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Is There a Relationship between CO_2 Emissions and Health Expenditures? Evidence from BRICS-T Countries

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Abstract: *One of the most important indicators of deterioration in environmental quality is the increase in carbon dioxide emissions. Increasing carbon dioxide emissions negatively affect the health of individuals and lead to the emergence of a number of chronic diseases. The most significant cost of chronic diseases which reduces employee productivity is the impact on health expenditures. The purpose of this study is to investigate the relationship between carbon dioxide emissions and health expenditures for BRICS-T countries (Brazil, Russia, India, China, South Africa, and Turkey) over the period 2000-2016. The panel causality test developed by Kónya (2006) was used as the method. Based on the empirical results, it was found that there is a unidirectional positive causal relationship running from carbon dioxide emissions to health expenditures in China. In the other selected countries, no such relationship has been identified.*

Keywords: CO2 Emissions, Health Expenditures, BRICS-T Countries, Panel Causality Test, Environmental Pollution

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1. Introduction

In the modern world, production is carried out with polluting energy sources that cause environmental destruction rather than renewable energy sources. The environmental destruction of the pollutant energy sources is realized largely by the increase of carbon dioxide emissions. The most important cost of carbon dioxide emission that causes environmental damage is health-related costs.

Health-related costs are classified under two headings: Physical costs and non-physical (difficult to measure, intangible) costs. Physical costs can also be analyzed under two subheadings. The first is direct medical costs. Public health and preventive services, treatment, long-term rehabilitation, and home care expenditures are direct expenditures. Services such as hospital services and medicine are within the scope of treatment services. Health problems arising from environmental pollution directly affect the expenditures for these services. The second is the indirect costs. Indirect costs include costs other than clinical services. Expenditures in fields of management and support services, health education, R&D activities, and health insurance, etc. constitute indirect cost items. Non-physical costs are not directly measurable expenses. Non-physical costs can be grouped under four headings. The first is the loss of production and blindness caused

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by the labor force being idle due to illness. Secondly, it is the costs that individuals give up on starting treatment. Especially in high-cost severe diseases; it is a serious resource waste that individuals give up treatment after a certain period of time or failure of treatment. The third is that individuals lose their income due to illness. Fourth, the economic growth performance is negatively affected as a result of the decrease in the contribution of the workforce to the production process due to illness and low productivity (Preker et al., 2016: 713). In terms of seeing the effects of environmental destruction on health, cost elements that are difficult to measure are extremely important as well as physical costs. However, the empirical analysis focuses on physical costs depending on the data constraint.

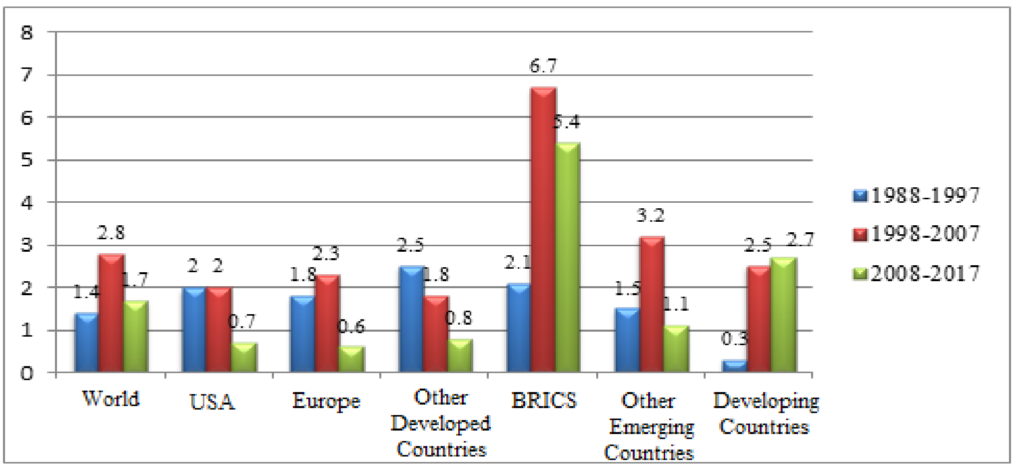
While analyzing the effects of environmental damage on health, it is necessary to focus on the main source of the increase in gas emissions. Environmental destruction is largely a cost of increased production. As the economic growth rates of countries increase, environmental quality deteriorates[1] due to the effects of carbon dioxide and other harmful gases originating from the inputs used in production, especially energy, and a large number of health issues are raised, which increase the demand for health spending. Increasing services aimed to eliminate health problems contribute to labor productivity. However, the increase in health spending caused by environmental problems creates a serious burden on the budget.

In countries where relatively high economic growth rates are achieved, the effects of health problems caused by increased carbon dioxide emissions on health expenditures can be determined by empirical research. If the findings obtained from these studies are transferred to the relevant public units, they can be considered as data sources in the determination processes of sustainable economic growth and development policies.

When a global comparison is made based on economic growth performance, it is observed that BRICS countries perform differently from other countries. As it is shown in Chart 1, growth rates in BRICS countries are significantly higher. The points that draw attention in Chart 1 are:

- Although there was a remarkable difference between the BRICS countries and other developing countries in terms of per capita growth rates in the period 1988-1997, no significant difference was observed when compared with developed countries.
- In the 1998-2007 period, the growth rate per capita in BRICS countries is well above both the world average and the average of developed countries and the average of other developing countries. The growth rate in these countries is almost 2.5 times higher than the world average.
- The difference between 2008 and 2017 is quite significant. The contraction effects of the 2008 Global Financial Crisis were felt more in developed countries. Despite deep recession trends in developed countries, strong growth performance has been achieved in BRICS countries.

Chart -1: Annual Per capita GNP Growth Rates (2005 $ PPP)



Source: Reddy et al., 2017:17.

The fact that the effects of the 2008 Global Financial Crisis devastated the growth performance of developed countries does not mean that BRICS countries are not affected at all. It should be emphasized that there is a considerable decrease in the growth performance of these countries when compared to the previous period.

Turkish economy showed a remarkable economic performance since the beginning of the 2000's. The average annual growth rate of Turkish economy during the period 2003-2018 is 5.5% (T. R. Ministry of Commerce, 2019: 8). Because of the success in macroeconomic stability and sustainable growth performance in the Turkish economy in last 15 years, a new classification as BRICS-T is created by adding Turkey to BRICS countries. It is expected that BRICS-T countries' weight will increase in the global economy in the 2020's.

The purpose of this study is to investigate the relationship between carbon dioxide emissions and health spending using data of the 2000-2016 period for BRICS-T countries (Brazil, Russia, India, China, South Africa, and Turkey). The panel causality test developed by Kónya (2006) was used to examine the relationships between the variables.

The reason why carbon dioxide emission is preferred as an indicator of environmental quality is that this variable has a decisive role in terms of health costs. As stated in Wang et al. (2019), carbon dioxide emission is the prominent greenhouse gas in terms of environmental damage and harmful effects on human health.

The selection of health expenditures in the study is due to the fact that this variable is important in terms of long-term economic growth and development performance. Health is one of the factors that increase human capital power. Education, which is another determining element of human capital, becomes meaningful if individuals are healthy. It is very difficult for unhealthy individuals to increase their knowledge and skills, and obtain maximum benefit from formal education processes. Individuals with high average life expectancies adopt improving their knowledge and skills with a long-term perspective by allocating more resources and time to education as a way of life. Knowledge and skill accumulation provide positive externalities at the social level as well as individual benefits.

Improvement in health at the individual and social level is closely related to increasing health expenditures. However, it should be emphasized that it is necessary to determine whether the increase in health expenditures is due to the costs arising from environmental costs instead of the goal of improving health. The increase in health expenditures due to environmental destruction leads to a decrease in the individual and social contributions of health.

Although there are many studies investigating health expenditures, the studies investigating the relationship between carbon dioxide emissions and health expenditures are not very numerous. In Moosa and Pham (2019)'s study, it was stated that there is a large literature on determinants of health expenditures, GDP per capita is the most important variable that determines health expenditures, whereas few studies reveal that environmental quality or environmental destruction is a key determining factor.

There are few studies investigating the relationship between carbon dioxide emissions and health expenditures in the related literature. This study fills this gap since our study investigates the relationship between carbon dioxide emission and health expenditures in BRICS-T countries. Besides, to the best of our knowledge, Kónya (2006) panel causality test has never been used in the empirical models applied in the researches in this field.

The study consists of three parts. The first part is the literature survey, the second part is the data and model, and the third part is the method and findings.

2. Literature Survey

There is an extensive literature that investigates the determinants of health spending. However, studies investigating the relationship between carbon dioxide emissions and health expenditures are not very numerous.[2] Most of the studies investigating the effects of carbon dioxide emission, which is one of the main determinants of health expenditures on health expenditures, have been carried out recently. The findings of the researches that predominantly identify positive relationships between the variables are summarized below:

Jerrett et al. (2003) investigated the relationship between health spending and environmental variables using data from 49 counties of Canada, Ontario. According to the findings, health expenditures per capita are higher in districts with high pollution output. Increasing investments to increase environmental quality leads to a decrease in health expenditures. Using the data of eight OECD countries for the period 1980-1999, Narayan and Narayan (2008) investigated the effect of environmental quality on health expenditures with the help of the panel co-integration test. In the study, sulfur acid emission, nitrogen oxide emission, and carbon monoxide emission are selected as environmental quality indicators. In the long term, it has been determined that besides income and carbon monoxide, sulfur oxide emission has a statistically significant and positive effect on health expenditures. Yahaya et al. (2016) investigated the impact of environmental quality on per capita health expenditures, using data of 125 developing countries for the period 1995–2012. Relationships between variables were analyzed using the panel co-integration test. It has been determined that environmental quality is one of the strong variables that determine health expenditures in developing countries. Among the variables chosen as the determinant of environmental quality, carbon dioxide is the highest explanatory variable in terms of per capita health expenditures. Compared to other environmental pollutants, the biggest contribution to the increase in per capita health expenditures comes from carbon dioxide.

Chaabouni and Saidi (2017) investigated the causal relationship between carbon dioxide emissions, health spending and economic growth, using data of 51 countries for the period 1995–2013. Countries covered by the study are classified as low income, upper middle income, and middle income. Relationships between variables were investigated using panel simultaneous equation models and generalized moment method (GMM). One-way causality has been identified from carbon dioxide emissions to health expenditures, excluding low-income countries. The authors suggested ensuring energy efficiency by increasing energy productivity and implementing energy-saving projects. Yazdi and Khanalizadeh (2017) investigated the role of environmental quality and economic growth in determining health expenditures by using the data of MENA countries for the period of 1995-2014. In the study, panel co-integration and panel ARDL methods were used. According to the findings, carbon dioxide emission has statistically significant positive effects on health expenditures.

Apergis et al. (2018) investigated the causality effects of carbon dioxide emissions on per capita health expenditures, using data of the US states for the 1966-2009 period. In the study, panel co-integration and panel quantile regression methods were used. According to the results obtained, the effect of carbon dioxide emission on health expenditures is stronger in regions where health expenditures are quantitatively high. The carbon dioxide emission per capita leads to an increase in per capita health expenditures at rates varying from state to state. Since the relationship between the variables is not the same in all states, the effects of policies that will decrease carbon dioxide emissions will not be felt in the same proportion in each state.

Raeissi et al. (2018) investigated the effects of air pollution (carbon dioxide emissions) on private and public health expenditures with Iran's data for the period of 1972-2014, using time series analysis methods. According to the results obtained, air pollution has a positive and significant effect on health expenditures. The increase in air pollution leads to the increase in diseases caused by pollution and the expansion of the demand for treatment. Governments also increase their spending on treatment services and preventive services. In the study, the effect of air pollution on health expenditures in the long term is greater than the short-term effects. When compared with other variables affecting health expenditures, it has been determined that environmental quality and other pollutants have the strongest effect.

Hao et al. (2018) investigated the impact of environmental pollution (sulfur dioxide emission and soot emission) on the health expenditures of residents using data of the 30 Chinese provinces for the period 1998-2015. In the study, the relationships between the variables were analyzed using the generalized moment method (GMM). According to the results obtained, environmental pollution increases the health expenditures of the citizens. On the other hand, the increase in sulfur dioxide emission per capita and the increase in soot emission increase public health expenditures per capita. The 1% increase in sulfur dioxide emission and soot emission increase the public health expenditures of citizens by 0.15% and 0.79%, respectively. Wang et al. (2019), using Pakistan's data for the period 1995-2017, investigated the relationship between carbon dioxide emissions, health expenditures, and economic growth. The authors found that carbon dioxide emissions had significant effects on health expenditures. In the study, Autoregressive (ARDL) model with Distributed lag was applied. Based on the empirical results, it was found that there was a one-way causality relationship from carbon dioxide emission to health expenditures.

Moosa and Pham (2019) analyzed the relationship between per capita health expenditures, per capita income and per capita carbon dioxide emission, using data of the world average and seven country groups over the period of 1995-2015. Relationships between variables were investigated using the ARDL model. According to the results obtained, the relationship between health expenditures and carbon dioxide emissions varies depending on the level of income per capita. The relationship between health expenditures and carbon dioxide emissions is positive for low-income countries; it is negative for high-income countries. Alimi, Ajide, and Isola (2019) investigated the causality relationship between carbon dioxide emission and health expenditures using the data of 15 ECOWAS countries for the period 1995-2014. In the study, the panel GMM method is used. The authors concluded that carbon emission has inelastic, statistically significant positive effects on public and national health expenditures. The deterioration of environmental quality increases the share of public and national health spending in GDP. There is no relationship between environmental pollution and private health expenditures.

Usman et al. (2019) investigated the impact of many economic and non-economic factors as well as carbon dioxide emissions on public and private health expenditures per capita, using the data of 13 developing countries for the period 1994–2017. Relationships between variables were analyzed using panel co-integration and panel Granger causality methods. In the long term analysis, carbon dioxide emissions have a positive and significant effect on public health expenditures. In contrast, carbon dioxide emissions are negatively associated with private healthcare spending. Finally, a one-way causality relationship has been identified between carbon dioxide emissions and public and private health spending. An and Heshmati (2019) investigated the relationship between air pollutants and health expenditures, using the data of South Korea's 16 settlements for the period 2010-2017. In the study, cost-benefit analysis was used. It was indicated that the increase in the NO_2, O_3 and PM_{10} variables increased health expenditures. Each of these variables had a positive and significant effect on health expenditures.

The number of studies that detect the negative relationship between carbon dioxide emission and health expenditures is limited. Zaidi and Saidi (2018) investigated the relationship between health expenditures, carbon dioxide emissions and economic growth using the data of Sub-Saharan African countries for the period 1990-2015. In the study, the relationships between variables were analyzed using Panel ARDL and VECM Granger causality tests. The results obtained are as follows: (1) Carbon dioxide emission in the long-run has a negative effect on health expenditures. (2) There is bilateral causality between health expenditures and carbon dioxide emissions. (3) 1% increase in carbon dioxide emission reduces health expenditures by 0.066%.

3. Data and Model

In this study, the relations between health expenditures and carbon dioxide emissions are analyzed for Brazil, Russia, India, China, South Africa, and Turkey. Data on health expenditures[3] (lhe) are taken from the World Bank database and data on CO_2 emissions[4] from the OECD (2019) database. The maximum length of time reached in common for selected countries is determined as the examination period between 2000-2016. The logarithmic transformation of the variable of health spending was realized and included in the analysis. Basically, the relationships between variables can be modeled as follows:

$$lhe_{i,t} = \beta_0 + \beta_i CO_{2_{i,t}} + u_{i,t} \quad (1)$$

$$CO_{2_{i,t}} = \alpha_0 + \alpha_i lhe_{i,t} + e_{i,t} \quad (2)$$

β_0 and α_0 in the models refer to constant terms. β_i ve α_i are the slope coefficients of the models. β_i is the coefficient that indicates the 1 unit change occurring in CO_2 will lead to a 1% change in lhe, while α_i is the coefficient that indicates that 1% change in lhe will lead to 1 unit change in CO_2. $u_{i,t}$ ve $e_{i,t}$ are error terms. The index i shows each unit/country size of the models (BRICS + T Countries), and t shows each time of the models (2000, 2001,…, 2016). The total number of countries (N) expressing the total number of all i's (i = 1,2,…, N) included in the models is 6 countries, and the entire time length T is (17) (N = 6, T = 17). Since there is no single country/unit dimension, panel data analysis was used in the study instead of time series analysis.

4. Method and Findings

In this study, the relationships between lhe and CO_2 of BIRCS-T countries were investigated using the panel causality test developed by Kónya (2006). In the causality test developed by Kónya (2006: 991), there is no obligation to determine the unit root presence in the variables and/or to determine the co-integration relationship between the variables. Also, it is important to have a cross-sectional dependency between countries and to have a heterogeneous structure in the models in order to use this causality test. For these reasons, in the study, firstly, the existence of horizontal cross-section dependence in variables and model was investigated. Secondly, the homogeneity test was performed to determine whether the coefficients in Model 1 and Model 2 differ from country to country. Finally, Kónya (2006) causality test was applied to the above models. The information about these methods are given below, and the findings of the related test are presented immediately after.

4.1. Cross-Sectional Dependency Test

In panel data analysis, it is necessary to investigate the cross-sectional dependency in variables and model. Cross-sectional dependency is related to whether a shock in a panel-owned unit/country affects other units/countries. Whether there is a cross-section dependency in variables or models have both econometric and economic implications. In this study, $BP_{LM,}$ developed by Breusch and Pagan (1980), which is frequently used in panel data analysis CD_{LM} developed by Pesaran (2004), LM_{adj} developed by Pesaran, Ullah, and Yamagata (2008), and finally LM_{BC} tests developed by Baltagi, Feng, & Kao (2012) were used to investigate the cross-section dependency. These tests can be superior to each other according to the N and T dimensions of the panel. However, since all of them are included in this study, they have not been elaborated. In order to understand the logic of these tests, it is possible to see how these tests work with the help of model 3. First, model 1 and/or 2 is estimated and residual terms such as $\varepsilon_{i,t}$, and t are derived from these models. With this derivative term derived, model 3 is estimated and statistics of the tests mentioned above are obtained[5].

$$\varepsilon_{i,t} = \alpha_i + \beta_i' z_{i,t} + \xi_{i,t} \quad (3)$$

In model 1 and 2, i is the country dimension of the variables and t is the time dimension of the variables. z_{it}, shows the independent variables in k × 1 dimension. In cross-section dependency tests for the model, $z_{i,t}$= ($\varepsilon_{i,t-1,}$… $\varepsilon_{i,t-p}$). α_i shows the constant term coefficient and β_i shows the slope coefficient. It is assumed that the residual term (ξit = ξ1t,…, ξNt) for each country now has a mean zero and constant variance. So it is $\xi_{it} \sim IID\ (0, \sigma_{i\xi}^2)$. The test statistics obtained using this information with the help of the following hypotheses provide information about whether there is a cross-section.

H_0: cov ($\xi_{i,t}$, $\xi_{j,t}$) = 0 or σ_{ij}=0 ve i ≠ j. (There is no cross-section dependence in the model.)

H_1 cov ($\xi_{i,t}$, $\xi_{j,t}$) ≠ 0 or σ_{ij}≠0 (There is cross-section dependence in the model.)

If the calculated test statistic is greater than the critical values or if the probability value of the test statistic is lower than the statistical significance levels, the H_0 hypothesis representing the hypothesis that there is no cross-section dependency is rejected. In this case, the finding of the existence of cross-section dependence is reached. Table 1 shows the cross-section dependency test results of Model 1 and Model 2.

Table 1. Cross Section Dependency Test Results

Model	Model 1		Model 2	
Test	Test Statistics	Probability	Test Statistics	Probability
BP_{LM}	76.47*	0.0001	80.40*	0.0001
CD_{LM}	10.12*	0.0001	10.84*	0.0001
LM_{BC}	9.94*	0.0001	10.65*	0.0001
LM_{adj}	-0.97	0.3289	8.06*	0.0001

* Indicates the cross-sectional dependency at 1% significance level.

Considering Table 1, H_0 is rejected because the probability values of BP_{LM}, CD_{LM} ve LM_{BC} cross-section dependency test statistics for both models are less than 1%. However, only the probability value of LM_{adj} test statistics shows the cross-section dependence for Model 2 according to a 1% significance level. It is seen that there is no cross-sectional dependency in Model 1. Since the other three test statistics show cross-section dependence in Model 1, we can say that Model 1 also has a cross-section dependency. The economic meaning of this is that a change or shock in one of the countries for these models will cause a change or shock in other countries. It is inevitable to have a cross-section dependency in countries that are already close to each other, such as their economic, political and geographical features. Therefore, the finding was not surprising. It is inevitable that the changes in macroeconomic variables and models of countries, especially in the globalizing world, trigger the changes in other countries.

4.2. Homogeneity Test

Homogeneity means that the slope coefficient β_i in model 1 is the same for every country subject to the panel. If β_i differs from country to country, the model is assumed to be heterogeneous. The concept of homogeneity/heterogeneity is an important concept for panel data econometrics. Whether there is homogeneity in the models causes the preference to be made in the methods to be used in the future stages. As stated above, models must be heterogeneous to perform Kónya (2006) causality test. The homogeneity test developed by Pesaran and Yamagata (2008) was used in this study to demonstrate whether Model 1 and Model 2 meet this requirement.

Pesaran and Yamagata (2008) developed this method. It is based on the random coefficient model developed by Swamy (1970). With this model, it is possible to test whether countries have different slope coefficients and also calculate slope coefficients. The method developed by Pesaran and Yamagata (2008: 55) offers asymptotically stronger test statistics that take into account the larger N and T size than Swamy (1970). These test statistics are shown as $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$[6]. For example, the hypotheses for the homogeneity test for Model 1 are shown as follows:

H_0: $\beta_i = \beta$, for all i's i=1,…,N'dir. (All coefficients of the countries are equal. The model is homogeneous.)

H_1: $\beta_i \neq \beta_j$, for some i≠j (Coefficient of at least one country is different. Model is heterogeneous.)

The decision-making rule for the tests is as follows: If the calculated $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ test statistics are greater than their critical values or the probability values of these statistics are lower than the statistical significance levels, H_0 is rejected. In other words, it is decided that the model is heterogeneous. Table 2 shows the homogeneity test results of Model 1 and Model 2.

Table 2. Homogeneity Test Results

Model	Model 1		Model 2	
Test	Test Statistics	Probability	Test Statistics	Probability
$\tilde{\Delta}$	12.71*	0.0001	10.13*	0.0001
$\tilde{\Delta}_{adj}$	13.93*	0.0001	11.10*	0.0001

* Shows heterogeneity at a 1% significance level.

According to Table 2, the probability values of both $\tilde{\Delta}$ test statistics and $\tilde{\Delta}_{adj}$ test statistics are lower than a 1% significance level in both models. This means that for Model 1, countries have different β, and similarly in Model 2, countries have different α. To give an example, taking into account the Model 1, the degree of influence of changes occurring in Brazil's CO_2 on lhe varies according to that of Turkey or other countries subject to analysis. Briefly, both of the models in the study are heterogeneous.

4.3. Kónya (2006) Panel Causality Test

According to the results of the cross-section dependency test, it is determined that the models have cross-section dependency and the slope coefficients of the models are heterogeneous according to the homogeneity test of these models. As stated before, two basic conditions for Kónya (2006) causality test are provided.

As stated in Kónya (2006: 982), the basis of this causality test is based on the Seemingly Unrelated Regression (SUR) system developed by Zellner (1962). With this system, Kónya (2006) applies the Granger causality test between variables to regressions for each country. It also generates bootstrap critical values for each country (i). Thus, it is stated by Kónya (2006) that it is a strong test compared to other panel causality tests.

The SUR system of the variables in this study can be written as follows:

$$\left.\begin{array}{l} lhe_{1,t} = \alpha_{1,1} + \sum_{l=1}^{ml\_lhe_1} \beta_{1,1,l} lhe_{1,t-1} + \sum_{l=1}^{ml\_CO2_1} \varphi_{1,1,l} CO_{2_{1,t-1}} + \varepsilon_{1,1,t} \\ lhe_{2,t} = \alpha_{1,2} + \sum_{l=1}^{ml\_lhe_1} \beta_{1,2,l} lhe_{2,t-1} + \sum_{l=1}^{ml\_CO2_1} \varphi_{1,2,l} CO_{2_{2,t-1}} + \varepsilon_{1,2,t} \\ \vdots \\ lhe_{N,t} = \alpha_{1,N} + \sum_{l=1}^{ml\_lhe_1} \beta_{1,N,l} lhe_{N,t-1} + \sum_{l=1}^{ml\_CO2_1} \varphi_{1,N,l} CO_{2_{N,t-1}} + \varepsilon_{1,N,t} \end{array}\right\} \quad (4)$$

and

$$\left.\begin{array}{l} CO_{2_{1,t}} = \alpha_{2,1} + \sum_{l=1}^{ml\_CO2_2} \varphi_{2,1,l} CO_{2_{1,t-1}} + \sum_{l=1}^{ml\_lhe_2} \beta_{2,1,l} lhe_{1,t-1} + \varepsilon_{2,1,t} \\ CO_{2_{2,t}} = \alpha_{2,2} + \sum_{l=1}^{ml\_CO2_2} \varphi_{2,2,l} CO_{2_{2,t-1}} + \sum_{l=1}^{ml\_lhe_2} \beta_{2,2,l} lhe_{2,t-1} + \varepsilon_{2,2,t} \\ \vdots \\ CO_{2_{N,t}} = \alpha_{2,N} + \sum_{l=1}^{ml\_CO2_2} \varphi_{2,N,l} CO_{2_{N,t-1}} + \sum_{l=1}^{ml\_lhe_2} \beta_{2,N,l} lhe_{N,t-1} + \varepsilon_{2,N,t} \end{array}\right\} \quad (5)$$

The system of model (equation) 4 is used to test the causality relationship from carbon dioxide emissions to health expenditures, and the system of model (equation) 5 is used to test the causality relationship from health expenditures to carbon dioxide emissions[7]. In both systems of equations, there are as many VAR models as the number of countries (N). In the VAR model approach, there is an imperative that the variables included in the equations are stationary or co-integrated Kónya (2006: 980). However, since there is a simultaneous correlation between the individual VAR models of many countries in the SUR system, the conditions of the VAR model do not need to be met. Wald test statistics are derived for each individual VAR model. Hypotheses can be tested by comparing these Wald test statistics obtained with the bootstrap critical values obtained for each country. In the system 4 and 5, while the coefficient $\varphi_{1,i}$ is not equal to zero for all countries and if the coefficient $\beta_{2,i}$ is equal to zero for all countries the result states that there is a one-way Granger causality from CO_2 to lhe; if $\varphi_{1,i}$ coefficient is equal to zero for all countries, and whereas $\beta_{2,i}$ coefficient is not equal to zero, then there is a one-way Granger causality from lhe to CO_2; there is bidirectional Granger causality between CO_2 and lhe if both coefficients are not equal to zero simultaneously. If both coefficients are simultaneously equal to zero, it is found that there is no Granger causality relationship between CO_2 and lhe. These causality relationships can be estimated separately for each country. Kónya (2006) panel causality test results are included in Table 3 and 4.

Table 3. Kónya Causality Test Results (Dependent Variable = lhe) **

H_0: *CO_2,deos nor Granger cause lhe.*

Country	Coefficient	Test Statistics	Critical values		
	CO_2	*Wald*	*10%*	*5%*	*1%*
Brazil	0.224	3.632	7.510	11.090	22.369
China	0.082	9.651*	8.917	13.185	26.067
India	-0.072	2.207	8.074	12.282	24.944
Russia	0.084	3.090	7.439	11.498	24.118
Turkey	-0.033	0.569	8.013	11.885	22.974
South Africa	0.045	6.976	7.194	10.487	21.238

* Refers to causality at 10%.

** Critical values were obtained by using 10000 repetitive bootsrap.

Table 3 shows the causality test results from CO_2 to lhe. According to the causality results based on the Kónya (2006) causality test, the "CO_2 is not the Granger cause of lhe" hypothesis is only rejected for China. Because the test statistics values obtained for China are greater than the bootsrap critical values that express 10% significance. Also, according to the coefficient results obtained, an increase in CO_2 in China affects lhe positively.

Table 4. Kónya Causality Test Results (Dependent Variable = CO_2) **

H_0: *lhe does nor Granger cause CO_2.*

Country	Coefficient	Test Statistics	Critical values		
	lhe	*Wald*	*10%*	*5%*	*1%*
Brazil	0.247	0.403	9.728	14.311	28.331
China	-0.022	0.001	14.401	20.368	38.026
India	-0.082	0.084	8.064	12.272	24.780
Russia	-0.087	0.025	7.922	12.198	24.539
Turkey	-0.592	8.014	8.015	11.931	24.514
South Africa	-1.229	0.609	7.114	10.802	23.430

** Critical values were obtained by using 10000 repetitive bootsrap.

Considering the studies in the literature, it is concluded that there are significant causal relationships or co-integration relations from carbon dioxide emission to health expenditures in the countries subject to analysis (Yahaya et al., 2016; Chaabouni and Saidi, 2017; Yazdi and Khanalizadeh, 2017; Apergis et al., 2018; Alimi, Ajide and Isola, 2019; Moosa and Pham, 2019; Wang et al., 2019). In this study, it is seen that there is a positive causality relationship from carbon dioxide emission to health expenditures only in China, not for all BRICS-T countries for the period 2000-2016.

Causal test results from lhe to CO_2 are shown in Table 4. According to the results, a significant causality relationship from lhe to CO_2 could not be determined for any country.

5. Conclusion

The relationship between carbon dioxide emissions and health spending has been investigated for the BRICS - T countries (Brazil, Russia, India, China, South Africa, and Turkey) over the period of 2000-2016. The relationship between the variables was examined using the panel causality test developed by Kónya (2006). According to the causality test results, the hypothesis that stated "CO_2 is not the Granger cause of lhe" is rejected only for China since the test statistics values obtained for China are greater than the bootsrap critical values that express 10% significance. According to the coefficient results, an increase in CO_2 in China affects lhe positively. Based on this result, it was found that there is a one-way positive causality relationship from carbon dioxide emission to health expenditures only in China, not for all BRICS-T countries in the period 2000-2016. On the other hand, based on causality test results it was concluded that it was not possible to find any causality relationship from lhe to CO_2.

For China, it is quite meaningful to find positive causality between carbon dioxide emissions and health expenditures. The average growth rate in the period of 2008-2017, including the years when the effects of the 2008 Global Financial Crisis deepened in China, is above the average growth rate of BRICS-T countries and is 7.7% (Reddy et al., 2017: 17). The highest growth rate in China, which is in the top rank in terms of carbon dioxide emissions in the world, has increased the emission of carbon dioxide, triggered health problems and put pressure on health expenditures.

Possible reasons for not detecting the causal relationship between carbon dioxide emissions and health expenditures in other countries examined in the study can be summarized at the following points:

It is hard to determine the reasons behind the increase in health expenditures. Many expenditures may apparently not related to environmental problems. Nevertheless, it is a fact that there are many of them directly or indirectly related to the health problems caused by environment pollution. It would be misleading to think of spending on health improvement projects, R&D spending, spending on physical infrastructure and education-training spending on health independently from health problems caused by environmental damage.

As the main component of health expenditures, the increase in public health expenditures is determined by state budget sources. During the analysis period, the 2008 Global Financial Crisis was experienced with the severe effects. Although the growth performance is relatively better in the countries included in the analysis, the contraction trends observed in almost every country before, during and after the crisis. And the deteriorated budget balances have reduced the power of the governments to increase public health expenditures.

It is not easy to demonstrate the impact of environmental degradation on health spending, health problems. Furthermore, it causes economic and social problems at the national and global level. Preventing environmental damage requires cooperation both at the national and international level. Besides, basic measures should be taken in both levels. At the national level, the sensitivity and the awareness of all social segments and ordinary citizens should be improved. Actually, sensitivity to avoid production and investments that may be harmful for the environment and human health is a matter of mentality. The sensitivity of everyone, from state administrators to ordinary citizens, does not completely eliminate environmental problems, but it makes a significant positive contribution.

Some of the prominent policy recommendations to reduce emissions of carbon dioxide and other harmful gases as well as strengthening social perception are stated below.

Attempts that will increase energy efficiency should be encouraged. Applications should cover all units such as residential and industrial organizations. Technological investments that reduce environmental pollution in residences and industrial establishments should be supported. Renewable energy investments should be encouraged and their use should be expanded.

Revenues from taxes paid by some production units or sectors are far behind the costs incurred by health expenditures caused by environmental pollution. When other health-related costs and environmental destruction are added to health expenditures, the burden on the public budget and, more importantly, social costs increase to a much larger extent. Disposal of pollution source production units or minimizing environmental impacts with technological innovations is an important requirement for long-term positive economic growth performance.

Finally, foreign direct investments should not be evaluated only in terms of production and employment, and environmental quality should not be compromised. The fact that some direct investments, which provide an increase in employment and revenue insight, increase physical and non-physical health costs should not be ignored.

Disclosure Statements

1. The authors of this article are admitted that they complied with the principles of research and publication ethics.

2. No potential conflict of interest was reported by the authors.

3. This article was screened for potential plagiarism using a plagiarism screening program.

End Notes

1. *The relationship between economic growth and environmental quality is analyzed with the help of the Environmental Kuznets Curve hypothesis (Kuznets, 1955). Grossman and Krueger (1991) is one of the first studies to address the Environmental Kuznets Curve hypothesis. In recent years, there has been a large literature investigating the relationship between economic growth and carbon dioxide emissions. For example, Marques, Fuinhas, and Leal (2018), who investigated the relationship between economic growth and carbon dioxide emissions, using the data of Australia for the 1965-2016 period found that economic growth led to carbon dioxide emissions. Erdoğan, Yıldırım, and Gedikli (2019) have identified a bidirectional causal relationship between carbon dioxide emissions and economic growth in their studies using BRICS-T countries' data for the period 1992-2016. Khan, Teng, and Khan (2019) investigated the impact of energy consumption and economic growth on carbon dioxide emissions using Pakistan's data for the 1965-2015 periods. They found that, besides economic growth, coal, oil and natural gas consumption had a positive effect on environmental pollution.*
2. *The literature survey part of this study is the revised version of the paper titled "Literature Review on the Relationship between Environmental Pollution - Health Expenditures". See. Gedikli and Erdoğan (2018).*
3. *Real health spending per capita, (PPP, $) Nominal health spending per capita was made real by the authors using the consumer price index (2010 = 100).*
4. *IEA CO_2 Emissions from Fuel Combustion Statistics: Indicators for CO_2 emissions.*
5. *More information can be found in the studies of Breusch and Pagan (1980), Pesaran (2004: 4-5), Pesaran, Ullah and Yamagata (2008: 108) and Baltagi, Feng and Kao (2012: 167).*
6. *Information about detailed and test formulas can be found in the paper of Pesaran and Yamagata (2008).*
7. *ml_lhe and ml_CO_2 represent the optimal (optimal) lag lengths, l lag length of the variables. This lag length was determined using the Akaike Information Criterion (AIC).*

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