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The Long-Run Association between Corruption and CO_2 Emission: Evidence from Developing Economies

Yolsuzluk ve CO_2 Emisyonu Arasındaki Uzun Dönem İlişkisi: Gelişen Ekonomilerden Kanıt

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ÖZ

Çevresel düzenlemeler ve politikaların belirsizliği yüksek şekilde yolsuz ülkelerde yaygındır. Bu çalışma; bir ülkede uzun dönemde yolsuzluğun karbondioksit emisyonunu kötüleştirdiğini öne süren hipotez için ampirik bir kanıt aramaktadır. Analizlerimizi uygulamak için 127 gelişmekte olan ekonominin 2002-2017 dönemi dengeli panel verileri kullanılmıştır. Yolsuzluk ve karbondioksit emisyonu arasında bir eş-bütünleşme ilişkisi elde edilmiştir. Tahmin sonuçlarına göre; uzun dönemde yolsuzluktaki bir artış karbondioksit emisyonunu istatistiksel olarak anlamlı şekilde arttırır. Diğer bir deyişle; yolsuzluktaki %1'lik bir artış karbondioksit emisyonunu %1,05 kadar yükseltir. Ayrıca, değişkenlerin serileri arasında iki yönlü nedensellik bulunmuştur.

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A B S T R A C T

Given the motivation of that lax environmental regulations and policies are common in highly corrupted countries; this study seeks empirical evidence for hypothesis asserting that corruption worsens CO_2 emission in a country in the long run. We used a balanced data of 127 developing economies for the period of 2002 and 2017 to implement our analyses. A cointegration association between corruption and CO_2 emission was identified. According to the estimation results, an increase in the corruption significantly increases CO_2 emission in the long run. In other words, CO_2 emission goes up by 1.05% given a 1% rise in corruption. Also, a two-way causality between series of corruption and CO_2 emission was found.

1. Introduction

Corruption is a common problem around the world. Due to its unfavourable effects, studies have tried to examine the costs of corruption. Specifically, interest in the economic effects of corruption has grown over the last few decades in the literature. For example, the work by Jain, et al., (2017) found that there exists a significant adverse impact of corruption on foreign portfolio investments. Zakharov (2019) also found that corruption will display a significantly

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negative impact on both fixed capital investment and foreign direct investment (FDI). On the contrary, Egger and Winner (2005) interestingly found strong evidence that a statistically significant and positive relationship between corruption and FDI appears. This finding suggested that public officials tend to have gains obtained from foreign investors. In addition, Cooray and Dzhumashev (2018) discovered that a greater corruption level is linked to a lower labour force participation rate and labour supply due to higher taxes on labour and the spreading of the shadow economy in 132 countries. Therefore, as expected from the empirical literature, many papers have argued whether there are harmful effects of corruption on economic growth. In this regard, many empirical studies have pointed out possible effects of corruption on economic growth (Huang, 2016; Alfada, 2019; Gründler and Potrafke, 2019). Using data from African economies, the study of d'Agostino et al., (2016) pointed out that the magnitude of negative effects of corruption on economic growth varies across different interactions between corruption and several types of government spendings.

In addition to the economic effects of corruption, the existing empirical papers have introduced the relationship between corruption and air pollution. Thus, it is worth highlighting to identify how the driving force of corrupt behaviours plays a significant role in air pollution. Previous studies, such as that of Candau and Dienesch (2017), reported an inverse correlation between corruption and environmental protection standards in high-income countries. Dincer and Fredriksson (2018) concluded that rising corruption levels reduce the power of environmental protection policies applied by the public authorities in a country. Therefore, it can be said that corruption is one of the virtual troubles to hamper environmental standards.

More specifically, corruption can also affect air pollution directly. In the literature on environmental quality, papers have discussed the relationship between corruption and air pollution (e.g., Chen et al., 2018; Sinha et al., 2019). For example, Lisciandra and Migliardo (2017) provided evidence of the direct effects of corruption on environmental quality. Empirical results revealed that corruption reduces environmental quality. In addition to the direct effects of corruption, a few papers in the corruption literature have investigated both the direct and indirect effects of corruption on levels of air pollution. An important example in this context is the work of Cole (2007), who attempted to examine the relationship between corruption and exposure to air pollution. It was suggested that there are both direct and indirect effects of corruption on exposure to air pollution. Consistently with the findings of the previous literature, the direct effect of corruption on exposure to air pollution was reported to be positive, although the indirect effect of corruption was interestingly negative. This indirectly negative effect of corruption on exposure to air pollution was examined, and it was suggested that reducing corruption leads to an increase in environmental degradation because increasing income level through reducing corruption leads to an increase in consumption and investment demand and thus rises air pollution emission.

This paper tries to close existing gaps in the literature in several ways. First, the goal of this study is to explore the causality relations between corruption and CO_2 emissions. Second, our paper addresses whether there is a long-run association between corruption and CO_2 emissions for observations of 127 economies over the period from 2002 to 2017 not just for long-run group mean estimations but also for long-run country specific estimations as well. Hence this study by providing long-run country specific coefficient estimations will help us to be informed on how the impact of corruption on CO_2 emissions varies across countries in the sense of both magnitude and direction of coefficients.

The remainder of our study is divided as follows. Section 2 offers a detailed theoretical and empirical literature review of corruption and air pollution. Section 3 presents the data and method used in this study. Section 4 provides and explains the empirical results of the analyses. Finally, Section 5 presents conclusions and a discussion.

2. Theoretical and Empirical Literature

2.1. Theoretical and Empirical Framework for Corruption

Governmental corruption is defined as individual misuse of a position by a public officer for personal benefit. For instance, public officers may accept bribes for providing receipts of permission or customs permits, or for forbidding the entry of a rival firm in the same contract (Shleifer and Vishny, 1993: 3). However, it is worth noting that corrupt behaviours are not associated with all illegal activities because acts realized through public power may only cause corrupt activities. Therefore, in general, corruption refers mainly to crimes committed by public officials for self-interest. In this regard, as defined above, although the definition of corruption seems straightforward, it has also been argued whether there are differences in various types of corruption. For example, the study of Jain (2001: 73-75) examined three specific forms of corruption, including grand, bureaucratic, and legislative corruption, within democratic societies. In this context, grand corruption means that political elites exploit their public power for personal gain, while bureaucratic corruption implies that appointed bureaucrats who act in unison with their superiors are more likely to seek bribes. Legislative corruption involves interest groups that prefer to influence the legislative power of legislators and thus may get unearned income through the laws to be enacted by legislators. On the other hand, legislators that enact legislation to create economic rents for the benefit of such interest groups will make profits, such as the accumulation of illegal assets through bribery and political power through re-election.

The costs of corruption are an indisputable truth, and this has led to pressure on economies at the macroeconomic level in all countries, although the corruption experiences of developed and developing countries appear to have different costs to a lesser or greater degree. Without doubt, corruption increases the likelihood of weak economic performance in a country in terms of many economic variables. In the conventional view of the corruption literature, the impacts of corruption are an important part of economy literature to examine its costs. Most authors have chosen to study the possible impacts of corruption, and this is particularly true in the case of economic impacts. For instance, Grandes and Coremberg (2020) demonstrated that the costs of corruption in countries with weak institutionalism are generally lower levels of total factor productivity and a destabilized macroeconomic structure in the economy. Moreover, the adverse relationships between corruption, economic growth, and income inequality are a key concern in the corruption literature. For instance, Gyimah-Brempong (2002) established that increased corruption levels in African countries bring about a decrease in economic growth, while corruption also increases income inequality in countries with higher corruption degree (see also Barreto, 2001; Wang, 2020).

In addition to explaining its costs, the solution of corruption problems may be one of the important issues behind efficient allocation of resources. As stated above, if corrupt behaviours cannot be prevented in a country, it will result in an increase in resource inefficiency and higher costs. Moreover, it becomes a main obstacle to improvements in economic, social, technologic, and institutional quality. Therefore, it leads to lower capacity of the country's economic potential in these areas. At this point, an important question is raised: What should governments do to minimalize the level of corruption in their states? An alternative empirical pathway may be to specify the determinants of corruption. Thus, examining the determinants of corruption becomes an important research issue in the corruption literature because the economic, social, technological, and institutional determinants of corruption could provide support to reduce corrupt behaviours. In other words, if the determinants of corruption could be identified in a country, it may help to find the causes of corruption and, therefore, this information would contribute to resolving the adverse effects of corruption problems. In this regard, numerous researchers have tried to discover the determinants of corruption to prevent its negative effects, involving economic, social, technological, and institutional dimensions (Hunady, 2017; Ghaniy and Hastiadi, 2017; Sassi and Ali, 2017; Jetter and Parmeter, 2018).

In the context of seeking ideal solutions for corruption, lawyers, businesspeople, and economists consider potential mechanisms to reduce corruption problems. For instance, according to lawyers, by increasing the punishment for misuse of power by public servants to gain personal benefit, it will be possible to reduce corruption. However, businessmen often argue that corrupt behaviours committed by public officers may be associated with their low salaries, because the salaries of bureaucrats are often quite low and inadequate compared to the salaries of private-sector ones. Thus, the basic method proposed for reducing corruption is to raise the wages of public officers. Although there are many suggested reasons, economists generally focus on the concept of competition, as corruption control is easier in countries in which there is perfect competition (see also Ades and Di Tella, 1999: 982; Svensson, 2005: 33).

2.2. Theoretical and Empirical Framework for Air Pollution

Although environmental quality has been demanded by societies, they also could not abandon consumption habits to reduce the exposure to air pollution. Higher consumption demands as a result of higher incomes result in higher production levels, thus deteriorating environmental quality due to more global warming and air pollution. Air pollution is an important sample of environmental problems. Policymakers have enforced national and international control policies against exposure to air pollution and global warming. In this regard, despite the positive effects of environmental control policies, the efficiency of air quality regulations remains a crucial issue. If policymakers apply ineffective environmental regulations, such as excessive or insufficient regulations, the potential consequences of air pollution will cause additional costs for economic activities. For example, if the negative effects of air pollution are undervalued, it could lead to excessive economic activities and increased mortality levels due to lower levels of air pollution regulations. On the other hand, excessive environmental regulations could hinder economic activities and, therefore, the economy could move away from its economic potential path (Yang and Zhang, 2018: 443). Therefore, there should be effective choices for environmental regulations; otherwise, ineffective regulations will cause one of the two negative effects of excessive levels of air pollution or low economic activities.

In this sense, several empirical studies have concentrated on the assessment of the relationships between environmental pollution and social variables, and between economic activities and environmental pollution.

From the perspective of environmental pollution regarding social issues, there are a vast number of empirical studies showing that pollution has significant effects on human health. Khoshnevis Yazdi and Khanalizadeh (2017) provided evidence that there is a significant impact of environmental quality on the determination of economic magnitude of health expenditures. Their results showed a positive and statistically significant influence of air pollution on the extent of health expenditures. Air pollution is among the most important causes of mortality and determinants of life expectancy. In this regard, mortality and life expectancy rates in most countries are basic indicators of human health problems based on air pollution. In previous studies, the typical sample for the impact of pollution on mortality and life expectancy has been the Chinese economy, because China has seen both higher income growth and air pollution levels together. In this sense, when looking at experience of China's economy, from 1990 to 2010, the rapid expansion of Chinese exports visibly worsened the country's environmental quality. In spite of positive effects of high exports into the world markets, the study of Bombardini and Li (2020) found evidence in support of the positive impact of pollution on infant mortality with export expansion in Chinese economy. Thus, higher export levels in China have been linked to higher air pollution that causes health problems, including higher levels of infant mortality. There are also several studies that economically examine the relationship between pollution and life expectancy. In Chinese economy, it is expected that economic growth is associated with higher life expectancy and can lead to lower mortality rates from non-cardiorespiratory diseases. On the other hand, the higher economic activity can also cause exposure to higher pollution levels, and this leads to falls in life expectancy due to high levels of cardiorespiratory diseases. Thus, air pollution is an important factor in explaining life expectancy in China's economy (Ebenstein et al., 2015: 227). Wen and Gu (2012) suggested that the higher outdoor air pollution levels in Chinese economy could lead to a reduction of life and health expectancies for older adults. Therefore, better air quality, which entails lower air pollution levels, is associated with positive effects on various variables while many studies have been performed to present empirical evidence of the inverse impacts of pollution.

From the perspective of environmental pollution regarding economic issues, this section is structured into two parts; first, a literature review of some studies done to explore empirical evidence on factors affecting exposure to air pollution is presented, and second, we focus on some studies that established the effects of air pollution on economic variables.

Firstly, the existing papers on the economic determinants of air pollution are mostly related to the growth of economic activities. In this regard, Omri (2013) investigated the relationship between energy consumption and economic growth. According to the results of that paper, a bidirectional causal relationship exists between energy consumption and economic growth. This implies that a rise in economic growth corresponds with a rise in energy consumption. In addition, papers reveal that energy use through economic activities is in a long-term relationship with air pollution. Thus, increases in economic activities have resulted not only in significant raises in energy usage but also increases in air pollution. For example, according to the findings of Katircioglu (2014), the long-term coefficient of energy consumption based on air pollution in Turkey is positively and statistically significant. In other words, in the long run, high levels of energy consumption will lead to environmental degradation. In the empirical literature, many researchers have also examined the validation of the environmental Kuznets curve (EKC) hypothesis, in which economic growth is also strongly associated with environmental quality. The EKC hypothesis implies a process that represents a popular inverted U-shaped relationship between economic growth and environmental quality. Namely, an increase in the income per capita causes more air pollution, i.e., environmental degradation, in the initial part of the process. In the next part of the process, the level of environmental pollution begins to decline with increased income per capita after reaching a specific threshold value of output. The studies of Apergis and Ozturk (2015), Solarin et al., (2017), and Kong and Khan (2019) concentrated on evaluating the robustness of the EKC hypothesis. More specifically, most previous papers have made empirical attempts to address the nexus between economic growth, air pollution, and energy consumption. In this regard, most such studies in the literature, such as those by Acaravcı and Ozturk (2010), Arouri et al., (2012), and Alam et al., (2016), have evaluated the growth-energy-pollutants nexus.

Secondly, the economic consequences of air pollution have been studied extensively in the literature. In this sense, it is believed that the costs of air pollution exposure have been associated with increased health problems. Focusing on the adverse impacts of pollution on human health, a number of papers in this context have found a negative relationship between the variables, including those of Jeong (2013), Brunekreef (2010), Lee et al., (2019), and Rovira et al., (2020). There are many papers specifically analysing the impacts of pollution on health expenditures. For example, Usman et al., (2019) confirmed that environment pollution significantly reduces public health, while there is a positive correlation between air pollution and public health expenditures in emerging economies. In addition to assessing increases in health problems through exposure to air pollution, it should be noted that health problems may also create economic losses. In this regard, previous papers have pointed out that environmental pollution may influence labour productivity. Health quality in the labour market is a very important factor for economic performance because it contributes human capital investments and thus higher economic growth. Many studies have already analyzed the relationship between air pollution and labour productivity (Graff Zivin and Neidell, 2012; Chang et al., 2019). Additionally, the study by Li and Zhang (2019) pointed to evidence that air pollution has a negative effect on foreign direct investment inflows. According to their results, economies having higher pollution levels are less preferable to foreign firms. Although they expect to reach maximum profits in the economies in which they invest, air pollution may increase their costs. If for example, a country has an important level of pollution, foreign firms must spend more on health insurance for the health of the labour force and thus get less profitability. The study by Li et al., (2020) also revealed that environmental pollution is a cost for income distribution in countries. Their results suggested that an increase in air pollution results in deteriorating income equality due to air pollution, which affects human health and widens income inequality by increasing brain drain.

Consequently, it is possible that deteriorating environmental quality could negatively affect economic performance.

3. Data and Methodology

This paper tries to discover the long-run relationship between corruption and CO2 emission in developing economies. The data used in analyses are a balanced data of 127 developing countries and cover the time period 2002-2017. Intuitively, a positive interaction is anticipated between corruption and CO2 emission since lax environmental regulations and policies prevail in highly corrupted societies. Therefore, we hypothesize that corruption deteriorates CO2 emission in a country.

Data on corruption are gathered from World Governance Indicators (WGI) database of the World Bank. As can be understood from its official description of “Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests”, corruption data reveal the degree of corruption existing in an economy. It is measured between -2.5 and 2.5 with higher score implying less corrupt activities. In order to evaluate interpretations easy, we multiplied those scores with -1 so that new higher values reflect the more corrupt activities. The data for CO2 emission are collected from The Emissions Database for Global Atmospheric Research (EDGAR).

Moreover, log transformations of both variables were used to get the elasticity coefficients. So, all the coefficients indicate the response of CO2 emission variable to corruption in percentage terms.

One of the potential problems in analyses using panel data is the presence of cross-section dependency across panels. Therefore, we conduct various tests to check the presence of cross-section dependency. In the case of cross-section independency, first generation unit root tests could be implemented as stationarity test. On the other hand, in the case of cross-section dependency, second generation unit root tests must be carried out. After checking the integration order of each variable and given that each variable is I(1), Westerlund’s (2005) cointegration tests are implemented to see if there is a long-run relation between CO2 emission and corruption. Next Swamy’s (1970) test for the parameter homogeneity is conducted to find out proper method in the estimation of long-run elasticity coefficients. Based on the finding of Swamy’s (1970) test, the Pesaran (2006) Common Correlated Effects Mean Group (CCEMG) estimation method, which takes into account cross-section dependence and allows for heterogeneous slope coefficients across countries, is identified as the suitable estimation method. Lastly, Dumitrescu and Hurlins’s (2012) Granger causality tests are performed to figure out the direction of the causality between CO2 emission and corruption variables.

In order to check the validity of our hypothesis we estimated following panel error correction model with one lag, which enables us to get short and long-run country specific coefficients:

$$\Delta LogCO_{2_{it}} = \psi_i(LogCO_{2_{it-1}} - \theta LogCORRUPTION_{it-1}) + \sum_{j=1}^{p-1} \lambda_{ij}\,\Delta LogCO_{2_{it-j}} + \sum_{j=0}^{p-1} \delta_{ij}\,\Delta LogCORRUPTION_{it-j} + \pi_i + u_{it}$$

where is error correction term for i-th country, and π_i stands for country specific fixed effect.

4. Empirical Findings

Table 1 documents Pesaran's cross-sectional dependency test (Pesaran, 2004; Pesaran, 2015) results. The null hypothesis of the test assumes cross-section independence across panels. As seen from the table, the null hypothesis is rejected at least at 5% significance level and thus both corruption and CO_2 emission variables are correlated across panels.

Table 1: Cross-sectional Dependency Test

Variable	CD- test	p-value
LogCORRUPTION	2.17	0.030
LogCO_2	187.091	0.000

Source: Authors.

Error tests for cross-section independence (i.e., Breusch and Pagan (1980) LM test, the Pesaran et al., (2008) bias adjusted LM test, and the Pesaran (2004) cross-dependence test) are conducted and reported in Table 2. The null hypothesis claims that there is no correlation in error terms across panels. According to the test results, the null hypothesis is rejected at 1% significance level.

Table 2: LM Error Test for Cross-Section Independence

LogCO_2 and LogCORRUPTION		
Test	Statistic	P-value
Breusch and Pagan (1980) LM Test	3.3e+04	0.0000
Pesaran et al., (2008) Bias Adjusted LM Test	420	0.0000
Pesaran (2004) Cross-Dependence Test	115	0.0000

Source: Authors.

As indicated by the findings of Table 1 and 2, we may conclude that the cross-section dependency exists for CO_2 emission and corruption variables; therefore, instead of first-generation panel unit root test, we utilize second generation panel unit root test accounting for cross-section dependency.

Regarding to second generation panel unit root tests, we first implemented CIPS test for unit roots developed by Pesaran (2007) and reported the results in Table 3. CIPS unit root test results imply that both corruption and CO_2 variables are stationary in first differences (i.e., I(1)) at 1% significance level.

Table 3: CIPS Unit Root Test

Variable	CIPS stat.	Critical Value at1%
LogCORRUPTION	-2.153	-2.36
LogCO_2	-2.080	-2.36
Variable	CIPS stat.	Critical Value at 1%
1st. Diff. LogCORRUPTION	-3.940***	-2.43
1st. Diff. LogCO_2	-3.624***	-2.43

*** stands for significance at 1% level.
Source: Authors.

Secondly Pesaran's CADF test proposed by Pesaran (2003) is conducted and the test results are displayed in Table 4. As seen from the table, each variable is non-stationary at levels, but they become stationary after taking their first differences at 1% significance level. That is, LogCORRUPTION and LogCO_2 series are integrated of order one (i.e., I(1)).

Table 4: Pesaran's CADF Test

Variable	t-bar	Critical Value at 1%
LogCORRUPTION	-1.923	-2.140
LogCO_2	-1.919	-2.140
Variable	t-bar	Critical Value at 1%
1st. Diff. LogCORRUPTION	-2.880***	-2.160
1st. Diff. LogCO_2	-2.376***	-2.160

*** stands for significance at 1% level.
Source: Authors.

Since all series are I(1) based on results of CIPS Unit Root Test and Pesaran's CADF Test, cointegration tests can be conducted between two series. Table 5 shows the Westerlund (2005) cointegration test findings. The table reports the results for two different cases. The first panel of Table 5 displays test result for the case in which alternative hypothesis claims cointegration in just some panels. The second panel of Table 5 documents test result for the case in which alternative hypothesis claims cointegration in all panels. In both cases, we are able to reject the null hypothesis at 1% significance level and these finding hints that CO_2 emission variable is cointegrated with corruption variable. In other words, there is a long-run association between the two variables.

Table 5: Westerlund Cointegration Test

H_0: No cointegration		
	Statistics	P-value
LogCO_2 and LogCORRUPTION	10.9176	0.0000
H_0: No cointegration		
H_a: All panels are cointegrated		
	Statistics	P-value
LogCO_2 and LogCORRUPTION	6.5824	0.0000

Source: Authors.

After identifying a long-run co-movement between two variables, we conducted Swamy's (1970) parameter homogeneity test to choose between the estimation methods assuming homogeneous and heterogeneous coefficients for all panels. The null hypothesis of the test asserts that parameters are homogeneous. The test results are shared in Table 6 and according to the table we can easily reject the null hypothesis. This hints that there is country-specific heterogeneity in coefficients and thus the relationship between CO_2 emission and corruption variables is heterogeneous across countries. Based on the result of Swamy test, Pesaran's CCEMG estimation method, which allows to heterogeneous coefficients across countries besides cross-section dependency, is employed in our long-run estimation analyses.

Table 6: Swamy's Parameter Homogeneity Test

	Statistics
LogCO_2 and LogCORRUPTION	1.5e+06***

*** stands for significance at 1% level.
Source: Authors.

Table 7 reports elasticity coefficients for CO_2 emission with respect to corruption for both mean group and group specific estimations. The table depicts the estimation results only for the countries for which coefficient of error correction term is negative and both coefficient of error correction term and long-run coefficient are statistically significant at conventional significance levels. Meantime we did not report the country specific short-run coefficients to save space and since our main objective is to conduct a long-run analysis not a short-run analysis. Considering the mean group estimation results, coefficient of error correction term significantly takes the anticipated negative sign, and this implies that there is a log-run association between CO_2 emission and corruption. The long-run coefficient for corruption is positive and statistically significant at 10% significance level. Thus, this result reveals that a 1% increase in corruption augments CO_2 emission on average by 1.05%. For group specific estimations, we do not have a unique pattern for the impact of corruption on CO_2 emission. As pointed out by the table, we have positive coefficients for sixteen countries (i.e., Central African Republic, Colombia, Congo, Democratic People's Republic of Korea, Dominica, Dominican Republic, Gambia, Haiti, Iraq, Jordan, Lao P.D.R., Maldives, Mali, Peru, Suriname, Zambia) and negative coefficients for eight countries (i.e., Equatorial Guinea, Ethiopia, Fiji, Guinea, Honduras, Lebanon, Myanmar, Qatar). However, most of the country specific estimations support our hypothesis. As a result, it can be stated that corruption in a country worsens CO_2 emission. Among the positive elasticity coefficients, first three largest ones are estimated for the countries of Congo, Democratic People's Republic of Korea, and Dominica respectively whereas among the negative elasticity coefficients, first three largest ones are computed for the countries of Equatorial Guinea, Myanmar and Ethiopia respectively.

Table 7: Long-run Coefficient Estimations

Mean Group Estimation Results				
	EC-coef.	P-value	Long-run coef.	P-value
	-1.0387	0.000	1.0523	0.051
Group Specific Estimation Results				
Country	EC-coef.	P-value	Long-run coef.	P-value
Central African Republic	-3.6551	0.011	8.8721	0.030
Colombia	-1.8030	0.004	7.0410	0.088
Congo	-0.5876	0.070	28.1777	0.000
Democratic People's Republic of Korea	-0.8917	0.019	24.5608	0.002
Dominica	-3.5226	0.000	22.9066	0.000
Dominican Rep.	-1.6597	0.000	2.7523	0.000
Equatorial Guinea	-2.2990	0.000	-13.9086	0.000
Ethiopia	-1.8050	0.000	-5.8068	0.000
Fiji	-0.9272	0.000	-1.1856	0.005
Gambia	-1.6250	0.060	5.7271	0.018
Guinea	-0.9551	0.029	-3.2952	0.015
Haiti	-0.9266	0.000	2.4396	0.023
Honduras	-1.7324	0.000	-2.8379	0.013
Iraq	-0.3645	0.084	9.0843	0.000
Jordan	-3.3464	0.004	2.2012	0.011
Lao P.D.R.	-3.7201	0.001	3.1726	0.096
Lebanon	-1.6247	0.000	-3.1382	0.000
Maldives	-1.2608	0.000	4.1372	0.004
Mali	-0.3750	0.020	9.4161	0.000
Myanmar	-1.7805	0.000	-6.7412	0.000
Peru	-0.9152	0.001	5.1860	0.001
Qatar	-1.6221	0.000	-0.3882	0.000
Suriname	-2.2807	0.000	1.0667	0.001
Zambia	-1.2475	0.000	5.8145	0.000

Source: Authors.

Table 8 shows the Dumitrescu and Hurlin Granger causality test results for direction of the causality between CO_2 emission and corruption. As can be seen from Table 8, there is bi-directional causality relationship between CO_2 emission and corruption.

Table 8: Results of Causality Test

H_0: LogCORRUPTION does not Granger-cause $LogCO_2$.

H_1: LogCORRUPTION does Granger-cause $LogCO_2$ for at least one country.

z-bar tilde Stat.	P-value	Optimal number of lags (BIC)
2.7693	0.0056	1

H_0: $LogCO_2$ does not Granger-cause LogCORRUPTION.

H_1: $LogCO_2$ does Granger-cause LogCORRUPTION for at least one country.

z-bar Stat.	P-value	Optimal number of lags (BIC)
8.1782	0.0000	1

Source: Authors

5. Conclusion

In this study, we examine the long-run association between corruption and CO_2 emission. Analyses are implemented by utilizing a balanced data of 127 developing economies for the period of 2002 and 2017. Our hypothesis claims that corruption increases the amount of CO_2 emitted in a country.

Since we identified cross-section dependence across groups, we used second generation unit root tests to figure out integration level of each series. Given the series are stationary in first differences, panel cointegration tests are conducted. Panel cointegration test findings disclose that series of corruption and CO_2 are cointegrated and hence they are related in long-run. In the light of Swamy's parameter homogeneity test, Pesaran Common Correlated Effects Mean Group estimation method is employed to analyze the long-run relationship between corruption and CO_2 emission. Even though we get mixed results for group specific estimation, we identified a positive statistically significant effect of corruption on CO_2 emission for mean group estimation. The finding of mean group estimation shows that corruption cause to an increase in CO_2 emission by 1.05% given a 1% rise in corruption. Meanwhile we found a two-way causality between series of corruption and CO_2 emission.

Based on this empirical finding, we can state that countries aiming at reducing CO_2 emission should take measures and follow policies combating against corruption in addition to the other measures and policies taken to alleviate CO_2 emission.

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