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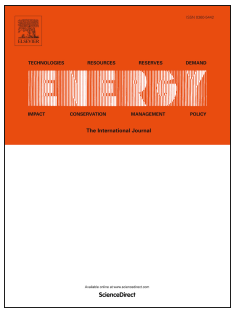

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The Moderating Role of Corruption between Economic Growth and CO_2 Emissions: Evidence from BRICS Economies

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Abstract

The policy debate on economic growth and CO_2 emissions is topical: corruption may affect this relationship by raising pollution at given income levels and by reducing *per capita* income. This research proposed a newly formulated conceptual framework to explore the moderating role of corruption on the relationship between growth and CO_2 emissions by applying a partial least square regression model for a panel of BRICS countries from 1996-2015. Overall, from our empirical findings, we infer that the moderating role of corruption is crucial in the relationship between economic growth and carbon dioxide emissions and control of corruption reduce CO_2 emissions. Furthermore, a significant moderating effect of corruption is observed on the relationship between urbanisation and carbon dioxide emissions in the case of BRICS countries, which signifies poor environmental performance therein. Also, control of corruption has a moderating effect on the relationship between trade and CO_2 emissions. The variance importance analysis confirms the reliability of our results. The novel finding of the study not only advances the prior litrature also provides a more clearer picture

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of the growth-emission nexus. The new findings can be of special interest to policymakers as they seek to control pollution at national level.

Keywords: Corruption; CO_2 emission; Economic Growth; Partial Least Square regression; BRICS Countries.

1. Introduction

Over the last three decades, the relationship between growth and CO_2 emissions has become a key issue among environmental economists. Previous studies have tested this relationship by using several econometric techniques, employing different panels of countries and concluded that growth is an important determinant of carbon dioxide emissions. There are three schools of thought regarding the growth-CO_2 emission nexus along with energy consumption. One school of thought supports the pioneering work of Grossman and Krueger [1] who argue that in the initial stages of economic growth CO_2 emissions increase, but later, with an increase in income, CO_2 emissions decrease according to the Environmental Kuznets Curve (EKC). The second school of thought has found that energy consumption is the main culprit behind growing CO_2 emissions worldwide [2–8]. The third school of thought has argued for a causal relationship between growth and CO_2 emissions [9]. Recently, Mirza and Kanwal [10] express bivariate causality between growth, energy consumption, and CO_2 emissions. The inference drawn from these studies reflects a lack of consensus.

The growth-CO_2 emission relationship is widely discussed in the literature; h owever, in the recent years the role of corruption in the growth-CO_2 emission nexuses reciving immense attention, however, little work has been conducted in this area of research. There are two schools of thought regarding the relationship between corruption and CO_2 emissions. One school of thought argues for the direct impact of corruption on CO_2 emission. Likewise, López and Mitra [11] examine the implications of corruption and rent-seeking behaviour by

governments in the relationship between pollution and growth and argue that corruption is unlikely to impede the presence of an inverted U-shaped EKC. For instance, Morse [12] suggests a significant positive relationship between corruption and environmental sustainability. Also, Ozturk and Al-Mulali [13] investigate the effect of control of corruption on CO_2 emissions and infer that control of corruption could reduce CO_2 emissions. The study also infers that both governance and control of corruption help to reinforce environmental regulation and induce industry to shadow this regulation. Good governance stimulates political freedom and raises public awareness towards improving the environment. Leitao [14] highlights flaws in governance structures that impede good governance and assist corruption in the environmental field. Pellegrini and Gerlagh [15] argue that level of corruption plays an important role in explaning the variance in environmental policies.

The second school of thought investigates the indirect effect of corruption on CO_2 emissions. Cole [16] concludes that corruption has both direct and indirect positive influence on CO_2 emissions in 94 countries. The indirect effect of corruption on CO_2 emissions is negative. Furthermore, indirect effects are found to be negative and larger in absolute value than direct effects. Biswas *et al*. [17] suggest that controlling the level of corruption can restrict the influence of the shadow economy. Also, Leitão [18] discusses the various degrees of corruption in a widespread panel of countries at different stages of development. Empirical findings suggest that different levels of corrupt practices and the different turning points in income levels suggest a different dimension of income–pollution paths across countries. Goel *et al*. [19] examine the influence of institutional quality on CO_2 emission primarily focus on the effect of corruption and the shadow economy in MENA countries. Results suggest that corrupt nations, especially those with a large shadow economy, tend to contribute negatively to pollution levels. Recently, Zhang *et al*. [20] investigate the direct and indirect effects of corruption on CO_2 emissions. Empirical results conclude that corruption reduces CO_2

emissions. Also, Umer *et al*. [21] suggest that public sector corruption influences trade openness by their beneficial trade policies. Sahli and Rejeb [22] stipulate that corruption has a positive direct impact on CO_2 emissions and a negative indirect effect of corruption on *per capita* income is observed. Rehman *et al*. [23] show that corruption affects the environment in the way that it delays the turning point in the EKC[1].

Overall, above studies produced contradictory findings regarding the direct and indirect effect of corruption on CO_2 emissions. Also, the relationship between growth and CO_2 emissions reflects a lack of consensus. Many have suggested several policies, but these fail to provide a consensus and the problem of carbon emissions worsens daily. This may raise the question as to whether the policies are implemented efficiently, or there are some the other factors which influence the growth-CO_2 emissions relationship. Taken together, the effect of both income and corruption on the environment is a subject of considerable controversy and disagreement.

To contribute in this research field we put an attempt and current study is a step forward to understand the unclear nexus between corruption, economic growth, and CO_2 emissions, that is, we examine the interaction effect of corruption and income on CO_2 emissions. Consequently, this study aim to estimate the impact of moderating role of control of corruption on the relationship between economic growth and CO_2 emissions incorporating urbanisation, trade, and population growth in a single multivariate framework. The current study presents a new mechanism for exploring the moderating role of control of corruption between the growth-CO_2 emissions nexus in the case of BRICS economies.

The contributions of this paper to the existing body of knowledge in the area of growth and CO_2 emissions are articulated as follows: first, none of the studies explicitly highlight the role of corruption is vital in explaining the inconclusive results of growth on CO_2 emissions.

[1] For a summary of the relevant literature, please see Table 1.

Thus the present study is merely a first step towards the quantitative assessment of the moderating effect of corruption on the relationship between growth and CO_2 emissions.

Second, prior studies are lacking an answer to whether control of corruption and higher incomes consistently improve the quality of the environment. To address the issue of climate change, the moderating role of control of corruption would guide policy-makers to adopt new techniques for implementation of environmental regulation in relation to the levels of corruption and income. The presence of such effects and their implication and extent is an empirical issue which deserves attention.

Third, against the devastating majority of statistical work, cointegration, and multivariate Granger causality approaches, the present study uses a partial least square regression (PLS) model that is able to handle the aforementioned integrated analytical framework. Besides, PLS regression is capable of solving some technical and econometric issues such as it being able to account for the problem of multi-collinearity in the model to capture the real effects as compared to ordinary least squares regression and various multivariate cointegration and Granger causality methods in estimating the link between carbon emissions and economic growth.

This paper is orginised as follow: in chapter 2 of the study we outline the data source , model specification and econoamtric startegy. Section 3 contains the results, analysis, and discuss. Finally, section 4 concludes with policy implications.

======INSERT TABLE 1 HERE======

2. Methodology and Data Source

2.1. Theoretical framework

The policy debate on economic growth and CO_2 emission variables are covered in the literature which examines the nexus between growth and CO_2 emissions [24–27]. These

studies mainly focus on the quadratic form of income-pollution relationship (the EKC). In this study, we discard this quadratic relationship, because it would distort our primary objective and may produce contradictory outcomes. Over the last three decades, the impact of growth on CO_2 emissions has been widely discussed, and people have suggested several policies, but these studies produce contradictory findings. Also, a lack of consensus, and the problem of carbon emissions, remains. This may raise the question as to whether these policies are implemented efficiently, or there are some other factors which influence the growth-CO_2 emissions relationship. Evidence of the potential effects of economic growth on CO_2 emission remains inconclusive: inconsistent findings reported on the relationship between economic factors and CO_2 emissions, it suggests that a moderaing influence needs to be introduced. Corruption may affect the growth-CO_2 emissions nexus in two distinct ways: by raising pollution at given income levels (direct effect) and by reducing *per capita* incomes (indirect effect). As earlier discussed that previous scholars have developed two schools of thoughts regarding the role of corruption in CO_2 emissions. Cole [16] concludes that the direct effect of corruption on CO_2 emissions is positive, and the indirect effect of corruption on CO_2 emissions is negative. Morse, [12] suggests a significant positive relationship between corruption and environmental sustainability. Recently, Zhang *et al*. [20] have studied the direct and indirect effect of corruption on CO_2 emissions. Empirical results conclude that corruption reduces CO_2 emissions. These studies do not make sense as to whether corruption effects CO_2 emissions directly, or indirectly. Thus in the present study, we suggest that corruption might have moderated the effects of economic growth on CO_2 emissions. The reason behind corruption are often contextual, bureaucratic traditions, embedded in a country's policies, political development, and social history. Still, corruption is likely to flourish in circumstances where institutions are weak, and government policies spawn economic rent-seeking. In return, economic and social costs upsurge in both environmental

and economic sectors due to corruption. More generally environmental costs of corruption increases as well. Bribery and failure to enforce laws and regulations are cross-cutting measures of corruption that weaken environmental wellbeing and, subsequently, the development of a country and the well-being of its people. The poor enforcement of existing environmental regulations can lead to environmental degradation, undermine development, and promulgate poor health [28]. Control of the corruption index indicates the degree of perception towards applying public power for private gain; it comprises both minor and major forms of corruption, and elites and private interests. Control of corruption can reinforce environmental regulation in the country. The vast body of literature has covered the relationship between growth and CO_2 emission and these studies have suggested various environmental regulations, however, these policy implications and regulations seem to be ineffective in lowering carbon dioxide emissions. Moderating effects can be tested by introducing interaction variables. The moderating role is defined as the interaction of moderator variable with independent variables. To introduce the moderating role we construct and adapt interaction variables [29].

In the literature, some other variables linked with economic growth have been discussed. Regarding trade, scholars are divided into two groups: one group argued that trade openness contributes to increasing CO_2 emissions and pollutes the environment [30–35], the second group of studies claims that trade is beneficial to the environment [36–38]. Also, Zhang and Lin, [39] and Danish *et al*. [40] examine whether or not urbanisation contributes to carbon emissions. Similarly, Wang *et al*. [41] and Zhang *et al*. [42] conclude that urbanisation increases CO_2 emissions and degrades the environment. On the other hand, Chikaraishi *et al*. [43] claim that increases in the rate of urbanisation are beneficial to the environment under the condition of growing the *per capita* income of a country. Based on the above argument,

the linear form of the relationship between growth and CO_2 emissions along with corruption and its interaction with core variables is presented below:

$$LOGCO_{2it} = \beta_0 + \beta_1 corr_{it} \times \beta_2 (LOGGDP_{it} \times LOGcorr_{it}) + \beta_3 (LOGT_{it} \times LOGcorr_{it}) + \beta_4 (LOGURB_{it} \times LOGcorr_{it}) + \beta_5 (LOGPG_{it} \times LOGcorr_{it}) + \omega_{it} \quad (1)$$

Where CO_{2it} are the CO_2 emissions of country *i* at year *t*, GDP is measured by *per capita* GDP, Corr is the control of corruption index. PG denotes the population, URB indicates the rate of urbanisation, and T denotes trade openness (Table 2). The contribtion in our anaylsis lies in to introduce the the interaction term of control of corruption CO_2 emission and economic growth. The coefficient β_2 in Eq. (3) is the main focus of this study.

2.2. Econometric Strategy

Using panel data, we perform Partial Least Square (PLS) regression modelling in the study. Several studies have used PLS regression model to analyse panel data [44–46]. The coefficient with a large standard error may change randomly due to small changes in the data. Such irregular changes lead to produce suprious regression for each variable which causes unreliability in its policy implications. The current study will define whether the problem of multi-collinearity exists in the model among explanatory variables, or not. Partial least squares regression is used to fit the model to resolve the issue of multi-collinearity in the model. It is used as a combined approach to extract information and to eradicate the correlation between individual items [47]. To reveal the underlying latent structures, partial least squares regression finds correlations between the independent and response variables. The dynamics explain both the response and predictor variations [48]. In the case of small sample sizes and missing values, PLS has produced more stable results than OLS models [49]. The main objective of applying a PLS method is that the latent variables t_1 and u_1 are detached from the data table of independent variable *X* and dependent variable *Y*, respectively, where t_1, and u_1 are a linear combination of x_1, x_2, ..., x_p and y_1, y_2, ..., y_p. Both t_1 and u_1 must meet the following conditions: t_1 and u_1 should carry as much of their data variation

information as possible to represent data tables X and Y better [44], secondly, t_1 and u_1 should achieve the maximum degree of correlation which gives t_1 the strongest explanatory power to u_1 [50].

2.3. Data Source and Variable Description

The dataset in the current study includes the rate of population growth, GDP growth, trade, urbanisation, control of corruption, and CO_2 emissions. Growth is measured by GDP *per capita*. Carbon dioxide is measured as CO_2 emissions (metric tonnes *per capita*). The data for CO_2 emissions are obtained from World Resource Institute data (WRI, 2016). Corruption is the measured rank of corruption (as a percentile rank, 0 (lowest) to 100 (highest). Population growth is measured as the rate of annual population growth [20]. Trade is measured as the sum of import and export of goods and services as measured by the share of GDP. Urbanisation is measured as urban population (% of total). Data for all variables are acquired from the website of World Development Indicators (WDI). Summary and unit of measurement of all the variables are listed in Table 2.

======INSERT TABLE 2 HERE======

3. Results and Discussion

Here we explain the correlation between all the core variables of the study. Higher correlation coefficients indicate the presence of multi-collinearity; subsequently, we estimate the variance inflation factor (VIF). Next, we estimate the main effect and moderating effect of corruption, which is the key focus of the present study.

The correlation analysis is reported in Table 3 shows that corruption is positively correlated with CO_2 emissions. Similarly, trade is negatively correlated with CO_2 emissions. The rate of population growth is positively correlated with CO_2 emissions. Urbanisation is

positively correlated with CO_2 emissions, and GDP growth is positively correlated with CO_2 emissions. Likewise, GDP growth is negatively correlated with corruption, the rate of population growth and trade, but is positively correlated with urbanisation. In the same way, corruption is negatively correlated with trade and urbanisation, but is positively correlated with the rate of population growth. According to Table 3, a high correlation exists in the core variables of the study. This indicate the presence of significant multi-collinearity, so we calculate the variance inflation factor (VIF) to detect multi-collinearity. It VIF is greater than 10, significant multi-collinearity exists and possibly affect estimates of ordinary least squares parameters [44]. The calculated value of VIF for some variables is greater than 10. Thus we cannot apply the OLS method. To account for the problem of multi-collinearity, we use PLS modelling.

======INSERT TABLE 3 HERE======

It is a common perception that most of the economic variables are non-stationary. To avoid meaningless results, we check the stationary level for the variable of interest. For panel data, several panel unit root tests are proposed in the literature. We can divide panel unit root test into two groups: LLC (Levin Lin Chu) test, Breitung test, and Hadri test groups. These tests are based on different cross-section sequences in panel data and are based on a common unit root process; second, IPS (IM Pesaran Shin) test, Fisher ADF test, and Fisher PP test groups. These tests have different roots and lessen the problem of homogeneity. For instance, BRICS economies have significant differences in their economic and emissions levels, therefore the second group of unit root test is most suitable for the study. So, we apply panel unit root tests such as the Fisher-ADF test, FisherPP test and Im, Pesaran, and Shin *W*-stat (IPS) which are based on the assumption of homogeneity. The null hypothesis of non-

stationary is tested for all the variables in the study. The results of panel unit root tests are listed in Table 4: we could not reject the null hypothesis at the first level, but at first difference, and all the indicators are significant at 1% and 5% level of significance. So it implies that all the variables are stationary at first difference level, thus we can now estimate the regression coefficients.

======INSERT TABLE 4 HERE======

PLS analysis is divided into two phases: a main effect and interaction effect (the moderating effect). Results of both main effect and moderating effect are shown in Table. Panel (1) demonstrates the model with the main effect and Panel (2) indicates the model with a moderating effect.

In fact, without the interaction term, economic growth is suggested to have a positive (β = 0.310 and t = 19.375), significant impact on CO_2 emissions; however, the introduction of interaction term corr x GDP indicates moderating role of control of corruption is crucial in the link between economic growth and CO_2 emissions (β = 0.181 and t = 25.851), *i.e.*, the effect of economic growth on CO_2 emissions varies due to control of corruption. Note that the pure positive effect of economic growth on CO_2 emissions is minimised by control of corruption as reported by econometric estimates in our study in BRICS countries as a result of economic growth. As for a reason, in our view growth increases CO_2 emissions, which is a global phenomenon, but control of corruption may be helpful to control CO_2 emissions generated by growth. In short, empirical analysis of our study is directed toward two possible mechanisms: the control of corruption may directly affect growth, which affects CO_2 emissions, and corruption has a moderating effect on the relationship between economic growth and CO_2 emissions. There are several possible reasons for this kind of result. The first

plausible reason may be that corruption may disturb the level of trade protection or other subsidies which could influence the composition of an economy [16]. Another plausible reason is that as the economic situation improves over time, the enviormental quality may deteriorate more due to inconsistency between economic growth and enviormental qaulity. Consequently, the rapid growth may generate increased CO_2 emissions [20]. Third, the basis of an economy is weaker in the early stages of economic development. Also, regular market competition has not been well established. Due to such conditions, the presence of corruption may quickly halt an immature economic system, which may ultimately cause CO_2 emissions to grow. Lastly, other institutional inefficiencies are emphasised along with corruption, as significantly distressing to the country's total factor productivity as well as government concerns for, and control of, the environment.

Additionally, corruption positively (and directly) influences CO_2 emissions, however, the indirect effect of corruption helps to reduce CO_2 emissions. In fact, this result is similar to that reported elsewhere [13, 16]. A possible reason for this is that political cost is greater than the cost of lowering regulations aimed at CO_2 emissions. Another possible mechanism may affect the composition of an economy by disturbing the level of trade protection or the extent to which certain industries receive tax breaks or other subsidies. As the level of corruption could influence the share of pollution-intensive industries within the share of the agriculture sector, service, and manufacturing sectors, this study offers a new vision for policy-makers aiming to control the emission of CO_2 by strengthening control over corruption.

Similarly, to the main effect, the coefficient of urbanisation has positive and significant ($\beta = 0.303$, $t > 2$) impact on CO_2 emissions; however, the introduction of interaction term corr x URB indicates in the relationship between urabnisation and CO_2 emission, the moderating role of corruption is crucial (β=0.178, t>2). So control of corruption is helpful in reducing CO_2 emissions due to urbanisation, but still, urbanisation seems to harm the environment and

control of corruption weakens this relationship. The literature mainly focuses on the direct relationship between urbanisation and CO_2 emissions. From a theoretical perspective, the literature regarding the role of urbanisation in CO_2 emissions proposes three theories [51]: first, according to ecological theory modernisation, the process of modernisation is a major cause of growing CO_2 emissions [52,53]. Second, Urbanisation Environmental Transition theory predicts a neutral effect of urbanisation on CO_2 emissions [54]. Third, urbanisation reduces carbon dioxide emissions by improving infrastructure [55]. The current results support ecological modernisation theory both in its main effect and interaction effect of corruption with urbanisation. In the case of BRICS countries, the results are in line with previous study [56]. Rapid growth in urbanisation threatens health, education, land, and energy supply resources. The pressure is not just applicable to human health it also pollutes the environment as suggested by our econometric findings. Increasing CO_2 emissions due to urbanisation can be eliminated by strengthening control over corruption.

Next, we concentrate on the trade-CO_2 emission nexus. The coefficient of trade has a significant negative effect on CO_2 emissions; however, the introduction of the interaction, effect corr x trade, indicates that moderting role of control of corruption is crucial in the link between urbanisation and CO_2 emissions (β = -0.167, t > 2) and has a negative but more elastic effect on CO_2 emissions. It means that control of corruption tends to weaken the relationship between trade and CO_2 emissions. This may be because trade liberalisation and its impact on environmental regulation are dependent on the level of corruption. The higher the level of corruption at government level, *ceteris paribus*, the higher the effect of trade openness on environmental stringency [57]. It can be justified by considering that the efficiency of government generates trade openness and it was determined that corruption in the public sector affect trade openness. Finally, application of environmental regulations depends upon on the level of corruption. Effective governance leads to environmental

regulations beneficial to the people [21]. Lastly, the control of corruption moderates the effect of population growth on CO_2 emissions; however, the coefficient thereof (β = 0.050) is very low. Also, the VIP value for population growth rate is less than the threshold level (0.8), so its effect in the analysis is negligible.

In Table 5, R^2Y indicates the fitting degree of the principal component extracted from Y variables and the original Y variables, and Q^2 denotes the cross-validation coefficient. These indicators increase at the same time by increasing in the number of principal components extracted; the maximum value is 1 [50]. It is held that the regression effect is ideal when R^2Y (cum) and Q^2 (cum) are all greater than 0.8. Table 5 shows the value of Q^2 (cum), R^2Y (cum) and R^2 are greater than 0.8 which confirmed the fitness, and efficacy, of the in both its main, and moderating, effects.

======INSERT TABLE 5 HERE======

To reflect the in-depth analysis, the explanatory potential of each independent variable for each dependent variable, variable importance analysis (VIP) can be calculated by using PLS Regression [58]:

$$VIP_j = \sqrt{\frac{K}{Rd\left(Y;t_1,.....,t_m\right)}\sum_{h=1}^{m} Rd\left(Y;t_h\right)w^2{}_{hj}} \qquad (2)$$

Where VIP_j is the VIP of x_j; p is the number of independent variables and $VIP^2{}_1$+ . . . . +$VIP^2{}_p$ = k, t_1, …, t_m are principal components extracted in variable X, R_d (Y; t_1, …, t_m) = $\sum_{h=1}^{m} Rd\,(Y; t_h)$ is the accumulative explanatory capability of principal components to Y, W_{hj} is the first j component of the W_h-axis, which can be calculated as the projection on the W_h-axis of the normalised variable x_j. It is used to measure the contributions of x_j to the

constitution of principal component t_h, and for any h = 1, 2, …, m, $\sum_j^k w_{hj}^2 = w'_h w_h = 1$. Any variable with a VIP value less than 0.8, should be removed because it indicates comparatively weak interpretative ability [59][2].

Fig. 1 shows the value of VIP of different variables in explaining the growth of CO_2 emissions. VIP values of all the variables are greater than 0.8, except growth rate of population. The VIP value of the trade is greatest during 1996-2015 in BRICS countries, followed by economic growth, urbanization, and control of corruption. This means that trade is the main contributor to the increasing CO_2 emissions in BRICS countries. This may be because of free trade, through which countries compromise on environmental standards to attract multinational enterprises. It may be possible that firms producing exports goods drive an increase in volumes of polluting goods in response to foreign direct investment. This supports the pollution-haven hypothesis, which states that increases in income demand a cleaner environment [33]. It may be possible that dirty industries from developed countries moved to BRICS countries due to less stringent environmental standards in these countries, and because some critical environmental regulations are ineffective in BRICS countries (*e.g.*, India and China). Growing GDPs and expanding foreign trade promote the importance of BRICS economies. Growing CO_2 emissions in India are due to the scale effect and in Brazil GHG emission releases are due to agriculture and waste. Trade is not the main factor behind environmental degradation in Brazil and India. China is a pollution haven due to capital-intensive manufacturing products which are known to be dirty industries [60]. So among the BRICS economies, China needs to take more responsibility for CO_2 emission mitigation.

The VIP value of GDP growth is larger than that from 1996 to 2015. The economic level is the main factor behind growing CO_2 emission in BRICS countries. The BRICS economies are mainly focused on rapid economic growth, and require responsiveness of energy-saving

[2] The description of VIP is extracted in orginal form (with permission) from the literature [50].

and emissions-reduction measures, therefore, in response, energy consumption increases as do CO_2 emissions [50]. The interpretive ability of urbanisation in rising CO_2 emissions is greater than 1: the effect of urbanisation on carbon emissions is evident and rapid urbanisation demands mobility for billions of urban residents who acquire the habit of consuming high-carbon lifestyle products. Also, urbanizstion demands infrastructure construction in the city, increasing the number of housing heating and refrigeration systems, and as a result increases energy consumption and CO_2 emissions. BRICS economies are involved in a stage of urban development along with economic globalisation. Growing urbanisation produces CO_2 emissions: as urban dwellers consume vast amounts of energy by enjoying more modern energy services both at household, commercial, and transport sector levels. Lastly, urbanisation causes a reduction in forest land area which indirectly increases CO_2 emissions [44]. Now to take control of corruption, as shown in Figure 1, we observe that corruption has a direct impact on CO_2 emissions, this may be because control over corruption in BRICS countries is particularly weak in the implementation of environmental regulation; but the interaction term of corruption with economic growth, urbanisation, and trade has a moderating impact on CO_2 emissions and helps to reduce pollution of the environment. This indicates that control over corruption is helpful in improving the environment.

======INSERT FIGURE 1 HERE======

4. Conclusion

We formulate a newly developed framework to explore the moderating role of control of corruption in the growth-CO_2 emission nexus by controlling the model with urbanisation, trade and growth rate of population for a panel of BRICS countries. The partial least square regression model is used to analyse panel data from 1996 to 2015. We perform VIP analysis to check the reliability of the results acquired from PLS regression.

The empirical findings of the study are directed towards some important policy implications. As control of corruption moderates and weakens the relationship between economic growth and CO_2 emissions, policies need to strengthen the control of corruption that may weaken the growth-CO_2 emission nexus. Another possible mechanism is that growth may increase the rate of CO_2 emissions but corruption could reduce the stringency of environmental regulations regarding GDP growth in the direction of reducing CO_2 emissions, resulting in them increasing. Implementation of environmental regulation depends upon on the level of corruption. Therefore, it is suggested that policy-makers strengthen their grip on corruption and implement environmental regulation efficiently for a clean environment. If government policies are effective, then people will pay for environmental regulation. We also urge governments to adopt green policies aimed at pollution abatement with strengthened monitoring capabilities against pollution and regulatin of abatement technologies or devices in the light of their strategy. Moreover, corruption is loosening environmental regulation which largely worsens the state of pollution, that then changes the effect of trade openness on the severity of environmental policy. Therefore, the policy-makers should aim to control corruption to avoid slackening environmental regulation associated with trade openness.

The governments in BRICS countries need to take preventive measures to mitigate the effects of their high growth of urbanisation and provide better facilities to improve the living standards of the people in rural areas. Green housing projects should be launched in remote areas to discourage rapid increases in urbanisation. Lastly, green city projects represent a sensible choice for BRICS countries in their quest to strengthen their level of control over corruption.

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Refrences

[1] Grossman GM, Krueger AB. Environmental Impacts of a North American Free Trade Agreement. Natl Bur Econ Res Work Pap Ser 1991;No. 3914:1–57. doi:10.3386/w3914.

[2] Al-Mulali U, Saboori B, Ozturk I. Investigating the environmental Kuznets curve hypothesis in Vietnam. Energy Policy 2015;76:123–31. doi:10.1016/j.enpol.2014.11.019.

[3] Jammazi R, Aloui C. Environment degradation, economic growth and energy consumption nexus: A wavelet-windowed cross correlation approach. Phys A Stat Mech Its Appl 2015;436:110–25. doi:10.1016/j.physa.2015.05.058.

[4] Salahuddin M, Gow J. Economic growth, energy consumption and CO2 emissions in Gulf cooperation council countries. Energy 2014;73:44–58. doi:10.1016/j.energy.2014.05.054.

[5] Heidari H, Turan Katircioğlu S, Saeidpour L. Economic growth, CO2 emissions, and energy consumption in the five ASEAN countries. Int J Electr Power Energy Syst 2015;64:785–91. doi:10.1016/j.ijepes.2014.07.081.

[6] Saidi K, Hammami S. The impact of CO2 emissions and economic growth on energy consumption in 58 countries. Energy Reports 2015;1:62–70. doi:10.1016/j.egyr.2015.01.003.

[7] Asongu S, El Montasser G, Toumi H. Testing the relationships between energy consumption, CO2 emissions, and economic growth in 24 African countries: a panel ARDL approach. Environ Sci Pollut Res 2016;23:6563–73. doi:10.1007/s11356-015-5883-7.

[8] Danish, Zhang B, Wang B, Wang Z. Role of Renewable Energy and Non-Renewable Energy consumption on EKC: Evidence from Pakistan. J Clean Prod 2017;156:855–64. doi:10.1016/j.jclepro.2017.03.203.

[9] Esso LJ, Keho Y. Energy consumption, economic growth and carbon emissions: Cointegration and causality evidence from selected African countries. Energy 2016;114:492–7. doi:10.1016/j.energy.2016.08.010.

[10] Mirza FM, Kanwal A. Energy consumption, carbon emissions and economic growth in Pakistan: Dynamic causality analysis. Renew Sustain Energy Rev 2017;72:1233–40. doi:10.1016/j.rser.2016.10.081.

[11] López R, Mitra S. Corruption, Pollution, and the Kuznets Environment Curve. J Environ Econ Manage 2000;40:137–50. doi:10.1006/jeem.1999.1107.

[12] Morse S. Water governance in Mexico: Political and economic aperatures and a shifting state-citizen relationship. Ecol Soc 2010;15:18. doi:22.

[13] Ozturk I, Al-Mulali U. Investigating the validity of the environmental Kuznets curve hypothesis in Cambodia. Ecol Indic 2015;57:324–30. doi:10.1016/j.ecolind.2015.05.018.

[14] Leitao A. Corruption and the Environment. J Soc 2016;5:2–5. doi:http://dx.doi.org/10.4172/2167-0358.1000173.

[15] Pellegrini L, Gerlagh R. Corruption and environmental policies: What are the implications for the enlarged EU? Eur Environ 2006;16:139–54. doi:10.1002/eet.414.

[16] Cole MA. Corruption, income and the environment: An empirical analysis. Ecol Econ 2007;62:637–47. doi:10.1016/j.ecolecon.2006.08.003.

[17] Biswas AK, Farzanegan MR, Thum M. Pollution, shadow economy and corruption: Theory and evidence. Ecol Econ 2012;75:114–25. doi:10.1016/j.ecolecon.2012.01.007.

[18] Leitão A. Corruption and the environmental Kuznets Curve: Empirical evidence for sulfur. Ecol Econ 2010;69:2191–201. doi:10.1016/j.ecolecon.2010.06.004.

[19] Goel RK, Herrala R, Mazhar U. Institutional quality and environmental pollution: MENA countries versus the rest of the world. Econ Syst 2013;37:508–21. doi:10.1016/j.ecosys.2013.04.002.

[20] Zhang YJ, Jin YL, Chevallier J, Shen B. The effect of corruption on carbon dioxide emissions in APEC countries: A panel quantile regression analysis. Technol Forecast Soc Change 2016;112:220–7. doi:10.1016/j.techfore.2016.05.027.

[21] Umer F, Khoso M, Alam S. Trade Openness , Public Sector Corruption , and Environment : A Panel Data. J Bus Econ Policy 2014;1:39–51.

[22] Sahli I, Rejeb J Ben. The Environmental Kuznets Curve and Corruption in the Mena Region. Procedia - Soc Behav Sci 2015;195:1648–57. doi:10.1016/j.sbspro.2015.06.231.

[23] Rehman FU, Nasir M, Kanwal F. Nexus between corruption and regional Environmental Kuznets Curve: The case of South Asian countries. Environ Dev Sustain 2012;14:827–41. doi:10.1007/s10668-012-9356-6.

[24] Brown SPA, McDonough IK. Using the Environmental Kuznets Curve to evaluate energy policy: Some practical considerations. Energy Policy 2016;98:453–8. doi:10.1016/j.enpol.2016.09.020.

[25] Pal D, Mitra SK. The environmental Kuznets curve for carbon dioxide in India and China: Growth and pollution at crossroad. J Policy Model 2017. doi:10.1016/j.jpolmod.2017.03.005.

[26] Kang Y-Q, Zhao T, Yang Y-Y. Environmental Kuznets curve for CO2 emissions in China: A spatial panel data approach. Ecol Indic 2016;63:231–9. doi:10.1016/j.ecolind.2015.12.011.

[27] Robalino-López A, Mena-Nieto Á, García-Ramos JE, Golpe AA. Studying the relationship between economic growth, CO2 emissions, and the environmental Kuznets curve in Venezuela (1980-2025). Renew Sustain Energy Rev 2015;41:602–14. doi:10.1016/j.rser.2014.08.081.

[28] Wick EC. Corruption & The Environment. 2013. doi:10.1001/jama.1971.03180240003002.

[29] Katircioğlu S, Taşpinar N. Testing the moderating role of financial development in an environmental Kuznets curve: Empirical evidence from Turkey. Renew Sustain Energy Rev 2017;68:572–86. doi:10.1016/j.rser.2016.09.127.

[30] Halicioglu F. An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy 2009;37:1156–64. doi:10.1016/j.enpol.2008.11.012.

[31] Yunfeng Y, Laike Y. China's foreign trade and climate change: A case study of CO2 emissions. Energy Policy 2010;38:350–6. doi:10.1016/j.enpol.2009.09.025.

[32] Ren S, Yuan B, Ma X, Chen X. International trade, FDI (foreign direct investment) and embodied CO2 emissions: A case study of chinas industrial sectors. China Econ Rev 2014;28:123–34. doi:10.1016/j.chieco.2014.01.003.

[33] Ertugrul HM, Cetin M, Seker F, Dogan E. The impact of trade openness on global carbon dioxide emissions: Evidence from the top ten emitters among developing countries. Ecol Indic 2016;67:543–55. doi:10.1016/j.ecolind.2016.03.027.

[34] Wang T, Watson J. Who Owns China's Carbon Emissions. Tyndall Cent Cliamte Chang Res 2007:1–7. doi:http://dcms.lwec.ulcc.ac.uk/sites/default/files/bn23.pdf.

[35] Le T-H, Chang Y, Park D. Trade Openness and Environmental Quality: International Evidence. Energy Policy 2016;92:45–55. doi:10.1016/j.enpol.2016.01.030.

[36] Managi S, Hibiki A, Tsurumi T. Does trade openness improve environmental quality? J Environ Econ Manage 2009;58:346–63. doi:10.1016/j.jeem.2009.04.008.

[37] Baek J, Cho Y, Koo WW. The environmental consequences of globalization : A country-speci fi c time-series analysis. Ecol Econ 2009;68:2255–64. doi:10.1016/j.ecolecon.2009.02.021.

[38] Boulatoff C, Jenkins M. Long-term Nexus Between Openness , Income , and Environmental Quality. Int Atl Econ Soc 2010:410–8. doi:10.1007/s11294-010-9283-y.

[39] Zhang C, Lin Y. Panel estimation for urbanization, energy consumption and CO 2 emissions:

A regional analysis in China. Energy Policy 2012;49:488–98. doi:10.1016/j.enpol.2012.06.048.

[40] Danish, Zhang B, Wang Z, Wang B. Energy production, economic growth and CO2 emission: evidence from Pakistan. Nat Hazards 2017. doi:10.1007/s11069-017-3031-z.

[41] Wang Q, Wu SD, Zeng YE, Wu BW. Exploring the relationship between urbanization, energy consumption, and CO2 emissions in different provinces of China. Renew Sustain Energy Rev 2016;54:1563–79. doi:10.1016/j.rser.2015.10.090.

[42] Zhang YJ, Yi WC, Li BW. The Impact of Urbanization on Carbon Emission: Empirical Evidence in Beijing. Energy Procedia 2015;75:2963–8. doi:10.1016/j.egypro.2015.07.601.

[43] Chikaraishi M, Fujiwara A, Kaneko S, Poumanyvong P, Komatsu S, Kalugin A. The moderating effects of urbanization on carbon dioxide emissions: A latent class modeling approach. Technol Forecast Soc Change 2015;90:302–17. doi:10.1016/j.techfore.2013.12.025.

[44] Wang Y, Zhao T. Impacts of energy-related CO2 emissions: Evidence from under developed, developing and highly developed regions in China. Ecol Indic 2015;50:186–95. doi:10.1016/j.ecolind.2014.11.010.

[45] Li H, Mu H, Zhang M, Gui S. Analysis of regional difference on impact factors of China's energy - Related CO 2 emissions. Energy 2012;39:319–26. doi:10.1016/j.energy.2012.01.008.

[46] Balsalobre-Lorente D, Shahbaz M, Roubaud D, Farhani S. How economic growth, renewable electricity and natural resources contribute to CO2emissions? Energy Policy 2018;113:356–67. doi:10.1016/j.enpol.2017.10.050.

[47] Lv Y, Liu J, Yang T, Zeng D. A novel least squares support vector machine ensemble model for NOx emission prediction of a coal-fired boiler. Energy 2013;55:319–29. doi:10.1016/j.energy.2013.02.062.

[48] Asumadu-Sarkodie S, Owusu PA. A multivariate analysis of carbon dioxide emissions, electricity consumption, economic growth, financial development, industrialization, and urbanization in Senegal. Energy Sources, Part B Econ Planning, Policy 2017;12:77–84. doi:10.1080/15567249.2016.1227886.

[49] Farahani HA, Rahiminezhad A, Same L, Immannezhad K. A comparison of Partial Least Squares (PLS) and Ordinary Least Squares (OLS) regressions in predicting of couples mental health based on their communicational patterns. Procedia - Soc Behav Sci 2010;5:1459–63. doi:10.1016/j.sbspro.2010.07.308.

[50] Wang Z, Yin F, Zhang Y, Zhang X. An empirical research on the influencing factors of regional CO2 emissions: Evidence from Beijing city, China. Appl Energy 2012;100:277–84. doi:10.1016/j.apenergy.2012.05.038.

[51] Poumanyvong P, Kaneko S. Does urbanization lead to less energy use and lower CO2 emissions? A cross-country analysis. Ecol Econ 2010;70:434–44. doi:10.1016/j.ecolecon.2010.09.029.

[52] Mol APJ, Spaargaren G. Ecological Modernisation Theory in Debate: A Review. Env Polit

2000;9:17–49. doi:10.1080/09644010008414511.

[53] Gouldson A, Murphy J. Ecological Modernisation: Restructuring Industrial Economies. Polit Q 1997;86:74–86. doi:10.1111/1467-923X.00117.

[54] Xuemei Bai, Hidefumi Imura. A Comparative Study of Urban Environment in East Asia: Stage Model of Urban Environmental Evolution. Int Rev Environ Strateg 2000;1:135–58.

[55] Capello R, Camagni R. Beyond Optimal City Size: An Evaluation of Alternative Urban Growth Patterns. Urban Stud 2000;37:1479–96. doi:10.1080/00420980020080221.

[56] Wang Y, Li L, Kubota J, Han R, Zhu X, Lu G. Does urbanization lead to more carbon emission? Evidence from a panel of BRICS countries. Appl Energy 2016;168:375–80. doi:10.1016/j.apenergy.2016.01.105.

[57] Damania R, Fredriksson PG, List JA. Trade liberalization, corruption, and environmental policy formation: Theory and evidence. J Environ Econ Manage 2003;46:490–512. doi:10.1016/S0095-0696(03)00025-1.

[58] Fan Y, Liu LC, Wu G, Wei YM. Analyzing impact factors of CO2 emissions using the STIRPAT model. Environ Impact Assess Rev 2006;26:377–95. doi:10.1016/j.eiar.2005.11.007.

[59] Loo BPY, Li L. Carbon dioxide emissions from passenger transport in China since 1949: Implications for developing sustainable transport. Energy Policy 2012;50:464–76. doi:10.1016/j.enpol.2012.07.044.

[60] Laike Y. CO 2 Emissions Embodied in International Trade — A Comparison on BRIC Countries 1. Work Pap No 03/2012 Univ Appl Sci 2012. doi:http://finance-and-trade.htw berlin.de/fileadmin/HTW/Forschung/Money_Finance_Trade_Development/working_paper_series/wp_03_2012_Yang_CO2-Emissions-BRIC.pdf.

Appendix

Nomenclature	
VIF	Variance Inflation Factor
PLS	Partial Least Square
VIP	Variance Inflation Factor
BRICS	Brazil, Russia, India, China, South Africa
OLS	Ordinary Least Square
EKC	Environmental Kuznets Curve
MENA	The Middle East and North Africa
WRI	World Resource Institute
WDI	World Development Indicator
OLS	Ordinary Least Square

Tables

Table 1:
Summary of literature regarding corruption and CO_2 emission

Author's	Country/Region	Model	Main Findings
Ozturk and Al-Mulali [13]	Cambodia	GMM Model and 2 SLS Model	Governance and control on corruption helps to reduce emission
Zhang et al. [20]	APEC countries	Quantile regression approach	The effect of corruption on emission is negative significant in countries with low emission countries but insignificant in emitting nations. The relationship between corruption and CO_2 emission heterogeneous.
Halkos and Tzeremes,[24]	G-20 Countries	Non-Parametric Analysis	Corruption appears to be the most influential factors on their carbon dioxide emission levels.
Cole,[16]	94 countries	Jointly estimate a two-equation model	The direct effect of corruption on CO_2 emission is positive for a large panel of 94 countries. Corruption has indirect and negative impact CO_2 emission is negative.
Leitão [18]	High and Upper Middle Income, Lower Middle, and Low-Income	Fixed effect and random effects Model	Evidence displays corruption, and per capita income is positively related to other. Also, at the turning point, suggesting various income–pollution paths through countries due to corruption.
Biswas et al.[17]	100 countries		The levels of corruption affect the shadow economy which affects the levels of pollution through avoiding environmental regulation policies.
Goel et al. [19]	MENA countries	Two-stage least squares (2SLS) Model	Results suggested that high corruption nation and with large shadow sector tends to contribute negatively to pollution levels.
Krishnan et al. [25]	Primary data from over hundred countries	Structural equation modeling (SEM)	e-government maturity will have indirect effects on economic prosperity and environmental degradation through corruption.
Morse, [12]	Cross-National Analysis	Correlation	Significant relationship between corruption and environmental sustainability

Table 2
The definitions and measurement methods for variables

Variables	Symbol	Measuring method	Unit of measurement
Carbon Dioxide Emission	CO_2	CO_2 emission per capita. Carbon dioxide emissions are those produced from the burning of fossil fuels and the production of cement. They comprise carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	Metric tonnes
Economic Growth	GDP	GDP per capita. GDP per capita is gross domestic product divided by midyear population. Data are in constant 2010 U.S. dollars.	US Dollar
Population Growth	GP	The growth rate of population. Annual population growth rate for the year. The population is based on the de facto definition of population, which sums all residents irrespective of legal status or citizenship.	%
Trade	T	Sum of import and export of goods and services	The share of GDP
Urbanization	URB	Urban Population. Urban population denotes to people living in urban areas as defined by national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects.	%
Control of Corruption	Corr	Percentile Rank of Corruption as borrowed from the website of world development indicator [52]. COR is the control of corruption index indicates the degree of perceptions towards applying the public power for private gain, it comprises both minor and major forms of corruption, and elites and private interests. Control of corruption can reinforce environmental regulation in the country. The index varies between −2.5 and 2.5 with higher values correspond to better corruption control [13].	Rank, 0 (lowest) to 100 (highest)

Table 3:
Results of correlation matrix and Multicollinearity

Variables	Correlation Matrix						Multicollinearity		
	LOGCO2	LOGCORR	LOGT	LOGURB	LOGPG	LOGGDP	R^2	Tolerance	VIF
$LOGCO_2$	**1.000**						0.890	0.110	9.093
LOGCORR	-0.060	**1.000**					0.725	0.275	3.636
LOGT	-0.332	-0.607	**1.000**				0.741	0.259	3.861
LOGURB	0.409	0.215	-0.688	**1.000**			0.993	0.007	135.48
LOGPG	-0.536	0.680	-0.191	-0.266	**1.000**		0.788	0.212	4.727
LOGGDP	0.563	0.174	-0.675	0.981	-0.341	**1.000**	0.993	0.007	153.46

Table 4:
Results of Panel unit root test

		ADF-Fisher Chi-Square Test		PP-Fisher Chi-Square Test		Im, Pesaran and Shin W-stat	
	Variables	Statistic	Probability	Statistic	Probability	Statistic	Probability
At Level	LOG CO_2	5.25799	0.9740	3.2801	0.8733	1.7126	0.9566
	LOG GDP	2.01646	0.9962	3.0147	0.9811	1.9246	0.9729
	LOG Corr	5.69357	0.8403	4.0463	0.9452	1.0655	0.8567
	LOG T	272.403	0.0000	28.157	0.0017	-2.7647	0.0028
	LOG PG	12.3712	0.2610	24.855	0.0056	-2.4021	0.0081
	LOG URB	21.6530[b]	0.0170	17.078	0.07084	-0.5374	0.7815
At first Difference	ΔLOG CO_2	45.425[a]	0.0000	25.566[a]	0.0044	-2.8352[a]	0.0023
	ΔLOG GDP	22.71[b]	0.0119	17.422[c]	0.0655	-1.735[b]	0.0414
	ΔLOG Corr	37.783[a]	0.0000	21.785[b]	0.0162	-2.0186[b]	0.0218
	ΔLOG T	35.67[a]	0.0001	22.347[b]	0.0134	-2.1528[b]	0.0157
	ΔLOG PG	23.42[a]	0.0093	23.785[a]	0.0082	-2.4509[a]	0.0071
	ΔLOG URB	21.31	0.0190	28.462	0.0015	-2.38334	0.0086

Note: Δ shows the first difference.
a, b and c show the significance level at 1%, 5%, and 10% significance level.
For estimation of unit roots test, we have used Eveiws 9.5 Version.

Table 5
The PLS results of Main effect and Main effect + Interaction Effect

	The PLS result of the equation of the Main effect			**The PLS result of the equation of Main effect+intrection Effect**		
Varibale	Coefficient	Std.error	t-statistics	Coefficient	Std.error	t-statistics
LOGCORR	0.241[a]	0.037	6.153	0.113[a]	0.013	10.230
LOGT	-0.352[a]	0.021	-16.76	-0.165[a]	0.007	23.571
LOGURB	0.303[a]	0.015	20.20	0.142[a]	0.012	11.833
LOGPG	0.094[b]	0.036	2.611	0.044[b]	0.015	2.933
LOGGDP	0.310[a]	0.016	19.375	0.145[a]	0.013	11.153
LogGTxLogcorr	--	--	--	-0.167[a]	0.009	18.555
LogURBxLogcorr	--	--	--	0.178[a]	0.006	29.666
LogPGxLogcorr	--	--	--	0.050[a]	0.016	3.125
Loggdpxcorr	--	--	--	0.181[a]	0.007	25.851
Robust analysis	**Panel (1)**			**Panel (2)**		
Q^2 cum	0.874			0.879		
R^2Y cum	0.876			0.880		
R^2	0.876			0.880		
MSE	0.223			0.216		

Note: a, b and c directs level of significance at 1%, 5%, and 10% significance level.
For estimation of the main effect, main+ interaction effect and multicollinearity we have used XLSTAT.2017.

FIGURES

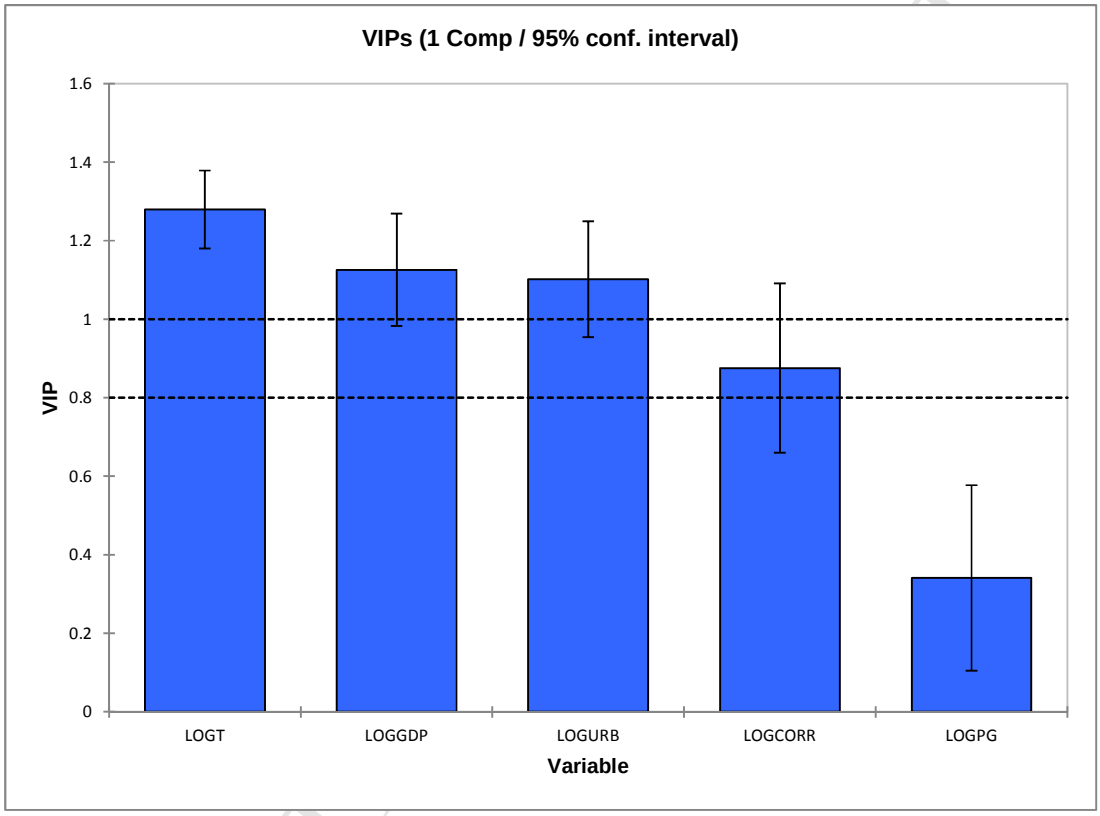

Fig 1: VIP histogram of BRICS countries

Highlights of the Study:

1. The interaction term of corruption is introduced in the growth-CO_2 emission nexus.
2. Partial least square method regression is applied.
3. Corruption weakens the relationship between economic growth and CO_2 emission.
4. Overall we infer that control of corruption decreases CO_2 emissions.