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Investigation of Causality Analysis between Economic Growth and CO_2 Emissions: The Case of BRICS – T Countries

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ABSTRACT

The most significant cost of increase in economic growth is an increase in energy consumption and carbon emissions as well. Energy consumption triggers carbon dioxide emissions, which is the main cause of environmental pollution. In recent years, struggling with climate changes, global warming and carbon dioxide emissions based environmental problems became critical issues. In doing so, this study investigates the relationship between carbon emissions and economic growth for BRICS-T countries for the period of 1992-2016. We apply Pedroni and, Westerlund and Edgerton panel cointegration approaches for examining cointegration between the variabes. The Fully-Modified OLS approach is applied for testing long-term relationship between economic growth and carbon emissions. The empirical results indicate that a 1% increase in economic growth increases carbon emissions by 0.79% but 1% increase in carbon emissions leads economic growth by 0.5%. The causality analysis reveals the presence of bidirectional relationship between carbon emissions and economic growth.

Keywords: Carbon Emissions, Economic Growth, BRICS-T Countries
JEL Classifications: P52, O10

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1. INTRODUCTION

Issues such as global warming and climate changes resulting from environmental pollution because of poisonous gases have been at the top of agenda in national and international levels in recent years. Actually, CO_2 emissions have two basic sources. The first source is the combustion of fossil fuels such as coal and crude oil. The second source is industrial processes that release CO_2 as a result of a chemical reaction and production. There are pros and cons for the countries while following the footprints of industrialization and economic growth. In most cases, there is a trade-off between a sustainable economic growth and clean environment. Increasing energy consumption for more economic activities brings increasing carbon emissions which is the basic reason of greenhouse effects and climate changes.

In existing literature, the relationship between environmental pollution and economic growth is explained by Environmental Kuznets curve (EKC). The EKC hypothesis, takes it roots from Kuznets curve which explained the relationship between economic growth and income inequality (Kuznets, 1955). The Kuznets curve implies that as an economy grows from lower income to higher income level, income inequality first increases. After reaching a turning point, income inequality declines. Similarly, according to EKC hypothesis, environmental pollution increases until economic growth reaches its peak; then it turns to decrease with an increase in economic growth over time. Economic development experience of almost every country shows that it is more reasonable to increase economic growth rather than environmental problems in early stages of industrialization. Although there is limited environmental degradation at early stages of economic development, increasing economic activities impact environment quality negatively. Increase in per capita income, completion of infrastructure investment with economic and social aspects, and providing a better standard of living have higher priority than dealing with environmental problems. Accordingly, parallel to the higher income levels, there will be more environmental expenditures, higher environmental awareness, and demand for qualified and clean environment. So, EKC model reflects an economic structure change in the share of agriculture, industry and service. Strategies to protect environment are being developed just after reaching this level. That process ends with a steady decrease in environment degradation (Yang et al., 2015, Panayotou, 2003).

In fact, Kuznets curve summarizes a dynamic process of changes. Environmental degradation increases at early stages of economic growth, and then gradually it starts to decrease as economic growth reaches a better level with a higher income per capita. This shows that pollution or environmental impact per capita is an inverted U-shaped between income per capita and carbon emissions (Shahbaz et al., 2015). The pioneering research on EKC hypothesis was published by Grossman and Krueger (1991). Grossman and Krueger (1991) noted that there are always some pollutants which are the natural byproduct of economic activity such as operation of motor vehicles or wastes of production process at the factories. Carbon emissions incraeses with economic activity. Grossman and Krueger (1991) explained that it is possible to observe the environmental impacts of the reduction of commercial barriers and commercial liberalization in three ways. The first way is the expansion of scale economy i.e. scale effect. Despite the expansion of the volume of economic activity with the liberalization of trade and investment, environmental degradation will be inevitable if the structure and, content of manufacturing and production do not change. Additionally, an increase in volume of foreign trade will lead to the expansion of international transportation and if necessary measures are not taken which in resulting, affacte air quality. The second way is the effect of change in composition of economic activity i.e. composition effect which reveals that countries are more likely to be attracted to sectors where they can benefit from competitive advantages. At this point, the reasons for which competitive advantages are based are important. If production decisions are made by making use of the differences and inconsistencies in environmental measures, increase in environmental pollution will be inevitable. The third way is the changes in production technologies i.e. technique effect. On other hand, foreign direct investment increases with liberalization of trade, may contribute to decrease in amount of pollution per production by leading to changes in production techniques. Namely, environmental problems of less developed countries will be reduced if foreign investors bring their modern technologies that are less polluting to target countries. In addition, if income level increases in the country where liberalization occurs, there will be more social demands and expectations of society. As the income level increases, social sensitivity to clean environment increases (Grossman and Krueger, 1991). Similarly, Elden and Song (1994) identified inverted-U relationship between environment pollution and economic growth. They found that four pollutant gas emissions have inverted-U relationship with per capita GDP.

It is fact that BRICS-T countries showed a great economic performance in last three decades. However, having a remarkable economic growth triggered environmental problems and increasing carbon emissions. As an example China has been ranked as the second largest economy with its 20% of world's GDP. Parallel to this level of economic growth, the country is the greatest global carbon emissions emitter by releasing 40% of global CO_2 emissions (Dong et al., 2017). However, output growths or poor environment protection policies are not the only reasons of increasing carbon emissions. In their study, Wang et al. (2018) pointed that in BRICS countries, corruption is one of the most serious reasons of increasing carbon emissions. So, corruption controlling policies in those countries will also lead reduction in carbon emissions. Alam et al. (2016) found that in come and energy usage show relationships with carbon emission in BRIC countries.

This study contributes to existing literature by two folds: (i) We prefer to apply panel data approaches for empirical analysis. Previous studies on the relationship between carbon emissions and output have problems with empirical methods applied for analysis. Since data for carbon emission is collected annually, number of observations is limited and time dimension decreases. To overcome this issue, panel data approaches can be a good alternative for empirical analysis. In panel data analysis, degree of freedom and efficiency of empirical estimations increase. Thus, more reliable and stable parameter estimations can be made. In doing so, we have applied Westerlund and Edgerton (2008) cointegration test for examining cointegration relationship between economic growth and carbon emissions. Further, Fully-Modified OLS (FMOLS) approach is applied to find long run effect of economic growth on carbon emissions and vice versa. (ii) Previous studies analyzed the relationships between carbon emissions and economic growth excluding Turkish economy. This study examines the relationship between economic growth and carbon emissions for BRICS countries including Turkish economy for empirical analysis. Our empirical evidence confirms the presence of cointegration between the variables. Moreover, a bidirectional relationship between carbon emissions and economic growth is also noted.

2. LITERATURE REVIEW

Since the pioneer study of Kraft and Kraft (1978) that investigated the linkage between energy consumption and gross national product, economic growth and CO_2 emissions causality nexus has been considered as one of the growing debates in theoretical and empirical literature. Thus, environmental economists, researchers and policy makers have been examining the relationship between CO_2 emissions and economic growth to implement reasonable policies in order to have sustainable economic development with clean environment. In recent years, not only the degree of the relationship between economic growth and CO_2 emissions, but also the direction of the causality still remains one of the debated issues. The findings of different country cases or country groups vary from each other; the results are even controversial that deprive the policy makers from implementing certain policies.

In this paper, the literature about the causality between economic growth and CO_2 emissions is reviewed under four sub-sections: 1) Causality running from economic growth to CO_2 emissions; 2) Causality running from CO_2 emissions to economic growth; 3) No causality nexus between CO_2 emissions and economic growth (neutrality); 4) Bidirectional causality between CO_2 emissions and economic growth (Ozturk, 2010).

2.1. Growth-Led Emissions Hypothesis

In their high coverage study, Wang (2013) studied 138 countries for 1971-2007 period in order to validate the relationship between CO_2 emissions and economic growth. The empirical results reveal that economic growth is the main reason for rising carbon dioxide emissions. Similarly, Gao and Zhang (2014) investigated 14 Sub-Saharan African countries for the period of 1980-2009. They confirmed the presence of a unidirectional causality relationship running from economic growth to CO_2 emissions. Kaisi and Mbarek (2017) reached the same empirical result for African countries: Algeria, Egypt and Tunusia for the period of 1980-2012. Zhang et al. (2014) examined the impact of economic growth, industrial structure and urbanization on carbon emissions intensity in China based on the data from 1978 to 2011. Lee and Yoo (2016) investigated the short run and long run causality issues among CO_2 emissions, economic growth and energy consumption in Mexico for the period of 1971-2007. Both studies showed that CO_2 emissions are cause of economic growth. Lu (2017) also reported the economic growth led carbon emissions for 1990-2012 period, using panel data for 24 Asian countries. Aye and Edoja (2017) examined the economic growth-carbon emissions nexus for a panel of 31 developing countries using data from 1973 to 2013. Their results indicated that economic growth has a negative impact on CO_2 emissions in the low growth regime whereas it has a positive effect in the high growth regime because of higher marginal effect. Deviren and Deviren (2016) collected data for 33 countries over the period 1970-2010 and noted that in highly developed countries, economic growth is accompanied with high carbon emissions. Similarly, Mikayilov et al. (2018) investigated the relationship between economic growth and CO_2 emissions for Azerbaijan over the period of 1992-2013. They found that economic growth has a significant and positive impact on CO_2 emissions. Bouznit and Pablo-Romero (2016) validated the growth led emissions hypothesis in case of Algeria for the period of 1970-2010. Li et al. (2018) also collected data for 30 Chinese provinces for the period of 2004-2016 to examine relationship between economic growth and carbon emissions by including FDI, high-tech industry, and population as additional determinants. They noted that economic growth, high-tech industry, FDI and population have a direct effect on carbon emissions. Dong et al. (2017) investigated the growth-emissions nexus by adding natural gas consumption and renewable energy consumption in emissions function for BRICS countries. They found the presence of unidirecitonal causality running from economic growth to carbon emissions in short run. Similarly, Nuryartono and Rifai (2017) also note that economic growth causes carbon emissions in Indonesia and Thailand. For EU countries, Kasperowicz (2015) reported the presence of groth-led-emissions hypothesis in short run.

2.2. Emissions-Led Growth Hypothesis

Joo et al. (2015) investigated the short-term and long-term causality nexus between energy consumption, CO_2 emissions, and economic growth in Chile. Their empirical evidence indicated that CO_2 emissions Granger cause economic growth. Similarly, Asumadu-Sarkodie and Owusu (2016) examined the causal relationship between carbon dioxide emissions, electricity consumption, industrialization and economic growth for Benin for the period 1980-2012 and reported the presence of emissions-led growth hypothesis. Chindo et al. (2015) investigated the cointegration relation between CO_2 emissions, economic growth and energy consumption in Nigeria over the period of 1971-2010. They noted that that CO_2 emissions has a significant and positive impact on GDP i.e. an increase in CO_2 emissions causes to increase in GDP. Lee and Yoo (2016) investigated short run and long run causality relationship in Korea and cofnirmed the presence of unidirectional causlaity runnig from carbon emissions to economic growth which latter validated by Ahmad and Du (2017). In case of G20 countries, Pao and Chen (2019) reported that economic growth Granger causes carbon emissions. Alshehry and Belloumi (2015) examined the dynamic causal relationship between energy consumption, carbon dioxide emissions, energy price and economic growth and noted the presence of emissions-led growth hypothesis.Similarly, Pao and Tsai (2010) for BRIC countries, Ozturk and Uddin (2012) for India, Bozkurt and Akan (2014) for Turkey, Obradović and Lojanica (2017) for Greece and Bulgaria also reported that economic growth is cause of carbon emissions in the long-run.

2.3. Bidirectional Causality Nexus between Economic Growth and CO_2 Emissions

Various studies using various countries data reported the presence of feedback effect between eocnomic growth and carbon emissions. For example, Yansui et al. (2016) investigated the relationship between urbanization, economic growth and CO_2 emissions for 31 provinces of China over the period of 1997-2010. They found feedback effect between carbon emissions and ecoomic growth although urbanization has significant effect on CO_2 emissions. Al-Mulali and Che Sab (2018) examined CO_2 emissions - economic growth nexus by including eletricty consumption as additional determinanat in emissions function for the Middle East countries. Their panel causality analysis revealed that economic growth and carbon emissions are interdependent. In case of Italy, Magazzino (2016) reported that economic growth causes carbon emissions and in resulting, carbon emissions cause economic growth in Granger sense. For BRICS countries, Haseeb et al. (2018) examined causal relationship between economic growth and carbon emissions by including financial development, globalization, energy consumption, and urbanization in emissions function. Their empirical results showed the presence of feedback effect between economic growth and carbon emissions. The bidirectional causality also exists between carbon emissions and economic growth reported by Long et al. (2015) for China, Yang and Zhao (2014) for India, Sebri and Ben-Salha (2014) for BRICS countries, and Tamba (2017) for Cameron.

2.4. No Causality between Economic Growth and CO_2 Emissions

Very few studies also reported nuetral effect between carbon emissions and economic growth. For example, Salahuddin and Khan (2013) examined the causal relationship between economic growth, energy consumption and CO_2 emission in Australia and indicated that carbon emissions and economic growth are independent. Ozturk (2015) found that EKC hypothesis in not exists in BRICS countries. Azevedo et al. (2018) used the BRICS countries data to examine the causal association between carbon emissions and economic growth. They found that neither carbon emissions cause economic growth nor economic growth cause carbon emissions. Gorus and Aydın (2019) studied eight oil-rich MENA countries (Algeria, Egypt, Iran, Iraq, Oman, Saudi Arabia, Tunusia and the UAE) for the period of 1975-2014. Thier empirical results show the presence of nuetral effect between carbon emissions and economic growth.

3. THE DATA AND ESTIMATION STRATEGY

3.1. Data Set and Methodology

This study analyzes the relationship between carbon emissions and economic growth for BRICS-T countries for the period of 1992-2016. BRICS-T countries (Brazil, Russia, India, China, South Africa and Turkey) have recently appeared with their rapid growth performances. The growth performance of BRICS-T countries has progressed way more than leading industrial countries in the world. Relatively high growth is accompanied with carbon emissions and thus high level of environmental pollution. Data were collected from the World Bank and International Energy Agency.

While investigating the relationship between carbon emissions and economic growth, it is seen that there might be problems related to the methods applied for empirical analysis. Due to the annual collection of data for carbon emissions, observation number remains relatively low and time dimension decreases. In order to overcome this problem, panel data analysis methods can be applied for empirical analysis. This is because panel data analysis produces stronger results when compared to time series methods. Al-Mulali (2011) stated that panel data could control individual heterogeneity unlike time series and cross-sectional data. In panel data analysis, the connection between the explanatory variables gets weaker. Consequently, degree of freedom and efficiency of the estimations increase. Thus, more reliable and stable parameter estimations can be made. One of the important problem in panel data analysis is the interdependence among the individual units (countries). This problem is called cross-section dependence. Since cross-section interdependence causes incorrect interpretations and the efficiency of test statistics to decrease, cross-section dependence was studied by using two different test statistics in our study: Breusch-Pagan Lagrange multiplier (LM) and Pesaran CD tests. The null hypothesis and test statistic stating that there is no cross-section dependence for the Breusch-Pagan LM test is as follows (Baltagi, 2001):

$$\phi_i(L): 1-\sum_{j=1}^{P_i}\varphi_{ij}L^j$$

$$H_0: \sigma_\mu^2 = 0 \quad (1)$$

$$LM = (NT/2(T-1))\left[\left(\sum_{i=1}^{N}e_i^2 / \sum_{i=1}^{N}\sum_{t=1}^{T}e_{it}^2\right)-1\right]^2 \quad (2)$$

The Pesaran CD test statistic assuming there is no cross-section dependence in the null hypothesis is calculated as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{i,j}\right)} \Rightarrow N(0,1) \quad (3)$$

Stationarity of the series is important in the selection of estimation models. In the present study, stationarity conditions of the series will be investigated following the examination of cross-section dependence. Of the most common methods in the research of stationarity conditions, LLC and IPS tests were used. These methods have the assumption that the series does not have cross-section dependence. Also, O'Connell (1998) indicated that the possibility to reject the null hypothesis increased in panel unit root tests in case of cross-section dependence among the series. In this context, Pesaran (2007) suggested a unit root test that considers cross-section dependence, which is called Pesaran Cross-sectionally-Augmented Dickey Fuller (CADF) test panel unit root test. This test is the one that allows the investigation of stationarity conditions of cross-section and panel data that can be used when T> N and N> T.

The long term relationship among the series will be analyzed by using Pedroni panel cointegration method. The Pedroni cointegration method used frequently in the literature is a first generation analysis method and has some drawbacks. Firstly, due to the structural break problem in panel data analysis, the estimation results of relationship among the series can show fake regression. If the time series dimension is very long, the problem of fake regression increases. The time dimension is relatively long. Another problem is that cross-section dependence previously mentioned is frequently seen in panel data models. The first generation panel data methods assume that cross-section dependence does not exist. The second generation tests take these problems into consideration (Groen and Kleibergen, 2003; Banerjee and Carrion-i-Silvestre, 2006; Westerlund, 2006).

3.2. Westerlund and Edgerton (2008) Panel Cointegration Test Methodology

Westerlund and Edgerton (2008) developed a test that allows cross-section dependence for panel data analysis, multi structural break at an unknown date in both constant and slope of cointegrated vector, and heteroscedasticity and series-correlation of error terms. We will use the Pedroni cointegration methodology and the Westerlund and Edgerton (2008) methodology. Westerlund and Edgerton (2008) developed a panel cointegration test derived from the LM based unit root tests developed by Schmidt and Phillips (1992), Ahn (1993) and Amsler and Lee (1995). This test allows for the unknown breaks in both constant and trend of the cointegrated regression, individual-specific constant and trend effects, cross-section dependence and heteroscedastic and auto-correlated error terms. y_{it} variable can be calculated as follows:

$$y_{it} = \alpha_i + \theta_i t + \delta_i D_{it} + x_{it}' t + (D_{it}x_{it})'\gamma_i + z_{it} \quad (4)$$

$$x_{it} = x_{it-1} + w_{it} \quad (5)$$

k-sized vector x_{it} variable was modelled according to the pure random walk process. In the equation, D_{it} is the dummy variable representing a structural break (D_{it}=1→t>T_i and otherwise 0). In this case, α_i and β_i represent the constant and trend before the break period. δ_i and γ_i show the change in the constant and trend in the break period. With the use of the unobserved common factors of z_{it} it is assumed to have the following data production process that allows for cross section dependence.

$$Z_{it} = \lambda_i^{'} F_t + v_{it} \quad (6)$$

$$F_{it} = \rho_i F_{it-1} + \mu_{it} \quad (7)$$

$$\phi_i(L)\Delta v_{it} = \phi_i v_{it-1} + e_{it} \quad (8)$$

Where $\phi_i(L): 1-\sum_{j=1}^{P_i}\varphi_{ij}L^j$ is a scalar polynomial in the lag operator L. F_t is r sized vector of the unobserved common factors F_t (j=1,...,r). For all j's when it is assumed that ρ_i<1 the stationarity of F_t is provided. In this case, the order of integration of composite regression error z_{it} will only be dependent upon idiosyncratic disturbance v_{it}. In conclusion, as for the relationship in equation-8, if ϕ_i<0, it is cointegrated and if ϕ_i = 0, it expresses a dummy relationship. In case that a cointegrated relationship among the series is determined, it is necessary to investigate the direction and size of relationship among the series. In case of long term relationships among the Pedroni (1999; 2000) series, panel estimators are biased and inconsistent. Therefore, Pedroni suggested the FMOLS methodology in existence of cointegrated relationship.

4. EMPIRICAL ANALYSIS

This study analyzes the relationship between carbon emissions and economic growth for BRICS-T countries (Brazil, Russia, India, China, South Africa and Turkey) for the period 1992-2016. The variables were transformed into natural logarithm. Our panel data set is balanced. Before analyzing the stationarities of the series, cross-section dependence conditions of the series were analyzed. The results can be seen in Annex 1 and 2. According to the results, the null hypothesis is rejected and cross-section dependence exits. In the results obtained for unit root analysis in case of cross-section dependence, the likelihood to reject the null hypothesis increases. Therefore, the stationarity conditions of the series were examined by using the CADF and Breitung test. Tables 1 and 2 indicate the CADF and Breitung test results respectively.

Table 1: Pesaran CADF panel unit root test results

Variables	Without trend			With trend		
	Lags	Z_t-bar	P-value	Lags	Z_t-bar	P-value
LNGDP	1	−3.252	0.001	1	−0.775	0.219
	2	−1.137	0.128	2	−0.841	0.200
	3	−0.109	0.457	3	1.433	0.924
	4	−1.038	0.150	4	1.934	0.973
	5	0.038	0.515	5	2.178	0.985
$LNCO_2$	1	−2.388	0.008	1	1.131	0.871
	2	−3.122	0.001	2	−0.120	0.452
	3	−3.336	0.000	3	0.011	0.505
	4	−1.164	0.122	4	0.965	0.833
	5	−2.334	0.010	5	1.564	0.941

CADF: Cross-sectionally-Augmented Dickey fuller

In Table 1, Pesaran CADF test results are indicated for 5 lags. It was concluded that real output series was not stationary for intercept and intercept and trend model except first lag of intercept model. The results are complex for carbon emissions. While the basic hypothesis was rejected for the intercept model, it was not rejected for the trend model. So, Breitung test was also used for analyzing the stationarity of the series. In case of cross sectional dependency, Breitung test allows stationary analysis by robust estimators for the series which have homogenious and heterogenous unit effects. Test results are illustrated in Table 2.

According to Table 2 results, both real output and carbon emissions series are difference stationary for intercept and intercept and trend models. Economic growth and carbon emissions are found stationary at first difference with intercept and trend. The unique stationarity properties of the variables leads us to apply panel cointegration approach for long run relationship between economic growth and carbon emissions. In doing so, we have applied the Pedroni panel cointegration approach and results are shown in Table 3.

The empirical results reported in Table 3, show a relationship only according to Panel v-statistic, whereas the other 6 test statistics imply that no cointegration relationship between the variables. As economic growth is treated as dependent variable, it is seen that cointegration relationship exists following panel v-statistic and rest empirical results show the absence of cointegration between the variables. This shows that cointegration is not present following Pedroni cointegration approach. The empirical results by Pedroni cointegration approach are ambiguous for not considering structural breaks and cross-section dependence stemming in the variables for examining cointegration relationship. Further, Pedroni cointegration test does not allow for heteroscedasticity and autocorrelation of error terms and individual-specific constant and trend effects. Therefore, Westerlund and Edge (2008) panel cointegration is suitable considering mentioned issues while investigating cointegration between the variables and results are detailed in Table 3.

In Table 4, we reported empirical results, economic growth is treated as dependent variable. The empirical results by Pedroni cointegration show no cointegration between the variables. In structural break models, estimations up to 5 breaks are made. The empirical results for breaks in regime model show the existence of a long run cointegration relationship between economic growth and carbon emissions. As we consider, carbon emissions is our dependent variable, empirical evidence shows the absence of cointegration between economic growth and carbon emissions with level breaks stemming in the series. However, in the presence of single break in the series, we note the presence of cointegrating relationship between the variables. This validates that economic growth and carbon emissions are cointegrated for

Table 2: Breitung panel unit root test results

Method	LNGDP				$LNCO_2$			
	Intercept		Trend and intercept		Intercept		Trend and intercept	
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
Breitung	6.777	1.000	0.960	0.832	4.777	1.000	1.221	0.889

Table 3: Pedroni panel cointegration test results

Dependent variable: $LNCO_2$			Dependent variable: LNGDP		
Within-dimension	**Statistic**	**Prob.**	**Within-dimension**	**Statistic**	**Prob.**
Panel v-statistic	1.437	0.075	Panel v-statistic	3.957	0.000
Panel rho-statistic	0.847	0.801	Panel rho-statistic	0.505	0.693
Panel PP-statistic	1.064	0.856	Panel PP-statistic	−0.08	0.468
Panel ADF-statistic	−0.483	0.314	Panel ADF-statistic	−0.072	0.471
Between-dimension	**Statistic**	**Prob.**	**Between-dimension**	**Statistic**	**Prob.**
Group rho-statistic	1.513	0.934	Group rho-statistic	1.670	0.952
Group PP-statistic	1.219	0.888	Group PP-statistic	0.792	0.785
Group ADF-statistic	−0.705	0.240	Group ADF-statistic	−0.01	0.495

ADF: Augmented Dickey fuller

long run relationship in case of BRIC-T countries. The presence of cointegration between economic growth and carbon emissions suggests to examine long run effect of economic growth (carbon emissions) on carbon emissions (economic growth). In doing so, we have applied FMOLS approach to examine long run effects.

The empirical results reported in Table 5 show that a 1% increase in economic growth raises carbon emissions by 0.79%. Moreover, a 1% increase in carbon emission leads economic growth by 0.94. These empirical results are similar with Sebri and Ben-Salha (2014), Haseeb et al. (2018) who noted the presence of cointegration between economic growth and carbon emissions.

As illustrated in Appendix 1, with its high GDP growth and high carbon emissions, China showed a discrete performance in GDP per capita and carbon emission series from the other countries in BRICS-T country group. Comparing with China, India and Russia had less carbon emissions level. Brazil, South Africa and Turkey had a positive trend in their real output performance and higher economic growth for the period of 1990-2016 but showed lower carbon emissions levels comparing with China, Russia and India. Contrary, comparing with those three countries, India showed a lower economic growth with higher carbon emissions. Natural logarithm was used in the empirical analysis.

Table 4: Westerlund and Edge (2008) panel cointegration test results

Dependent variable: LNGDP	$Z_\tau (N)$		$Z_\varphi (N)$	
Model	**Value**	**P-value**	**Value**	**P-value**
No break	0.819	0.794	0.824	0.795
Level break	−0.715	0.237	−0.45	0.326
Regime shift	−2.131	0.017	−1.359	0.087
Dependent variable: $LNCO_2$	$Z_\tau (N)$		$Z_\varphi (N)$	
Model	**Value**	**P-value**	**Value**	**P-value**
No break	−0.911	0.181	−0.869	0.193
Level break	−2.663	0.004	−2.822	0.002
Regime shift	0.309	0.621	0.376	0.646

Table 5: FMOLS test results

Dependent variable: LNGDP				
Variable	**Coefficient**	**Std. error**	**t-statistic**	**Prob.**
$LNCO_2$	0.942	0.075	12.541	0.000
Dependent variable: $LNCO_2$				
Variable	**Coefficient**	**Std. error**	**t-statistic**	**Prob.**
LNGDP	0.790	0.063	12.428	0.000

FMOLS: Fully-modified OLS

5. CONCLUSION AND POLICY IMPLICATIONS

This paper investiagted the causality nexus between carbon emissions and economic growth in rapid growing BRICS-T countries (Brazil, Russia, India, China, South Africa and Turkey) using data for the period of 1992-2016. In doing so, Pedroni (2000) Westerlund and Edgerton (2008) panel cointegration approaches are applied to examine cointegration between eocnomic growth and carbon emissions. The empirical results confirm the presence of cointegration between economic growth and carbon emissions. Furthermore, a 1% increase in economic growth leads carbon emissions 0.79% and in resulting, a 1% incraese in carbon emissions increases economic growth by 0.5%. The panel cointegration analysis reveals the presence of bi-directional causal relationship between carbon emissions and economic growth.

In developing countries, like BRICS-T countries, there is a trade-off between economic growth and environment degradation. This confirms the presence of macroeconomic and social costs associated with growth-pollution feedback relation. Higher economic growth, more carbon emissions and visa versa. Those countries do not pay great attention to protect environmental quality or implement strict environment protectionist measures. The governments even sacritifice environmental quality to achieve higher economic growth. They also allow polluting industries to have cost advantageous investments for foreign capital investment. Furthermore, sample countries other than Turkey have energy production from oil/fossil fuels which is highly related to environment pollution. Neverthless, it is a fact that polluting environment and increased carbon emissions create barriers to achieve sustainable development goals. Furthermore, it may have a higher price to neutralize the negative externalities of pollution-based economic growth. Increased carbon emissions and degraded environement not only negatively affect the health of labor force but also, there will be no livable environment for the next generations.

By keeping in mind all these side effects of environment degradation, BRICS-T countries should implement more efficient and clean energy policies. Besides, these countries should improve new techologies for cleaner and more efficient energy mix to ensure sustainable environment with economic growth. The countries should also have an energy transition which have higher renewable energy proportion in total energy mix. Namely, every country should creat its own national energy policy on the basis of energy mix, energy resources and needs for energy-growth relationship.

Foreing direct investment is critical for developing countries to sustain economic growth. It is also important that while inviting foriegn investors, the governments should be aware of non-polluting and environmental friendly investments are accepted. Accordingly, the governments should implement environment protectionist measures and regulations for foreing direct investment and domestic investment in order to have a sustainable development with clean environment. And also, while struggling against carbon dioxide emissions caused by the continuation of production by conventional energy sources, governments should implement convenient energy policies that will activate the alternative energy resources in order not to decrease the growth rates.

It is also necessary to disseminate energy saving models in urban and rural transformation processes, to support the use of modern technology instead of old technologies that lead to high pollution, to ensure the transformation of low value added companies and sectors that harm the environment, and to support the education activities that improve environmental awareness. All in all, it is highly recommended to investigated countries to improve energy productivity by increasing energy efficiency, implementing new energy saving projects (smart cities, efficient urban transformations, new energy saving technologies, more convenient public transportation etc), more qualified energy infrastructure and energy conservation to reach higher economic growth levels with sustainable environment and less carbon emissions.

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ANNEX

Annex 1

Cross-section dependence test		
Series: $LNCO_2$		
Null hypothesis: No cross-section dependence (correlation)		
Test	**Statistic**	**Prob.**
Breusch-Pagan LM	291.307	0.000
Pesaran scaled LM	49.351	0.000
Bias-corrected scaled LM	49.235	0.000
Pesaran CD	9.245	0.000

LM: Lagrange multiplier

Annex 2

Cross-section dependence test		
Series: LNGDP		
Null hypothesis: No cross-section dependence (correlation)		
Test	**Statistic**	**Prob.**
Breusch-pagan LM	337.990	0.000
Pesaran scaled LM	57.874	0.000
Bias-corrected scaled LM	57.758	0.000
Pesaran CD	18.305	0.000

LM: Lagrange multiplier