990 and 2014. In the study where they used the GDP, foreign direct investment, population density and CO_2 variables, the dynamic panel GMM was used. The findings showed that there was a relationship between the CO_2 and foreign direct investment, as well as the population density and foreign direct investments. Moreover, as GDP increases, CO_2 also increase.

Sulaiman and Abdul-Rahim (2018) analyzed Nigeria during the period between 1971 and 2010. In that study where population growth, GDP, energy consumption and CO_2 variables were used, the ARDL and VECM Granger causality tests were used. A cointegration relationship was identified through the empirical findings of the study in which CO_2 were a dependent variable. Only the CO_2 were the determining factor in the long run, in the results of causality analysis. In the short run, there is a two-way causality between population growth and GDP. In addition, a one-way causality from energy consumption to GDP and from energy consumption to CO_2 were identified. Hundie (2018) examined Ethiopia during the period of 1970 – 2014. In that study where the CO_2 was a dependent variable, a cointegration relationship was found based on the results of the ARDL method. In addition, a two-way causality relationship between energy consumption and CO_2 was identified. A one-way causality from GDP to CO_2 was identified. In their study of 20 OECD countries for the period of 1870-2014, Churchill et al. (2018) used CO_2, GDP, population and financial development variables. According to the results of cointegration test and the AMG Estimator method, the EKC hypothesis was confirmed in 9 countries. Khan et al. (2019) used GMM for the study which s/he examined Pakistan for the period of 1975 - 2016. In the empirical findings, the EKC hypothesis was accepted. Moreover, fossil fuels and a high density of population increases CO_2, harming sustainable development. Alam et al. (2016) examined India, Indonesia, China, and Brazil during the period of 1970 - 2012. In the study where the CO_2, GDP, energy consumption, trade openness and population growth variables were used, CO_2 was the dependent variable. Based on the empirical findings of the study, it concluded that the relationship between the CO_2 and population growth was significant for India and Brazil. In addition, according to the findings of the EKC hypothesis, in Brazil, China and Indonesia, CO_2 will decrease over time as GDP increases.

Onafowora and Owoye (2014) examined eight countries during the period of 1970 - 2010. In that study where CO_2, GDP, energy consumption, trade and population density variables were used, CO_2 was the dependent variable. A cointegration relationship was identified in the model based on the results of the ARDL test. In addition, the study showed that the EKC hypothesis applied to Japan and South Korea. Ibrahiem (2016) examined Egypt for the period of 1980 - 2010. CO_2 was the dependent variable in the study. A cointegration relationship was identified in the study. The CO_2 are positively related to energy consumption, while they are negatively related to trade openness and population. According to the causality analysis, there is a two-way causality relationship between GDP and CO_2. Lin et al. (2016) examined five African countries for the period of 1980 - 2011. According to the empirical results, energy structure and energy density were the two main factors of the rise in CO2 in Africa. Population growth and urbanization were found to be negatively related to CO_2.

2. Data Set and Methodology

2.1. Data Set

In this empirical study, the data from the period of 1971-2017 was used. The CO_2 emissions (CO_2), economic growth (GDP), primary energy consumption (E) and population density (P) variables were used in the study focusing on 14 Asia-Pacific countries[2]. The model used in the study:

$$CO2_{it} = \beta_{0i} + \beta_{1i} lnGDP_t + \beta_{2i} lnE_t + \beta_{2i} lnP_t + \varepsilon_{it} \tag{1}$$

Where CO_2 is in million tonnes of carbon dioxide, GDP is in current US dollars, E is in million tonnes oil equivalent and P is in people per sq. km of land area. The natural logarithm of all variables was taken and included in the model.

2.2. Methodology

2.1.1. Cross Sectional Dependency Analysis

The cross sectional dependency in the variables and the panel needs to be identified in the panel data analysis. If the cross sectional dependence in the variables or panel is not taken into account, potential errors in the unit root and cointegration tests to be selected may cause serious errors in the results. While first-generation tests must be used in the absence of cross-sectional dependency, second-generation tests must be used in its presence. In this study, the cross-sectional dependency was tested first. For this purpose, the Breusch-Pagan (1980) CDLM_1 and Pesaran (2004) CDLM_2 tests were used to analyze in the panel.

$$CDLM_1 = \mathrm{T} \sum_{\mathrm{i}=1}^{\mathrm{N}-1} \sum_{j=i+1}^{\mathrm{N}} \hat{\rho}_{\mathrm{ij}}^2 \tag{2}$$

where $\hat{\rho}_{\mathrm{ij}}$: indicates the estimated cross-sectional correlations between residual sets.

There is no cross-sectional dependency under the hypothesis H_0. Under the hypothesis H_0, N is fixed while $T \rightarrow \infty$. The statistics exhibit N(N-1)/2 degrees of freedom, and a Chi-squared asymptomatic distribution.

$$CDLM_2 = \left(\frac{1}{\mathrm{N(N-1)}}\right)^{1/2} \sum_{\mathrm{i}=1}^{\mathrm{N}-1} \sum_{j=i+1}^{\mathrm{N}} (\mathrm{T}\hat{\rho}_{\mathrm{ij}}^2 - 1) \tag{3}$$

[2] "Australia, Bangladesh, China, China Hong Kong SAR, India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, Philippines, South Korea, Sri Lanka and Thailand."

$CDLM_2$ statistics exhibit a standard normal distribution under Pesaran (2004), H_0 hypothesis, where T→∞ and N→∞.

The Breusch-Pagan (1980) CDLM_1test and the Pesaran (2004) CDLM_2 test provide good results when the time dimension is larger than the cross-sectional dimension (T> N).

2.2.2. Panel Unit Root Analysis

This test is based on extended Dickey-Fuller (ADF) regression:

$$\Delta x_{it} = z_{it}'\gamma + \rho_i x_{it-1} + \sum_{j=1}^{k_i} \phi_{ij}\Delta x_{it-j} + \varepsilon_{it} \tag{4}$$

In this context, k_i lag length, z_{it} refers to deterministic terms and ρ_i section-specific primary autoregressive parameters.

The standard IPS test can lead to false inferences in the case of external economies or shocks. That is why the cross-sectional extended IPS test recommended by Pesaran (2007) should be used. In this context, the cross-sectional extended ADF (CADF) regression;

$$\Delta x_{it} = z_{it}'\gamma + \rho_i x_{it-1} + \sum_{j=1}^{k_i} \phi_{ij}\Delta x_{it-j} + \alpha_i \bar{x}_{t-1} + \sum_{j=0}^{k_i} \eta_{ij}\Delta \bar{x}_{t-j} + \nu_{it} \tag{5}$$

Where $\bar{x}_t$ is the cross sectional average of x_{it}, and $\bar{x}_t = N^{-1}\sum_{i=1}^{n} x_{it}$. The arithmetic mean of the CADF statistics calculated for each section is calculated to determine the existence of unit root for the wider panel.

$$CIPS = t - bar = N^{-1}\sum_{i=1}^{N_i} t_i \tag{6}$$

Where, t_i refers to the OLS t-rate of ρ_i in equation 10. The critical value is compared against the table values provided by Pesaran (2007). Pesaran (2007) CADF hypotheses: H_0: “Variable is unit-rooted” and H_1: “Variable is stationary”.

2.2.2. Homogeneity Analysis

The homogeneity of the slope coefficients in the cointegration equations:

For larger samples: $\tilde{\Delta} = \sqrt{N}\frac{N^{-1}\tilde{S}-k}{\sqrt{2k}}$ (7)

For smaller samples: $\tilde{\Delta}_{adj} = \sqrt{N}\frac{N^{-1}\tilde{S}-k}{\sqrt{Var(t,k)}}$ (8)

where, N refers to the number of cross-sections, S refers to Swamy test statistics, k refers to the number of explanatory variables, and Var(t,k) refers to the standard error. The hypotheses of the homogeneity test of Pesaran and Yamagata (2008) are as follows: H0: “Slope coefficients are homogeneous” and H1: “Slope coefficients are heterogeneous”.

2.2.2. Panel Unit Root Analysis

According to Engle and Granger (1987), the findings reached via the causality test based on a VAR model with reference to the first difference could be misleading, in case a cointegration relationship exists with the variable. To overcome this problem, the VECM entails estimation using the VAR model, by increasing a lagged error correction term. To analyze the causality relationships in panel data, the VECM model can be formulated as follows (Nazlioglu and Soytas, 2012).

$$\Delta CO2_{it} = \gamma_{1i} + \sum_{p=1}^{k}\gamma_{11ip}\Delta CO2_{it-p} + \sum_{p=1}^{k}\gamma_{12ip}\Delta GDP_{t-p} + \sum_{p=1}^{k}\gamma_{13ip}\Delta E_{t-p} + $$
$$+ \sum_{p=1}^{k}\gamma_{14ip}\Delta P_{t-p} + \theta_{1i}\hat{\varepsilon}_{it-1} + \vartheta_{1it} \tag{10}$$

$$\Delta GDP_{it} = \gamma_{1i} + \sum_{p=1}^{k} \gamma_{11ip} \Delta GDP_{it-p} + \sum_{p=1}^{k} \gamma_{12ip} \Delta CO2_{t-p} + \sum_{p=1}^{k} \gamma_{13ip} \Delta E_{t-p} + + \sum_{p=1}^{k} \gamma_{14ip} \Delta P_{t-p} + \theta_{1i} \hat{\varepsilon}_{it-1} + \vartheta_{1it} \tag{11}$$

$$\Delta E_{it} = \gamma_{1i} + \sum_{p=1}^{k} \gamma_{11ip} \Delta E_{it-p} + \sum_{p=1}^{k} \gamma_{12ip} \Delta CO2_{t-p} + \sum_{p=1}^{k} \gamma_{13ip} \Delta GDP_{t-p} + + \sum_{p=1}^{k} \gamma_{14ip} \Delta P_{t-p} + \theta_{1i} \hat{\varepsilon}_{it-1} + \vartheta_{1it} \tag{12}$$

$$\Delta P_{it} = \gamma_{1i} + \sum_{p=1}^{k} \gamma_{11ip} \Delta P_{it-p} + \sum_{p=1}^{k} \gamma_{12ip} \Delta CO2_{t-p} + \sum_{p=1}^{k} \gamma_{13ip} \Delta GDP_{t-p} + + \sum_{p=1}^{k} \gamma_{14ip} \Delta E_{t-p} + \theta_{1i} \hat{\varepsilon}_{it-1} + \vartheta_{1it} \tag{13}$$

where k refers to optimal lag length; and $\hat{\varepsilon}_{it}$ refers to the residue from the panel FMOLS estimation of equation 1. This model enables both short- and long-term estimations with respect to Granger causality analysis.

2. Results and Discussion

The cross-sectional dependency of the variables must be tested before the unit root test to be used in the study is selected. The cross-sectional dependency test results are tabulated below.

Table 1. Cross sectional dependency tests

	CO2		**GDP**		**E**		**P**	
	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
$\mathbf{CDLM_1}$	138.573	0.001	170.571	0.000	159.341	0.000	192.116	0.000
$\mathbf{CDLM_2}$	3.526	0.000	5.898	0.000	5.066	0.000	7.495	0.000

The cross-sectional dependency of the variables must be tested before the unit root test to be used in the study is selected. The $\mathrm{CDLM_1}$ and $\mathrm{CDLM_2}$ cross-sectional dependency test results are presented in Table 1. An examination of the obtained results reveals that the H_0 hypothesis of "there is no cross-sectional dependency" is rejected for the CO_2, GDP, E and P variables and there is a cross-sectional dependency in the variables. Therefore, the unit root test to be employed should be one of the second generation tests.

Table 2. The results of the CADF panel unit root test

	Constant	
	Level	First Difference
	t-stats	t-stats
CO2	-1.791	-4.139
GDP	-2.129	-4.435
E	-1.925	-4.299
P	-2.119	-2.745

Note: The critical table values for CIPS for N=14 T=47 is -2.25 at 5% for fixed values on p.280, table IIb.

Table 2 provides the results of the panel unit root test. The maximum lag length is chosen to be 3, the variables of the CO_2, GDP, E and P are unit-rooted since the H0 hypothesis of "Variable is unit-rooted" cannot be rejected. The variables became stationary as a result of taking their first difference.

Table 3. Cross Sectional Dependency and Homogeneity Tests

$CO2_{it} = \alpha_i + \beta_{1i}GDP_{it} + \beta_{2i}E_{it} + \beta_{2i}P_{it} + \varepsilon_{it}$	Statistic	p-value
Cross-section dependency tests:		
$CDLM_1$	346.344	0.000
$CDLM_2$	18.927	0.000
Homogeneity tests:		
$\tilde{\Delta}$	34.304	0.000
$\tilde{\Delta}_{adj}$	36.243	0.000

Table 3 presents the results of the cross sectional dependency. The findings led to the rejection of the H_0 hypothesis. Therefore, it was concluded that there was a cross sectional dependency in the panel. The results of the homogeneity test are also presented in Table 3. Based on the test results, the slope coefficients in the cointegration equations were found to be homogeneous.

Table 4. Westerlund (2006) cointegration test with multiple breaks

Description	**Test**	**Statistic**	**Bootstrap p-value**	
No break in constant	LM-stat	0.451	0.912	
Break in constant	LM-stat	3.155	0.670	
Country	**Break Number**	**Break Dates**		
Australia	3	1990	1999	2008
Bangladesh	1	2000		
China	2	1994	2004	
China Hong Kong SAR	2	1982	1995	
India	3	1981	1991	2001
Indonesia	3	1982	1991	2000
Japan	1	2007		
Malaysia	2	1983	2006	
New Zealand	3	1979	1991	2002
Pakistan	2	1990	2006	
Philippines	2	1979	2006	
South Korea	1	1986		
Sri Lanka	1	1983		
Thailand	3	1981	1999	2008

The results of the cointegration test with multiple breaks are presented in Table 4. It was not possible to reject the H_0 hypothesis of "there is cointegration in the panel" as the Bootstrap p-value is greater than 0.05 according to the no break in constant and break in constant results. Therefore, a cointegration relationship was identified in the panel.

The structural break dates of each country are also provided in Table 4. The obtained break dates were found to be consistent for estimating the significant changes in countries. For example, the 1990 recession in Australia (Sturm and Williams, 2004) and the 2008 global crisis caused structural breaks in Australia. The India-Pakistan crisis (Sridharan, 2005) caused by the rise in tensions in Kashmir between Pakistan and India in 1990 led to structural breaks in these countries, while the 1979 oil crisis caused structural breaks in New Zealand and the Philippines (Go, 1994). The coup attempt in Philippines in 2006 also caused a structural break (https://en.wikipedia.org/wiki/2006_state_of_emergency_in_the_Philippines+&cd=1&hl=en&ct=clnk&gl=en). The 1994 devaluation in China (Fernald et al., 1998), the constitutional crisis in

Malaysia in 1983 (Rawlings, 1986), the civil war that began in 1983 in Sri Lanka (Grobar and Gnanaselvam, 1993), and the political crisis of 1982 in China Hong Kong SAR (Shu-Ki, 1999) caused structural breaks.

Table 5. Panel VECM Causality

	Short run causality				Long run causality
Dependent Variable	Δ (CO2)	Δ (GDP)	Δ (E)	Δ (P)	Ect(t-1)
Δ (CO2)	-	6.591[0.086]	9.860[0.019]	7.513[0.057]	-0.310 (-4.701)
Δ (GDP)	6.887[0.075]	-	9.784[0.020]	2.539[0.468]	0.214 (1.547)
Δ (E)	5.968[0.113]	8.014[0.045]	-	17.878[0.000]	-0.078 (-1.403)
Δ (P)	2.660[0.447]	0.1679[0.982]	6.070[0.108]	-	0.007 (1.327)

Note: Maximum lag number is set to 3 and optimal lags for each country is determined by the means of Akaike information criterion.

The Panel VECM causality results are presented in Table 5. According to the short-term causality results, a one-way causality from E to CO_2 and from P to CO_2 was detected. There is a one-way causality from P to E. There is also a two-way causality between CO_2 and GDP and between E and GDP. Long-term causality results are presented in the sixth column. The ECM_{t-1} coefficient results are significant for the CO_2 emission variable and are between -1 and 0. Accordingly, a long-term causality from GDP, E and P to CO_2 was identified.

Conclusion

In this study, the effects of population density, GDP and energy consumption on the CO_2 in 14 Asia-Pacific countries were examined for the period of 1971 - 2017. The Cross Sectional dependency of the variables was identified first in the panel data analysis where annual data were used. The variables were found to be stationary at the I(1) level as a result of the Pesaran (2007) CADF unit root test which is a second-generation panel unit root test. The cointegration relationship between the variables was analyzed by the Westerlund (2006) panel cointegration test with structural breaks. The dates of structural breaks were obtained for each country.

In this study, the causality relationship between the variables was explored by using the VECM Granger causality model. A one-way causality relationship from GDP to CO_2 in the long run, as well as a two-way causality relationship between GDP and CO_2 in the short run were identified. Accordingly, policy makers need to develop environmentally friendly economic growth models instead of economic growth models that increase CO_2 emissions.

There is a causality relationship from the long-term energy consumption to CO_2, based on the causality relationship between energy consumption and CO_2. There is also evidence of a two-way causality between energy consumption and CO_2. The empirical evidence that energy consumption raises CO_2, suggests that green energy policies should be introduced. In order to implement these policies which are necessary for a clean environment, it would be appropriate for the required infrastructure services to be initiated as well. Energy from fossil fuels cause serious damage to the ecology which is very difficult to compensate for.

The main policy results of this study are as follows. First, policy makers need to implement policies for renewable energy, to shift energy and diversify towards such energies. Although the transition process to renewable energy is costly, such energy sources must be preferred as they have a positive impact on the environment in the long run and are also economical. However, it is quite difficult for undeveloped and developing countries to bear this cost in the short run. Therefore, the direct or indirect capabilities possibly provided to such countries by developed countries would accelerate the transition to clean energy. CO_2 emissions affect not only a specific country but also other countries. Therefore, support to be provided to these countries would directly affect the developed countries.

Secondly, environmentally friendly models must be preferred for economic growth, instead of environmentally pollutant models. The factors that cause environmental pollution must be examined in detail and the required suggestions for solutions must be provided. To this end, policy makers and economists need to work together and produce environmentally friendly policies that will not hamper a country's development. Third, there is a short-term and long-term causality from population density to CO_2 emissions. Policy makers need to balance population density to be able to reduce the CO_2 emissions. The cautious balancing of the population would be helpful in ensuring sustainable development. Population density is one of the factors that directly affect CO_2 emissions as it's also the causality of energy consumption. Policies that balance population density would not only lower CO_2 emissions, but would also directly affect energy consumption.

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ETİK ve BİLİMSEL İLKELER SORUMLULUK BEYANI

Bu çalışmanın tüm hazırlanma süreçlerinde etik kurallara ve bilimsel atıf gösterme ilkelerine riayet edildiğini yazar(lar) beyan eder. Aksi bir durumun tespiti halinde Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi'nin hiçbir sorumluluğu olmayıp, tüm sorumluluk makale yazarlarına aittir.