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Application of the bootstrap panel method an empirical study of the granger causality between carbon dioxide emissions and economic growth in emerging countries

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This study discusses the dilemma countries face when implementing energy conservation policies to protect environmental resources. Implementation of such policies has reduced carbon dioxide CO_2 emissions and decreased industrial production momentum along with economic growth. This study employs the bootstrap panel Granger-causality method to address the conditions of heterogeneity and cross-sectional dependence to allow consideration of cross-country correlations. This study analyzes the link between economic growth and CO_2 emissions in 22 emerging countries from 1993 to 2011. The empirical results show that in a few countries positive and negative bidirectional causality exists between economic growth and CO_2 emissions while many countries surveyed exhibited a positive unidirectional relationship between CO_2 emissions and economic growth. A few countries showed other relationship patterns. These results imply that to pursue economic growth a country should adopt more environmentally-friendly sources of energy in addition to using those that produce CO_2 emissions.
Keywords: economic growth carbon dioxide CO2 emission bootstrap panel Granger-causality test emerging country countries.

INTRODUCTION

Purpose

The main purpose of this study is to investigate the 22 emerging countries in four continents by geographic location namely Africa Asia Europe and America and discuss them respectively to explore the possible causal relationship between CO_2 emissions and economic growth. Under this aspect the study further explores when there is a unidirectional causal relationship from CO_2 emissions to economic growth whether the reduction of CO_2 emissions will impedes economic growth or when there is unidirectional causal relationship from economic growth to the CO_2 emissions whether the reduction of CO_2 emissions will have a negative impact on economic growth.

In this study the bootstrap panel Granger-causality measurement method proposed by Konya 2006 is used to re-examine the nexus between CO_2 emissions and economic growth.

METHODOLOGY

Panel Causality Tests

Based on the proposal of Granger 1969 the Granger causality indicates that the past historical data of variable X can improve the ability of predicting another variable Y. Given the situation that cross-sectional dependence and heterogeneity exist between countries this method can illustrate this feature. Although different panel causality methods have been proposed the bootstrap penal causality method proposed by Konya 2006 is able to take into account both cross-sectional dependence and country-specific heterogeneity. The causal relationship can be tested through the bootstrap panel causality approach by estimating and Wald testing the country-specific critical values based on the SUR. The stability of variables under this system is not necessarily required indicating that there is no need to test the nature of the variables in advance through ADF and co-integration.

The utilization of the bootstrap panel causality method to estimate the system is described as follows

$$y_{1,t} = \alpha_{1,1} + \sum_{i=1}^{ly_1} \beta_{1,1,i} y_{1,t-i} + \sum_{i=1}^{lx_1} \delta_{1,1,i} x_{1,t-i} + \varepsilon_{1,1,t}$$
$$y_{2,t} = \alpha_{1,2} + \sum_{i=1}^{ly_1} \beta_{1,2,i} y_{2,t-i} + \sum_{i=1}^{lx_1} \delta_{1,2,i} x_{2,t-i} + \varepsilon_{1,2,t}$$
$$\vdots$$
$$y_{N,t} = \alpha_{1,N} + \sum_{i=1}^{ly_1} \beta_{1,N,i} y_{N,t-i} + \sum_{i=1}^{lx_1} \delta_{1,N,i} x_{1,N,t-i} + \varepsilon_{1,N,t}$$

and

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$$x_{1,t} = \alpha_{2,1} + \sum_{i=1}^{ly_2} \beta_{2,1,i} y_{1,t-i} + \sum_{i=1}^{lx_2} \delta_{2,1,i} x_{1,t-i} + \varepsilon_{2,1,t}$$
$$x_{2,t} = \alpha_{2,2} + \sum_{i=1}^{ly_2} \beta_{2,2,i} y_{2,t-i} + \sum_{i=1}^{lx_2} \delta_{2,2,i} x_{2,t-i} + \varepsilon_{2,2,t}$$
$$\vdots$$
$$x_{N,t} = \alpha_{2,N} + \sum_{i=1}^{ly_2} \beta_{2,N,i} y_{N,t-i} + \sum_{i=1}^{lx_2} \delta_{2,N,i} x_{N,t-i} + \varepsilon_{2,N,t}$$

where y denotes the economic growth x is the CO_2 emissions and l is the length of time delayed. Because each equation under the system has different predetermined variables as long as the error terms may contemporaneously have correlations i.e. cross-sectional dependencies such an equation set is regarded as the SUR system.

To test Granger-causality on the system the causal relationship can be divided into four categories 1 if estimated parameters $\delta_{1,i}$ are not all zero and $\beta_{2,i}$ are all zero there is a unidirectional causal relationship from variable X to variable Y 2 If estimated parameters $\delta_{1,i}$ are all zero and $\beta_{2,i}$ are not all zero there is a unidirectional causal relationship from variable Y to variable X 3 If neigher estimated parameters $\delta_{1,i}$ nor $\beta_{2,i}$ are zero there is bidirectional leading–lagging Granger causality between variables X and variables Y. 4 If both estimated parameters $\delta_{1,i}$ and $\beta_{2,i}$ are zero there is no any Granger causality between variables X and variables Y.

Because the causality test is resulted from the selection of a lag structure the choice of the optimal lag number is very important. Therefore the number of lag periods should be described and determined prior to estimation. For the large panel data the equation the variables and the lag structure may lead to a computational burden. To solve this problem Konya 2006 proposed to take into account the maximum lag period between different variables rather than between the same equations. If a lag periods is assumed as 1-4 to estimate the potential pair combinations of ly_1 lx_1, ly_2 and lx_2 under the system in accordance to the Schwarz Bayesian criterion SBC the minimum SBC value will be selected to determine the number of the optimal lag periods.

RESULTS AND DISCUSSIONS

Results and Discussions of the Bootstrap Panel Causality Tests

The determination of the cross-sectional dependence existence and slope heterogeneity in all the countries of four continents can support the empirical results of the bootstrap panel Granger-causality approach. The empirical results of Granger causality between economic growth GDP and CO_2 emissions in the four continents are shown in Table 4.4 – 4.11.

The results of Table 4.3 show that there exists no nexus from economic growth to CO_2 emissions. The results of Table 4.4 show that for the five countries located in Africa, at the 5% significance level the Wald statistics of Egypt and Morocco are greater than the bootstrap critical value and are against the null hypothesis that economic growth will not outpace CO_2 emissions and present a unidirectional relationship from economic growth to CO_2 emissions. However there are no significant relationships between South Africa Zambia and Namibia according to the statistical results.

As we learned from the results in Table 4.5 and 4.6 for the seven countries in Asia there is a bidirectional causal relationship between the economic growth and CO_2 emissions in Korea whereas there is a unidirectional causal relationship from the economic growth to CO_2 emissions in India the Philippines and Malaysia. In China Thailand and Indonesia on the other hand there is no relationship between economic growth and CO_2 emissions.

The results from Table 4.7 and 4.8 show that for the five countries in Europe there is a unidirectional relationship from economic growth to CO_2 emissions in Poland but there is a unidirectional relationship from CO_2 emissions to economic growth in Hungary. In Turkey the Czech Republic and Russia on the other hand there is no relationship between economic growth and CO_2 emissions.

As we learned from the results in Table 4.9 and 4.10 for the five countries of America there is a bidirectional relationship between economic growth and CO_2 emissions in Mexico but there is a unidirectional relationship from economic growth to CO_2 emissions in Brazil Colombia and Chile. In Peru however there is no relationship between economic growth and CO_2 emissions.

The causal relationships between economic growth and CO_2 emissions in the above 22 emerging countries of the four continents are shown in Table 4.11.

CONCLUSIONS

The present study analyzes the causal relationships between the economic growth and CO_2 emissions in 22 emerging countries for the period from 1993 to 2011. For the five countries located in Africa there are unidirectional relationships from economic growth to CO_2 emissions in Egypt and Morocco. For the seven countries located in Asia there is a bidirectional relationship between economic growth and CO_2 emissions in Korea whereas in India the Philippines and Malaysia there are unidirectional relationships from economic growth to CO_2 emissions. For the five European countries there is a unidirectional relationship from economic growth to CO_2 emissions in Poland whereas in Hungary there exists a unidirectional relationship from CO_2 emissions to economic growth. For the five American countries there are bidirectional relationships between economic growth and CO_2 emissions in Mexico whereas in Brazil Colombia and Chile there are unidirectional relationships from economic growth to CO_2 emissions.

In addition to the positive and negative bidirectional causality between economic growth and CO_2 emissions respectively in Mexico and Korea there is a positive and unidirectional relationship from CO_2 emissions to economic growth in Egypt Morocco India Malaysia and Poland whereas the results of the Philippines are on the opposite. At last we observe the negative and unidirectional relationship from CO_2 emissions to economic growth only in Hungary.

RECOMMENDATIONS

Based on the discussion of the causal relationship between economic growth and CO_2 emissions of the above 22 emerging countries we have learnt the dilemma faced by the countries on the implementation of energy conservation policies for the protection of environmental resources because the implementation of energy conservation policies has not only reduced the CO_2 emissions but also driven down the industrial production momentum along with their economic growth. However for the two countries of Korea and the Philippines in this study the former has negative and the bidirectional causal relationship between economic growth and CO_2 emissions and the latter has a negative and unidirectional causal relationship from economic growth to CO_2 emissions. That is to say to pursue the positive economic growth of a country in addition to the use of energy that produces CO_2 emissions policy makers can adopt alternative energy that is more environment friendly as the energy for corporate expansion to promote the economic growth of the country.

Table 4.1. Cross-sectional Dependence Tests

Continent	Variable	CD_{bp}	CD_{lm}	CD
Africa	Economic	12.989***	0.549***	6.945***
Asian	growth/	37.028***	3.244***	15.869***
Europe	CO_2	20.958***	1.431***	8.811***
America	emissions	8.156***	1.754***	4.347***

Note *** at the 1% significance level the null hypothesis of invalid cross-sectional dependence is rejected.

Table 4.2. Slope Homogeneity Tests

Continent	Variable	SH
Africa		226.9***
Asian	Economic growth/ CO_2 emissions	245.23***
Europe		150.97***
America		114.47***

Note *** at the 1% significance level the null hypothesis of slope homogeneity is rejected.

Table 4.3. H_0 CO_2 Emissions Will Not Outpace Economic Growth

Country	Wald Statistic	Bootstrap Critical Values		
		1%	5%	10%
Egypt	2.716	17.416	9.333	6.199
Morocco	0.009	17.371	8.284	5.514
South Africa	0.816	18.855	10.034	6.502
Zambia	4.767	19.038	10.392	6.966
Namibia	2.170	24.534	11.481	7.626

Note 1. Bootstrap critical values are obtained from 10,000 replications.

Table 4.4. H_0 Economic Growth Will Not Outpace CO_2 Emissions

Country	Wald Statistic	Bootstrap Critical Values		
		1%	5%	10%
Egypt	37.022***	15.162	7.530	5.102
Morocco	17.234***	16.695	8.368	5.596
South Africa	1.804	14.432	7.394	5.060
Zambia	8.132	23.775	12.550	8.931
Namibia	2.528	21.725	10.924	7.414

Note 1. Bootstrap critical values are obtained from 10,000 replications.

Table 4.5. H_0 CO_2 Emissions Will Not Outpace Economic Growth

Country	Wald Statistic	Bootstrap Critical Values		
		1%	5%	10%
India	1.676	29.190	15.878	10.751
The Philippines	0.283	22.697	11.148	7.355
Indonesia	1.431	30.468	16.205	11.081
Malaysia	3.288	26.511	13.671	8.966
Thailand	0.000	27.848	12.640	8.242
Korea	12.339**	21.163	10.573	7.083
China	9.147	29.003	13.350	9.164

Note 1. Bootstrap critical values are obtained from 10,000 replications.

Table 4.6. H_0 Economic Growth Will Not Outpace CO_2 Emissions

Country	Wald Statistic	Bootstrap Critical Values		
		1%	5%	10%
India	15.449***	15.100	8.270	5.518
The Philippines	6.051*	15.112	7.926	5.363
Indonesia	0.485	15.836	7.258	5.007
Malaysia	11.229**	14.116	7.410	5.058
Thailand	0.974	17.794	8.502	5.692
Korea	16.853**	17.697	9.337	6.271
China	0.725	25.273	13.020	8.752

Note 1. Bootstrap critical values are obtained from 10,000 replications.

Table 4.7. H_0 CO_2 Emissions Will Not Outpace Economic Growth

Country	Wald Statistic	Bootstrap Critical Values		
		1%	5%	10%
Hungary	22.071***	17.139	8.727	5.666
Poland	0.282	16.421	8.489	5.527
Russia	2.050	19.335	8.854	5.771
Turkey	1.055	17.692	8.733	5.514
The Czech Republic	0.427	17.343	8.252	5.567

Note 1. Bootstrap critical values are obtained from 10,000 replications.

Table 4.8. H_0 Economic Growth Will Not Outpace CO_2 Emissions

Country	Wald Statistic	Bootstrap Critical Values		
		1%	5%	10%
Hungary	0.212	15.054	7.544	4.944
Poland	15.824***	15.542	8.283	5.701
Russia	1.878	14.139	7.539	5.011
Turkey	0.512	14.595	7.679	5.035
The Czech Republic	0.008	12.864	7.033	4.769

Note 1. Bootstrap critical values are obtained from 10,000 replications.

Table 4.9. H0 CO2 Emissions Will Not Outpace Economic Growth

Country	Wald Statistic	Bootstrap Critical Values		
		1%	5%	10%
Brazil	0.836	19.311	10.081	6.774
Mexico	8.388**	14.854	8.178	5.812
Colombia	1.548	15.134	7.560	4.976
Chile	2.974	15.904	7.950	5.273
Peru	0.285	15.941	8.064	5.492

Note 1. Bootstrap critical values are obtained from 10,000 replications.

Table 4.10. H_0 Economic Growth Will Not Outpace CO_2 Emissions

Country	Wald Statistic	Bootstrap Critical Values		
		1%	5%	10%
Brazil	20.285***	14.528	6.966	4.608
Mexico	14.058**	18.615	8.775	5.574
Colombia	5.466*	13.874	7.339	4.870
Chile	30.269***	13.079	7.180	4.956
Peru	4.009	15.344	7.582	4.995

Note 1. Bootstrap critical values are obtained from 10,000 replications.

Table 4.11. The Leading–Lagging Relationships between Economic Growth and CO_2 Emissions

Africa	
Egypt	GDP→CO_2
Morocco	GDP→CO_2
South Africa	No leading–lagging relationship between economic growth and carbon emissions
Zambia	No leading–lagging relationship between economic growth and carbon emissions
Namibia	No leading–lagging relationship between economic growth and carbon emissions
Asia	
India	GDP→CO_2
The Philippines	GDP→CO_2
Indonesia	No leading–lagging relationship between economic growth and carbon emissions
Malaysia	GDP→CO_2
Thailand	No causal relationship between economic growth and carbon emissions
Korea	CO_2↔ GDP
China	No causal relationship between economic growth and carbon emissions

Table 4.11. Continued

Europe	
Hungary	CO_2→GDP
Poland	GDP→CO_2
Russia	No causal relationship between economic growth and carbon emissions
Turkey	No any causal relationship between economic growth and CO_2 emissions
The Czech Republic	No causal relationship between economic growth and carbon emissions
America	
Brazil	GDP→CO_2
Mexico	CO_2↔ GDP
Colombia	GDP→CO_2
Chile	GDP→CO_2
Peru	No causal relationship between economic growth and carbon emissions

Note 1. → Unidirectional causal relationship
2. ↔ Bidirectional causal relationship

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