Impacts of Corruption on Sustainable Development: A Simultaneous Equations Model Estimation Approach

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Abstract
The concept of sustainable development epitomizes theoretical frameworks advocating in favor of at least maintaining the rate of development attained in the previous period. Traditionally, development was viewed from a narrow dimension that focused primarily on the development of the economy. However, with time, development has gathered emphasis from a broader perspective incorporating economic, social and environmental welfares into consideration. However, corruption is perceived to be a major factor inhibiting sustainable development all around the globe. The aim of this paper is to shed light on the corruption-sustainable development nexus from the perspective of select 47 countries across Asia, Africa and Latin America and the Caribbean (LAC). The paper attempts to estimate the elasticities of socioeconomic and environmental development indicators with regard to corruption and other macroeconomic fundamentals using annual data from 2000 to 2015. In addition, the paper also tests the Environmental Kuznets's Curve hypothesis in a panel framework and estimates the threshold levels of income at which the environmental degradation takes place with economic growth. Panel unit root and cointegration tests are used while the Three-Stage Least Squares (3SLS) estimation technique is employed to calculate the associated elasticities. Moreover, in order to check the robustness of the relationships, Panel Vector-Error Correction Model (VECM) and Granger causality test are also considered to understand the short run and long-run causal associations between the variables. In light of the estimated results, corruption is found to have a negative relationship with socioeconomic development across the Asian, African and LAC subpanels. In addition, corruption negatively affects environmental development in the context of the Asian and African subpanels while positively affecting in context of the LAC subpanel. Moreover, the findings also suggest that the EKC hypothesis holds true only in the cases of the full panel and the LAC subpanel, with the threshold per capita GDP being around 12,000 US$ and 12,780 US$, respectively. Our paper also finds short run bidirectional causality between corruption and socioeconomic development in the context of all the countries cumulatively which did not hold to be true in the long run. Furthermore, corruption and CO_2 emissions portray short bi-directional causality in context of the selected Asian economies and a

unidirectional causality running from corruption to CO_2 emission for all the economies as a whole.

1. Introduction

Development and its sustainability have been the core agenda of economies all around the globe. It is believed that development is meaningless if it cannot be sustained over and over again. There are many ways in which the concept of sustainable development had been put forward in existing literature. The United Nations (UN) classified sustainable development as a systematic process through which the short run demands are met without axing the longer run demands (World Commission on Environment and Development, 1987). The utmost importance of sustainable development, from a multidimensional aspect, has also recently been brought to the limelight through the UN's Sustainable Development Goals (SDGs) declaration on 25th September 2015. The SDGs as a whole is a successor to the Millennium Development Goals (MDGs) and comprises of 17 global goals with 169 targets aimed at ensuring sustainable development worldwide. Basically, the SDGs form a backdrop to minimization and gradual elimination of all the micro and macroeconomic factors that inhibit the development of the economy, society and the environment across the globe.

Traditionally, development was viewed from a narrow dimension that focused primarily on the development of the economy through increments in national incomes. Nations, in quest of expediting their economic growth rates, specifically concentrated on industrialization without putting much emphasis on the other non-economic welfare issues. However, with time, development had gathered further significances from a broader perspective via the addition of the social and environmental welfare policies to the economic development policies already in action. The foundations of social development are based on the fact that attainment of mere economic welfare does not guarantee social welfare as well since the economic welfare distributions may not disseminate proportionately among the population. Thus, economic development at times may not match the corresponding social development aspects. In addition, human resource development is also believed to be interconnected to social development which ultimately would complement the overall socio-economic development of a nation (Terziev and Georgiev, 2017). Simultaneously, environmental development has also been acknowledged recently following the worldwide concerns regarding the global climate change adversities taking place. It is believed that in absence of environmental sustainability, the progress made with respect to socioeconomic development across the world could well be undermined and reversed due to the environmental pressures that have accumulated over the years (OECD, 2012). Thus, sustainability of development can be classified as a cumulative process of ensuring economic, social and environmental sustainability. In this regard, a transition from non-renewable to renewable energy-use is often believed to complement the energy-sustainability targets of the government worldwide (Murshed 2018; Murshed 2019a; Murshed 2019b).

However, corruption is considered to be one of the major issues that can hold up the development drives (Murshed and Ahmed 2018). Although corruption is sometimes argued to foster development mainly due to it being the grease to the squeaky wheels of bureaucracy, the long-term impacts clearly outweigh the short-run benefits. Corruption usually hampers the development strategies making the associated strategies ineffective in reaching the desired national goals optimally. It is believed that in the presence of corruption a nation is always likely to be below par in attaining its economic, social and environmental developments. Thus, investigation of the impacts of corruption on the multi-dimensional macroeconomic indicators of development has always been a crucial area of research amongst economists and policymakers worldwide. Reinikka and Smith (2004) portrayed a negative relationship between corruption and economic development by asserting that rising corruption rates severely dampens national incomes in economies. Likewise, corruption and its attributes to upholding societal development had also been analyzed by researchers. According to Gupta *et al.* (2000), curbing the rates of corruption within an economy can lead to social development in the form of lower child and infant mortality rates reduced the percentage of babies with low birth-weights and declined number school dropouts. On the other hand, the adverse impact of corruption on the aggregated socioeconomic development of an economy is also acknowledged in the literature. For instance, corruption in the context of the education sector deteriorated human resource development in Russia which could eventually lead to unfavorable impacts on its economic development as well (Osipian, 2012). Finally, linkages between rising corruption levels and environmental degradation, jeopardizing environmental sustainability, have also been explained in studies by Islam (2016) and Liao *et al.* (2016). It is believed that corruption restrains application of laws aimed at mitigating environmental pollution whereby environmental sustainability as put to the sword at times.

The aim of this paper is to shed light on the corruption-sustainable development nexus from the perspective of select 47 countries across Asia, Africa and LAC (see table 11 in the appendix for the list of the countries). The paper attempts to estimate the elasticities of socioeconomic and environmental development indicators with regard to corruption and other macroeconomic fundamentals using annual data from 2000 to 2015. In addition, the paper also tests the Environmental Kuznets's Curve (EKC) hypothesis in a panel framework and estimates the threshold levels of income at which the environmental degradation takes place with further economic growth. Although there had been a plethora of studies focusing on the separate effects of corruption on socioeconomic and environmental sustainability, our paper fills the gap in the empirical literature by analyzing the corruption-development association under a simultaneous equations model framework. The following questions have been particularly addressed in our paper:

1. Does corruption impede attainment of socioeconomic and environmental development?
2. Does corruption diminish the efficacy of public and private investments?
3. What are the possible causal associations between the three dimensions of development and corruption?
4. Does the EKC hypothesis hold in presence of corruption? If yes, what is the threshold level of economic growth?

The rest of the paper is structured as follows. Section 2 provides an overview of corruption, socioeconomic and environmental development trends across Asia, Africa and LAC. This is followed by a review of relevant literature in section 3. The model specification and attributes of data considered in this paper are given in section 4. Subsequently, chapter 5 describes the econometric methodologies employed all throughout the paper while chapter 6 reports the estimated results. Finally, chapter 7 makes concluding remarks and sheds light on possible policy implications.

2. An Overview of Corruption, Socioeconomic and Environmental Indicators across Asia, Africa and LAC

2.1. Trends in Corruption

The CPI scores and corruption rankings of different countries across Asia, Africa and LAC are provided in table 1. Corruption has always been a grueling phenomenon across South and Southeast Asian regions. Statistical evidence suggests that South Asia has gone on to become the world's most corrupt region (Transparency International, 2014) whereby the development within this region has been scrutinized to a large extent. Despite the efforts to counter corruption practices in the South Asian countries, nominal improvements have been accounted for over the recent past (The Economist, 2017). Moreover, the corruption rankings, as done by the Transparency International (TI), of most of the South Asian countries exhibited declining trends between 2015 and 2016 (Transparency International, 2016a) which raises concerns regarding the sustainable development issues within this region. According to the Corruption Perceptions Index (CPI) figures in 2016, Bangladesh heads the list of South Asian regions in terms of being relatively more corrupted compared to India, Sri Lanka and Pakistan. Likewise, corruption has been a problem for the Southeast Asian economies as well. It has been estimated that almost 1% of the total economic growth annually is forgone courtesy corruption practices in the ASEAN since most of the associated member countries rank high in corruption (ASEAN Studies Program, 2016). The region's corruption vulnerability has affected its investments over the years. According to the businessmen's perceptions of bribery, Cambodia, Myanmar, Laos and Vietnam lie in the bottom tier of most corrupt countries globally (Transparency International, 2015). In contrast, Malaysia has done well in tackling its corruption issues compared to Indonesia, Philippines and Thailand, maintaining an average CPI score of 50.25 in between 2012 and 2015.

The corruption scenario in African countries is dismal too and the 2016 African elections have made matters even worse. Poor governance and unethical behavior of the police within this region has accounted for low CPI scores on average all throughout Africa (United Nations, 2016). The average CPI score within the Sub Saharan African region in 2016 was 31, which is lower than any average CPI score across the globe. Moreover, 89% of all the African nations depicted CPI scores of less than 50 in 2016 (Transparency International, 2016a). It is to be mentioned that despite the adoption of several anti-corruption measures, South Africa, Nigeria, Tanzania and Kenya have failed to get hold of the corruption phenomenon in these countries, resulting in high levels of CPI and bribery perceptions. Within this region, Somalia and Ghana were the worst decliners in CPI scores in 2016 (Banoba, 2017). Amongst the Sub Saharan African nations in 2016, Somalia was classified as the most corrupt country while Botswana emerged as the least corrupt economy, both having CPI scores of 10 and 60, respectively.

The menace of corruption has also skyrocketed across the LAC nations as well. The average CPI score in this region was 44 in 2016, which reflects the associated governments' ineffectiveness in implementing anti-corruption policies and acts. In light with the results from a survey conducted by the TI, two out of three people on average feel that corruption is on the rise within their economies while half of the people also expressed their unhappiness following payment of a bribe to avail public services (Pring, 2017). Mexico led in terms of perceptions of bribery in 2016 while Venezuela, having a CPI score of 17, was termed as the highly corrupt nation within the LAC region (Transparency International, 2016b). A major attribute of corruption in the LAC region was lack of cooperation from the police in these countries. 47% of the people, surveyed by TI in 2016, felt that their respective police departments were the most corrupt in nature.

Table 1: Corruption scenario in selected Asian, African and LAC nations (2015-2016)

Country	CPI 2016	CPI 2015	CPI Score Difference (2016-2015)	CPI 2016 Rank	CPI 2015 Rank	Rank difference (2015-2016)
Asia						
Bangladesh	26	25	1	145	139	-6
India	40	38	2	79	76	-3
Indonesia	37	36	1	90	88	-2
Malaysia	49	50	-1	55	54	-1
Pakistan	32	30	2	116	117	1
Philippines	35	35	0	101	95	-6
Sri Lanka	36	37	-1	95	83	-12
Thailand	35	38	-3	101	76	-25
Africa						
Angola	18	15	3	164	163	-1
Botswana	60	63	-3	35	29	-6
Cameroon	26	27	-1	145	130	-15
Central African Republic	20	24	-4	159	145	-14
Chad	20	22	-2	159	147	-12
Gambia	26	28	-2	145	123	-22
Ghana	43	47	-4	70	56	-14
Kenya	26	25	1	145	139	-6
Madagascar	26	28	-2	145	123	-22
Malawi	31	31	0	120	111	-9
Mali	32	35	-3	116	95	-21
Mauritius	54	53	1	50	45	-5
Mozambique	27	31	-4	142	111	-31
Namibia	52	53	-1	53	45	-8
Niger	35	34	1	101	98	-3
Nigeria	28	26	2	136	136	0
Republic of Congo	20	23	-3	159	146	-13
Senegal	45	44	1	64	61	-3
Sierra Leone	30	29	1	123	119	-4
Somalia	10	8	2	176	167	-9
South Africa	45	44	1	64	61	-3
Sudan	14	12	2	170	165	-5
Tanzania	32	30	2	116	117	1
Uganda	25	25	0	151	139	-12
Zimbabwe	22	21	1	154	150	-4

Latin America and Caribbean						
Argentina	36	32	4	95	106	11
Brazil	40	38	2	79	76	-3
Chile	66	70	-4	24	23	-1
Costa Rica	58	55	3	41	40	-1
Ecuador	31	32	-1	120	106	-14
El Salvador	36	39	-3	95	72	-23
Haiti	20	17	3	159	158	-1
Jamaica	39	41	-2	83	69	-14
Mexico	30	31	-1	123	111	-12
Panama	38	39	-1	87	72	-15
Paraguay	30	27	3	123	130	7
Peru	35	36	-1	101	88	-13
Uruguay	71	74	-3	21	21	0
Venezuela	17	17	0	166	158	-8

Source: Transparency International (2016a)

2.2. Stylized Facts on Socioeconomic Development

The Human Development Index (HDI) can be referred to as a key indicator of socioeconomic development within an economy since it ranks countries in terms of their healthcare, education and income per capita statistics as a whole. In the context of South Asia, Sri Lanka, as per the HDI report published by the United Nations Development Program (UNDP) 2016, heads the list with an HDI score of 0.757 in 2015 followed by India, Bangladesh and Pakistan with scores 0.624, 0.579 and 0.550, respectively. However, the HDI growth rate in Sri Lanka in 2015 is slower than many of the South Asian neighbors (Ramakrishnan, 2016). On the other hand, Bangladesh has been the forerunner accounting for the highest annual HDI growth rate of 1.64% between 1990 and 2015 amongst the South Asian economies (UNDP, 2017). Amongst the Southeast Asian economies, only Singapore and Brunei Darussalam have been classified as countries with very high human development, having HDI scores of 0.925 and 0.865 and HDI rankings of 5 and 30, respectively. Recently, Vietnam had surpassed Philippines in terms of HDI ranking mainly due to the nation's improvement in income inequality scenario (UNDP, 2016a). On the other hand, Cambodia registered the highest rate of HDI improvement from 2014 to 2015 with an average growth rate of 1.84%, which was relatively higher than the average HDI growth rate across East Asia and Pacific (Khemer Times, 2017).

Likewise, most of the world economies, the African countries on average also depicted a positive trend in terms of HDI improvement stepping into 2015 from 2014 (UNDP, 2016a). The average HDI score in this region was 0.497. According to the UNDP, the top three African economies in 2015 were Seychelles, Mauritius and Algeria with corresponding HDI scores of 0.782, 0.781 and 0.745. Conversely, Central African Republic, Chad and Niger were languishing at the bottom of the list with disappointing HDI scores of 0.352, 0.356 and 0.393, respectively (Woods, 2017). However, high rates of income inequality have also simultaneously exerted adverse impacts on these economies. It has been estimated that almost 32% of HDI scores are marginalized when adjusted with income inequality (Copley, 2017). Moreover, almost 50% of the African nations belong to low human development status which is a concerning issue when it comes to attainment of SDGs within these economies by 2030.

The LAC region is comparatively better off than the South Asian, Southeast Asian and African countries in terms of HDI scores. The average HDI score in this region was 0.751, slightly higher than the average HDI score in high human development countries with HDI score of 0.746 on average. In the context of the Caribbean economies, Jamaica in 2015 registered an HDI score of 0.730 indicating an impressive annual HDI improvement growth rate of 12.1% between1990 and 2015. However, the nation's inequality woos curb its HDI score and rank improvement by almost 16.6% (Campbell-Livingston, 2017). In the Latin American region, Venezuela held on to its high human development nation tag in 2015, having a higher HDI ranking than its regional neighbors Brazil, Peru and Columbia. However, Venezuela's HDI performance was even more impressive in the sense that the country managed to attain favorable outcomes in the HDI components despite the ongoing economic turmoil following adverse oil price shocks. Over the period of 2000 and 2015, the country's HDI scores improved by more than 13% (UNDP, 2016b). A detailed overview of the HDI components regarding the countries considered in this study is provided in Table 2.

Table 2: HDI components across Asia, Africa and the LAC in 2015

HDI Rank	Country	HDI	Life expectancy at birth (years)	Expected years of schooling	Mean years of schooling	GNI per capita (2011 PPP $)
			Asia			
59	Malaysia	0.789	74.9	13.1	10.1	24,620
73	Sri Lanka	0.766	75.0	14.0	10.9	10,789
87	Thailand	0.740	74.6	13.6	7.9	14,519
113	Indonesia	0.689	69.1	12.9	7.9	10,053
116	Philippines	0.682	68.3	11.7	9.3	8,395
131	India	0.624	68.3	11.7	6.3	5,663
139	Bangladesh	0.579	72.0	10.2	5.2	3,341
147	Pakistan	0.550	66.4	8.1	5.1	5,031
			Africa			
64	Mauritius	0.781	74.6	15.2	9.1	17,948
108	Botswana	0.698	64.5	12.6	9.2	14,663
119	South Africa	0.666	57.7	13.0	10.3	12,087

125	Namibia	0.640	65.1	11.7	6.7	9,770
135	Congo	0.592	62.9	11.1	6.3	5,503
139	Ghana	0.579	61.5	11.5	6.9	3,839
146	Kenya	0.555	62.2	11.1	6.3	2,881
150	Angola	0.533	52.7	11.4	5.0	6,291
151	Tanzania	0.531	65.5	8.9	5.8	2,467
152	Nigeria	0.527	53.1	10.0	6.0	5,443
153	Cameroon	0.518	56.0	10.4	6.1	2,894
154	Zimbabwe	0.516	59.2	10.3	7.7	1,588
158	Madagascar	0.512	65.5	10.3	6.1	1,320
162	Senegal	0.494	66.9	9.5	2.8	2,250
163	Uganda	0.493	59.2	10.0	5.7	1,670
165	Sudan	0.490	63.7	7.2	3.5	3,846
170	Malawi	0.476	63.9	10.8	4.4	1,073
173	Gambia	0.452	60.5	8.9	3.3	1,541
175	Mali	0.442	58.5	8.4	2.3	2,218
176	Congo (Dem.)	0.435	59.1	9.8	6.1	680
179	Sierra Leone	0.420	51.3	9.5	3.3	1,529
181	Mozambique	0.418	55.5	9.1	3.5	1,098
186	Chad	0.396	51.9	7.3	2.3	1,991
187	Niger	0.353	61.9	5.4	1.7	889
188	Central African Republic	0.352	51.5	7.1	4.2	587
Latin America and the Caribbean						
38	Chile	0.847	82.0	16.3	9.9	21,665
45	Argentina	0.827	76.5	17.3	9.9	20,945
54	Uruguay	0.795	77.4	15.5	8.6	19,148
60	Panama	0.788	77.8	13.0	9.9	19,470
64	Costa Rica	0.776	79.6	14.2	8.7	14,006
71	Venezuela	0.767	74.4	14.3	9.4	15,129
77	Mexico	0.762	77.0	13.3	8.6	16,383
79	Brazil	0.754	74.7	15.2	7.8	14,145
87	Peru	0.740	74.8	13.4	9.0	11,295
89	Ecuador	0.739	76.1	14.0	8.3	10,536
94	Jamaica	0.730	75.8	12.8	9.6	8,350
110	Paraguay	0.693	73.0	12.3	8.1	8,182
117	El Salvador	0.680	73.3	13.2	6.5	7,732
163	Haiti	0.493	63.1	9.1	5.2	1,657

Source: UNDP (2016b)

2.3. Carbon Dioxide (CO_2) emission trends

The global susceptibility to adverse climate changes has drawn the attention of environmentalists and policymakers worldwide. Thus, environmental sustainability has become a concerning issue dominating the national and international agendas across the globe. UNDP has referred CO_2 emissions as one of the key drivers of environmental degradation contributing heavily to the global greenhouse effect. Table 3 provides the trends in annual per capita CO_2 emission in the countries considered in this paper, between 2000 and 2015. In general, low and middle income countries are classified as the top CO_2 emitting nations compared to the high income countries. Furthermore, growth in CO_2 emission is believed to peak in context of transitional economies (Ritchie and Roser, 2017). Statistical reports suggest that China has historically been a major contributor to global CO_2 emissions. China's total annual volume CO_2 emissions went past that of the rest of the world in 2010 and the trend has continued till date (Olivier, 2017). Moreover, the geographic location of South Asian nations makes these regional countries highly vulnerable to negative externalities of environmental pollution through CO_2 emissions in particular. India has pioneered in terms of CO_2 emissions in South Asia, closely followed by Pakistan, Sri Lanka and Bangladesh (see table 3). In contrast, Malaysia is the leading emitter of CO_2 amongst the Southeast Asian nations considered in this paper, emitting around 8 metric tonnes of CO_2 per capita in 2015.

It is to be mentioned that the average per capita CO_2 emission in the South Asian and Sub Saharan African economies is comparatively lower than that in the North American countries. In the African region, Democratic Republic of Congo and Zimbabwe respectively have the lowest and highest volume of per capita CO_2 emission in 2015. On the other hand, Venezuela is has classified itself as a leader in the Latin American region in terms of per capita CO_2 emission in 2015, accounting for almost 6.2 metric tonnes of CO_2 emission per capita. Conversely, Haiti is at the most favorable position amongst the LAC countries emitting only 0.25 metric tonnes of CO_2 per capita in 2015 (World Bank, 2017).

Table 3: Trends in per capita CO_2 emissions in Asia, Africa and LAC (2000-2015)

Country	2000	2005	2010	2015
Asia				
Bangladesh	0.212	0.275	0.394	0.448
India	0.980	1.069	1.397	1.665
Pakistan	0.768	0.888	0.946	0.904
Sri Lanka	0.549	0.625	0.659	0.839
Indonesia	1.245	1.508	1.768	2.007
Malaysia	5.423	6.800	7.772	7.913
Philippines	0.940	0.867	0.905	1.014
Thailand	2.879	3.782	4.195	4.501
Africa				
Angola	0.580	0.980	1.243	1.287
Democratic Republic of Congo	0.017	0.027	0.031	0.056
Cameroon	0.225	0.212	0.340	0.276
Central African Republic	0.071	0.057	0.059	0.065
Chad	0.021	0.040	0.043	0.051
Republic of Congo	0.325	0.264	0.451	0.606
Kenya	0.331	0.238	0.294	0.306
Nigeria	0.622	0.763	0.577	0.560
Tanzania	0.078	0.140	0.154	0.217
Uganda	0.059	0.076	0.116	0.131
Sudan	0.159	0.274	0.345	0.313
Botswana	2.187	2.207	2.326	2.909
Madagascar	0.119	0.095	0.093	0.130
Malawi	0.076	0.067	0.075	0.074
Mauritius	2.268	2.684	3.132	3.277
Mozambique	0.075	0.087	0.113	0.244
Namibia	0.865	1.137	1.428	1.484
Gambia	0.199	0.203	0.256	0.260
Ghana	0.332	0.325	0.406	0.527
Mali	0.075	0.070	0.064	0.076
Niger	0.061	0.053	0.071	0.109

Senegal	12.791	13.296	14.813	16.446
Sierra Leone	14.333	10.024	10.246	10.246
South Africa	18.387	19.478	20.230	20.462
Zimbabwe	24.265	15.211	18.347	23.447
Latin America and Caribbean				
Argentina	3.836	4.141	4.558	4.671
Brazil	1.871	1.858	2.133	2.502
Chile	3.853	3.828	4.252	4.688
Costa Rica	1.395	1.617	1.665	1.642
Ecuador	1.641	2.203	2.441	2.681
Haiti	0.160	0.224	0.213	0.253
Jamaica	3.880	3.825	2.590	2.651
Mexico	3.916	4.299	3.958	3.939
Panama	1.911	2.053	2.515	2.434
Peru	1.169	1.345	1.961	1.929
Paraguay	0.696	0.661	0.821	0.856
El Salvador	0.979	1.070	1.048	1.018
Uruguay	1.598	1.737	1.893	2.118
Venezuela	6.224	6.164	6.513	6.139

Source: World Bank (2017).

3. Literature Review

3.1. Corruption and Economic Growth Literature

Many studies over the years have focused on the corruption and its impacts on attainment of economic development. For instance, Mikaelsson and Sall (2014) probed in the corruption-economic growth nexus in context of 40 developing countries. The authors performed OLS estimation techniques to estimate a linear regression model in which GDP growth rate per capita was expressed as a function of corruption and other growth determinants. The regression results confirmed that in the presence of corruption economic growth in the developing countries, as a whole got stalled and declined over time, suggesting a negative relationship between these two macroeconomic indicators. The results corroborated to those found by Ibraheem *et al.* (2013) who used similar methodology and to deduce a negative association between corruption and economic growth in Nigeria.

The intertemporal causal association between corruption and level of GDP was analyzed by Lučić *et al.* (2016) for a panel of 40 countries. The study used relevant data spanning across 1995 and 2011 for theoretical analysis incorporating the narrative method and for empirical analysis tapping normative method. The authors basically wanted to understand the degree of causality running from corruption to economic growth in the short, medium and long-term periods of five, 10 and 15 years, respectively. The associated Pearson correlation coefficient values revealed that the causality is strongest in the medium periods compared to the other two time periods considered.

The menace of corruption impeding growth in the Chinese provinces was investigated by D'Amico (2015). The study was based on the conceptual framework put forward by Barro (1998) and used a similar regression model holding the provincial incomes in the Chinese economy as a function of corruption prevention efforts and several other determinants of national income. Relevant annual time series data from 1998 to 2003 was employed for performing OLS estimation and also for a cross-province correlation analysis between corruption and economic growth. The findings asserted that corruption indeed exerted a detrimental impact on the provincial incomes in China whereby an increase in corruption prevention efforts by 1 percentage point simultaneously led to a rise in income level by 0.002 percentage points.

3.2. Corruption and Healthcare and Education Literature

The nexus between healthcare expenditure and corruption was analyzed by Gupta *et al.* (2000). They used annual time series data accumulated from 128 advanced and developing countries, between 1985 and 1997, and employed OLS estimation and Instrumental Variable (IV) method. The healthcare regression model consisted of health status as the dependent variable while corruption and other control variables were held as the regressors. In light of the findings, Gupta *et al.* (2000) concluded that corruption hampered healthcare development in the aforementioned countries resulting in higher child and infant mortality rates and a greater percentage of low-birth weights. They referred to corruption as a barrier against delivery of social services including healthcare and education. The findings are in line with those by Sharma (2010) who asserted that corruption and politics are the main reasons behind Nepal being ranked as the lowest healthcare providing country in South Asia.

On the other hand, Dridi (2014) analyzed the effects of corruption in the education sector in a cross-country analysis between 103 countries, using annual data spanning from 1980 to 2002. The paper employed linear regression models expressing multiple indicators of education as functions of corruption index and other control variables that can affect the education indicators. Cross-sectional analyses were carried out tapping the Two-Stage Least Squares (2SLS) and OLS methods. The results confirmed that corruption adversely affects education quality and enrolment rates. The estimated results also revealed that an increase in corruption index by one point led to a drop in the secondary school enrolment rate by 10 percentage points, validating the negative nexus between education and corruption. The conclusions can be linked with the remarks made by Jajkowicz and Drobiszova (2015) in which the authors have found a negative relationship between corruption and government expenditure on the education sector in the context of 21 OECD countries. The authors asserted that a rise in the corruption level tends to exert a crowding out effect marginalizing the education expenditure while increasing public expenditure on defense and general public services. These findings corroborate the inferences made by Delavallade (2006). According to Delavallade, corruption distorts the public expenditure allocations resulting into reduction in government spending for education sector development purposes.

3.3. Corruption and Environment Literature

The effects of corruption with regard to environmental sustainability has been analyzed in literature holding harmful gaseous emissions as a proxy for environmental degradation. For instance, Ünver and Koyuncu (2017) investigated the nexus between corruption and CO_2 emissions in the context of a panel of 173 countries between 1995 and 2013. The authors estimated two regression model, fixed and random effects model in which CO_2 emission was thought to be determined three measures of corruption and other control variables. In addition correlation analysis between the variables was also performed. The results from the regressions revealed a statistically significant positive association between all three measures of corruption and volume of CO_2 emissions in the aforementioned panel. This implied that corruption is indeed a threat to environmental sustainability in these countries. The negative impact of corruption on the environment of 29 provincial states of China was also put forward by Lao *et al.* (2012). The findings revealed that anti-corruption initiatives in China seem to have effective impacts in reducing Sulphur Dioxide (SO_2) emissions in China.

4. Model Specification and Data

This paper employs two core regression models particularly to identify the effect of corruption on socioeconomic and environmental development indicators across Asia, Africa and the LAC. The regression models are given by:

$$HDI_t = \beta_0 + \beta_1 CPI_t + \beta_2 GDP_t + \beta_3 GOV_t + \beta_4 FAID_t + \beta_5 FDI_t + \beta_6 TRADE_t + \beta_7 CO2_t + \varepsilon_t \text{ ......(i)}$$

$$CO2_t = \rho_0 + \rho_1 GDP_t + \rho_2 GDP_t^2 + \rho_3 CPI_t + \rho_4 GOV_t + \rho_5 FAID_t + \rho_6 FDI_t + \rho_7 TRADE_t + \theta_t \text{ ....(ii)}$$

where HDI is Human Development Index (used as a proxy to denote socioeconomic development within the panel), CPI is Corruption Perceptions Index (used as a proxy to capture the effect of corruption), GDP is Gross Domestic Product per capita (used to denote the standard of living), GOV is the government size, FAID is net official development assistance received, FDI is foreign direct investment inflows, TRADE is the volume of exports and imports and CO_2 is the per capita carbon dioxide emission.

Model (i) is employed to understand the effect of corruption and other macroeconomic variables on the socioeconomic development indicator variable, HDI. HDI is a commonly used proxy in the sense that HDI calculation incorporates healthcare, educational and standard of altogether. In contrast, model (ii) is hired to analyze the effect of corruption and other factors on CO_2 emissions affecting environmental sustainability. In addition, this model also investigates the EKC hypothesis (Dinda, 2004) by incorporating a squared term of the variable GDP. Relevant data spanning from 2000 to 2015 was acquired in the context of all the countries considered in the paper. The units of the variables used and the corresponding data sources are provided in table 4.

Table 4: The units and sources of the variables considered in the paper

Variable	Units	Source
HDI	Number	United Nations Development Programme (UNDP)
CPI	Number	Transparency International
CO_2	metric tonnes per capita	World Bank
GDP	current US$	World Bank
GOV	% of GDP	World Bank
FAID	Current US$	World Bank
FDI	% of GDP	World Bank
TRADE	% of GDP	World Bank

Note: Data of all the variables were accumulated for the period between 2000 and 2015.

5. Methodology

5.1. Three-Stage Least Squares (3SLS) Estimation

Endogeneity problem in data series is a key issue whereby the OLS estimation assumptions are violated making this regression methodology inappropriate. Thus, the Three-Stage Least Squares (3SLS) simultaneous equations model estimation technique (Zellner and Theil, 1962) provides the solution to the endogeneity problem faced in the OLS estimation. For instance, heteroscedasticity in data violates one of the assumptions of OLS estimation method, however, in the 3SLS method although the structural error terms may be correlated across the simultaneous equations, it is assumed that within each equation the error terms are both serially uncorrelated and homoscedastic.

The term 3SLS reflects a certain mechanism of estimation that combines a set of simultaneous equations model, sometimes known as Seemingly Unrelated Regression (SUR), with Two-Stage Least Squares (2SLS) estimation. It is basically a type of Instrumental Variables (IV) estimation that allows correlations of the unobserved error terms across several equations and enhances the efficiency of equation-by-equation regression by considering such correlations across the simultaneous equations. Unlike the 2SLS approach for an array of simultaneous equations, which separately estimates the slope coefficients of each equation, the 3SLS methodology estimates all coefficients instantaneously. The estimation technique hinges on the assumption that each equation

is at least just-known since unknown equations are not considered in the 3SLS estimation. As the name suggests, the 3SLS estimation procedure involves estimation of a model of simultaneous equations in three stages. In the first stage, 2SLS method is incorporated to estimate the residuals of the simultaneous equations. The second stage involves the addition of the optimal instrumental variable using the estimated residuals to develop the disturbance variance-covariance matrix. Finally, the third stage involves a joint estimation of the set of simultaneous equations using the optimal instrument.
This was followed by the panel unit root tests and cointegration analysis which are prerequisites for performing the causality analyses.

5.1. Vector Error Correction Model (VECM)

Engle and Granger (1987) showed that a VECM is an appropriate method to model the long-run as well as short-run dynamics among the cointegrated variables. Causality inferences in the multi-variate framework are made by estimating the parameters of the following VECM equations.

$$\Delta Y = \alpha + \sum_{i=1}^{m} \beta i \Delta Y_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta X_{t-j} + \sum_{k=1}^{0} \delta \Delta M^s + \sum_{l=1}^{p} \zeta \Delta N + \theta Z_{t-1} + \varepsilon_t \text{ ………………… (iii)}$$

$$\Delta X = a + \sum_{i=1}^{m} b_i \Delta Y + \sum_{j=1}^{n} c_j \Delta X_{t-j} + \sum_{k=1}^{0} d \Delta M^s + \sum_{l=1}^{p} e \Delta N + f Z_{t-1} + \xi_t \text{ …………………….. (iv)}$$

z_{t-1} is the error-correction term which is the lagged residual series of the cointegrating vector. The error-correction term measures the deviations of the series from the long run equilibrium relation. For example, from equation (iii), the null hypothesis that X does not Granger-cause Y is rejected if the set of estimated coefficients on the lagged values of X is jointly significant. Furthermore, in those instances where X appears in the cointegrating relationship, the hypothesis is also supported if the coefficient of the lagged error-correction term is significant. Changes in an independent variable may be interpreted as representing the short run causal impact while the error-correction term provides the adjustment of Y and X toward their respective long run equilibrium. Thus, the VECM representation allows us to differentiate between the short- and long-run dynamic relationships. The Chi-Square test statistic is used to determine the short run causalities between pairs of variables in the model.

5.1. Granger Causality Test

When we take y and x as our variables of interest, then the Granger causality test (Granger, 1969) determines whether past values of y add to the explanation of current values of x as provided by information in past values of x itself. If previous changes in y do not help explain current changes in x, then y does not Granger cause x. In a similar way, we can examine if x Ganger causes y just be interchanging them and carrying out this process again. There could be four probable outcomes: (a) x Granger causes y (b) y Granger causes (c) Both x and y granger causes the other and (d) neither of the variables Granger causes the other.

In this paper, the causality tests among all the concerned variables are conducted. For this the following set of equations are estimated:

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \cdots\cdots + \alpha_l x_{t-l} + \beta_1 y_{t-1} + \cdots\cdots + \beta_l y_{t-l} + u_t \quad \text{.................................. (v)}$$

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots\cdots + \alpha_l y_{t-l} + \beta_1 x_{t-1} + \cdots\cdots + \beta_l x_{t-l} + v_t \quad \text{................................(vi)}$$

We consider the above set of equations for all possible pairs of (x, y) series in the group. The reported F-statistics are the Wald statistics for the joint hypothesis. After confirming the long run causalities between the variables considered in the model, the VECM approach provides the short run causal relationships.

We resorted to using EViews 7.1 and STATA 15 software to execute the econometric tests throughout our paper.

6. Results

Results from the 3SLS regression analysis in the context of model (i) are reported in table 5. In light of the results, it can be seen that corruption has a positive relationship with HDI in case of all the three subpanels which coincides with the *a priori* expectations with corruption being a key socio-economic development impeding factor. This implies that corruption does affect the efficacy of the development policies within an economy which calls for effective measures to be taken in order to tackle corruption. Moreover, our results also reveal that the coefficient of trade is positive and statistically significant for the full panel as well as for the subpanels suggesting that a rise in the trade volumes in these nations get translated into an improvement in their HDI.

The 3SLS estimation results in context of model (i)

Endogenous Dependent Variable: HDI								
Explanatory Variables	Full Panel		Asian Panel		African Panel		LAC Panel	
	Coeff.	St. Dev.	Coeff.	St. Dev.	Coeff.	St. Dev.	Coeff.	St. Dev.
CPI	0.005 (0.121)	0.003	0.010* (0.001)	0.010	0.009* (0.000)	0.002	0.025* (0.000)	0.004
GDP	-6.7E-6 (0.198)	5.28E-6	0.000* (0.000)	0.000	0.000* (0.000)	8.9E-6	-2.85E-6 (0.251)	2.48E-6
GOV	-0.007* (0.000)	0.001	0.004*** (0.057)	0.002	-0.001 (0.290)	0.001	0.006* (0.000)	0.002
FAID	0.000 (0.135)	0.000	-0.001*** (0.090)	0.001	0.000 (0.774)	0.000	-0.002 (0.185)	0.000
FDI	0.003** (0.043)	0.002	-0.001 (0.903)	0.005	-0.003* (0.000)	0.001	-0.000 (0.995)	0.002
TRADE	-0.004*** (0.098)	0.000	0.003* (0.000)	0.000	0.001* (0.000)	0.000	0.000* (0.005)	0.000

CO_2	0.107* (0.000)	0.015	-0.133* (0.000)	0.026	-0.012 (0.346)	0.013	0.050* (0.000)	0.009
R-squared	0.858		0.619		0.394		0.487	

Notes: Optimal lag selection is based on Schwarz Information Criteria (SIC)
Probability values are reported in parentheses.
*, **, and *** denote statistical significances at 1%, 5% and 10% levels, respectively.*

Table 6 presents the results from the 3SLS estimation of model (ii). According to the reported findings, it can be seen that the coefficients of corruption in the context of all the three subpanels are negative and statistically significant. This implies that corruption across the Asian, African and the LAC countries poses a significant threat to their environmental sustainability as a rise in the levels of corruption triggers the corresponding rise in the volume of CO_2 emissions. In addition, the validity of the EKC hypothesis is found only in the context of the full panel and the LAC panel which is evident from the signs and statistical significance of the relevant slope coefficients of GDP and GDP^2. In case of the full panel, the elasticity of per capita CO_2 emissions with regard to per capita GDP is 0.00065 + 2(-0.0000000271) GDP. Thus, the threshold level of per capita GDP at the turning point of the inverted-U shaped EKC is estimated to be $-\frac{0.00065}{2(-0.0000000271)}$ = 11,992.62 (current US $). Similarly, in case of the LAC subpanel, the elasticity of per capita CO_2 emissions with regard to GDP per capita is 0.00069 + 2(-0.0000000271) GDP. Thus, the corresponding threshold level of per capita GDP is estimated to be $-\frac{0.00069}{2(-0.0000000270)}$ = 12,777.78 (current US$).

Table 6: The 3SLS estimation results in context of model (ii)

Endogenous Dependent Variable: CO_2								
Explanatory Variables	**Full Panel**		**Asian Panel**		**African Panel**		**LAC Panel**	
	Coeff.	**St. Dev.**	**Coeff.**	**St. Dev.**	**Coeff.**	**St. Dev.**	**Coeff.**	**St. Dev.**
GDP	0.001* (0.000)	0.000	0.000*** (0.060)	0.000	0.000 (0.892)	0.000	0.001* (0.000)	0.000
GDP^2	-2.71E-8* (0.000)	3.50E-9	2.87E-8* (0.000)	6.78E-9	1.05E-7* (0.000)	2.12E-8	-2.7E-8* (0.000)	5.68E-9
CPI	0.043 (0.125)	0.028	-0.162*** (0.077)	0.092	-0.073** (0.018)	0.031	-0.235* (0.001)	0.069
GOV	0.023** (0.035)	0.011	0.011 (0.581)	0.021	0.017 (0.213)	0.013	-0.061*** (0.066)	0.033
FAID	-0.006* (0.000)	0.001	-0.028* (0.000)	0.005	-0.006* (0.000)	0.002	-0.009* (0.007)	0.003
FDI	-0.054* (0.000)	0.010	0.055 (0.263)	0.049	-0.022** (0.050)	0.001	-0.036 (0.313)	0.036
TRADE	0.010* (0.000)	0.002	0.018* (0.000)	0.002	0.001 (0.655)	0.003	0.690* (0.000)	0.451
R-squared	0.550		0.938		0.492		0.455	

Notes: Optimal lag selection is based on Schwarz Information Criteria (SIC)
Probability values are reported in parentheses.
*, **, and *** denote statistical significances at 1%, 5% and 10% levels, respectively.*

In order to check the robustness of our findings, we also investigated the short and long run causal associations between the variables considered in the paper. Table 7 reports the VECM approach results in the context of model (i). The findings confirm a bidirectional causal nexus between CPI and HDI in context of the full panel while a unidirectional causality is found to be running from HDI to CPI in context of the African subpanel, in the short run. In contrast, no causal linkage between these two macroeconomic variables is found in the context of the Asian and the LAC subpanels. The estimated short run causal associations also reveal that FDI and TRADE influence HDI in context of the full panel and the African subpanel, respectively.

Table 7: VECM results in context of model (i)

Sources of Causation for Full Panel									
Dep. Var.	**Short Run**								**Long Run**
	D(HDI)	**D(CPI)**	**D(GDP)**	**D(GOV)**	**D(FAID)**	**D(FDI)**	**D(TR)**	**D(CO_2)**	**ECT**
D(HDI)	-	5.186*** (0.075)	0.377 (0.828)	1.604 (0.448)	2.132 (0.344)	6.957** (0.031)	2.553 (0.279)	1.130 (0.568)	-0.000 (0.314)
D(CPI)	5.790*** (0.055)	-	4.544 (0.103)	11.471** (0.003)	0.789 (0.674)	0.242 (0.886)	2.165 (0.339)	1.746 (0.418)	-8.58E-05 (0.882)
D(GDP)	3.072 (0.215)	0.922 (0.631)	-	0.942 (0,624)	0.051 (0.975)	7.534** (0.023)	0.637 (0.727)	9.303* (0.001)	-0.009 (0.011)
D(GOV)	3.359 (0.186)	0.621 (0.733)	3.228 (0.199)	-	11.115* (0.004)	8.989** (0.011)	3.218 (0.200)	1.320 (0.517)	0.000 (0.475)
D(FAID)	5.353*** (0.069)	0.721 (0.697)	0.980 (0.613)	6.731** (0.035)	-	11.177* (0.004)	1.025 (0.599)	0.092 (0.955)	-0.067 (0.001)
D(FDI)	0.030 (0.985)	0.066 (0.967)	2.041 (0.360)	1.395 (0.498)	12.566* (0.002)	-	2.964 (0.227)	2.834 (0.243)	-0.286 (0.000)
D(TR)	3.731 (0.155)	6.347** (0.041)	13.960* (0.000)	2.290 (0.318)	2.324 (0.313)	2.835 (0.242)	-	0.024 (0.988)	-0.005 (0.151)
D(CO_2)	3.112 (0.211)	0.180 (0.914)	2.781 (0.249)	1.415 (0.493)	1.975 (0.373)	2.550 (0.280)	1.468 (0.480)	-	0.002 (0.195)
Sources of Causation for Asian Subpanel									
Dep. Var.	**Short Run**								**Long Run**
	D(HDI)	**D(CPI)**	**D(GDP)**	**D(GOV)**	**D(FAID)**	**D(FDI)**	**D(TR)**	**D(CO_2)**	**ECT**
D(HDI)	-	1.069 (0.586)	1.113 (0.573)	0.491 (0.782)	0.479 0.787	1.267 (0.531)	4.434 (0.109)	0.385 (0.825)	9.23E-05 (0.972)
D(CPI)	0.361 (0.835)	-	4.540 (0.103)	3.216 (0.200)	1.364 (0.506)	2.766 (0.251)	3.346 (0.188)	2.697 (0.260)	-0.005 (0.519)
D(GDP)	1.813 (0.404)	4.031 (0.133)	-	0.676 (0.713)	0.715 (0.700)	7.658** (0.022)	1.639 (0.441)	7.082** (0.029)	-0.107 (0.000)
D(GOV)	1.008 (0.604)	0.509 (0.776)	1.088 (0.580)	-	3.426 (0.180)	0.643 (0.725)	0.938 (0.626)	0.246 (0.884)	-0.003 (0.793)
D(FAID)	5.681*** (0.058)	0.432 (0.806)	1.375 (0.503)	0.647 (0.724)	-	1.320 (0.517)	0.503 (0.778)	2.719 (0.257)	0.005 (0.344)
D(FDI)	10.369* (0.006)	0.675 (0.714)	8.585** (0.014)	0.429 (0.807)	1.308 (0.520)	-	4.843*** (0.089)	8.311** (0.016)	-0.305 (0.000)
D(TR)	5.481***	0.354	9.012**	2.746	0.062	0.436	-	3.268	-0.002

	(0.065)	(0.838)	(0.011)	(0.253)	(0.962)	(0.804)		(0.195)	(0.599)
D(CO_2)	2.130	5.847***	7.074**	1.568	0.430	3.213	9.131**	-	0.082*
	(0.345)	(0.054)	(0.029)	(0.457)	(0.807)	(0.201)	(0.010)		(0.000)
Sources of Causation for African Subpanel									
Dep. Var.	**Short Run**								**Long Run**
	D(HDI)	**D(CPI)**	**D(GDP)**	**D(GOV)**	**D(FAID)**	**D(FDI)**	**D(TR)**	**D(CO_2)**	**ECT**
D(HDI)	-	3.986	2.401	1.232	2.205	2.717	5.622***	0.766	-0.000
		(0.136)	(0.301)	(0.540)	(0.332)	(0.257)	(0.060)	(0.682)	(0.381)
D(CPI)	6.436**	-	0.763	12.182*	0.502	0.247	1.738	0.712	-0.004
	(0.040)		(0.683)	(0.002)	(0.778)	(0.884)	(0.419)	(0.700)	(0.531)
D(GDP)	0.546	0.965	-	0.147	5.136***	3.979	0.428	2.240	0.000
	(0.761)	(0.617)		(0.929)	(0.077)	(0.137)	(0.807)	(0.326)	(0.245)
D(GOV)	2.362	0.725	1.232	-	7.216**	6.631**	1.730	0.976	-0.000
	(0.307)	(0.696)	(0.540)		(0.027)	(0.036)	(0.421)	(0.614)	(0.383)
D(FAID)	4.426	0.044	3.736	4.440	-	16.264*	1.469	0.023	-0.329*
	(0.109)	(0.978)	(0.155)	(0.109)		(0.000)	(0.480)	(0.989)	(0.000)
D(FDI)	0.035	0.234	2.869	1.111	19.735*	-	3.763	0.993	-0.265*
	(0.983)	(0.890)	(0.238)	(0.574)	(0.000)		(0.152)	(0.609)	(0.000)
D(TR)	1.957	6.288**	0.725	1.593	2.540	3.569	-	1.616	-0.005
	(0.376)	(0.043)	(0.696)	(0.451)	(0.281)	(0.168)		(0.446)	(0.282)
D(CO_2)	1.948	0.699	0.363	3.593	2.508	5.163***	1.191	-	-0.002**
	(0.378)	(0.705)	(0.834)	(0.166)	(0.285)	(0.076)	(0.551)		(0.045)
Sources of Causation for LAC Subpanel									
Dep. Var.	**Short Run**								**Long Run**
	D(HDI)	**D(CPI)**	**D(GDP)**	**D(GOV)**	**D(FAID)**	**D(FDI)**	**D(TR)**	**D(CO_2)**	**ECT**
D(HDI)	-	1.787	0.115	2.551	0.558	0.396	0.174	3.188	-0.001
		(0.409)	(0.944)	(0.279)	(0.756)	(0.820)	(0.917)	(0.203)	(0.940)
D(CPI)	2.256	-	4.905***	0.396	0.033	0.257	3.412	0.639	0.000
	(0.324)		(0.086)	(0.820)	(0.984)	(0.879)	(0.182)	(0.727)	(0.982)
D(GDP)	3.902	0.676	-	1.423	0.087	1.833	2.262	2.443	0.010
	(0.142)	(0.713)		(0.491)	(0.957)	(0.400)	(0.323)	(0.295)	(0.606)
D(GOV)	11.731	0.434	2.462	-	1.601	8.294**	0.949	0.577	-0.117**
	(0.003)*	(0.805)	(0.292)		(0.449)	(0.016)	(0.622)	(0.749)	(0.014)
D(FAID)	0.681	4.494	0.084	3.082	-	2.412	0.407	2.182	-0.020
	(0.711)	(0.106)	(0.959)	(0.214)		(0.299)	(0.816)	(0.336)	(0.194)
D(FDI)	1.263	3.454	2.162	6.274*	0.080	-	1.774	46.489*	-1.633
	(0.532)	(0.178)	(0.339)	(0.043)	(0.961)		(0.412)	(0.000)	(0.000)*
D(TR)	2.648	2.030	1.999	1.520	1.777	12.865*	-	8.694**	0.004
	(0.266)	(0.362)	(0.368)	(0.468)	(0.411)	(0.002)		(0.013)	(0.002)
D(CO_2)	6.777**	0.825	1.381	4.173	1.679	11.064*	0.947	-	-0.294*
	(0.034)	(0.662)	(0.501)	(0.124)	(0.432)	(0.004)	(0.623)		(0.008)

*Notes: The Chi-square statistics for the explanatory variables are reported while the corresponding probabilities are given in the parentheses. The short run causality is determined by the statistical significance of the Chi-squares statistics. *, ** and ** denote the statistical significance of the Chi-squares statistics at 1%, 5% and 10% levels of significance.*

Results from the VECM approach estimation in the case of model (ii) are reported in table 8. It can be seen that bidirectional causality between CPI and CO_2 and a unidirectional causality from CPI to CO_2 exist in contexts of the Asian and the African subpanels, respectively. This implies that corruption is effective in influencing CO_2

emissions in countries belonging to these subpanels, putting their environmental sustainability into question.

Table 8: VECM results in context of model (ii)

Dep. Var.	Short Run							Long Run
Sources of Causation for Full Panel								
	D(CO_2)	D(CPI)	D(GDP)	D(GOV)	D(FAID)	D(FDI)	D(TR)	ECT
D(CO_2)	-	2.734 (0.255)	0.305 (0.859)	1.383 (0.501)	1.493 (0.474)	2.690 (0.261)	1.141 (0.565)	0.002 (0.141)
D(CPI)	1.466 (0.480)	4.116 (0.128)	-	11.532* (0.003)	1.431 (0.489)	0.271 (0.873)	2.173 (0.338)	-0.001 (0.653)
D(GDP)	9.585* (0.008)	-	1.264 (0.532)	0.820 (0.664)	0.116 (0.944)	6.391** (0.041)	0.782 (0.0.677)	-0.008 (0.025)**
D(GOV)	1.539 (0.463)	0.876 (0.646)	2.969 (0.227)	-	11.293* (0.004)	10.056* (0.007)	3.508 (0.173)	-0.000 (0.175)
D(FAID)	0.082 (0.960)	0.868 (0.648)	1.120 (0.571)	6.085** (0.048)	-	15.079* (0.001)	0.731 (0.694)	-0.112* (0.000)
D(FDI)	3.081 (0.214)	0.115 (0.944)	2.841 (0.242)	1.765 (0.414)	16.184* (0.000)	-	3.035 (0.219)	-0.263* (0.000)
D(TR)	0.043 (0.979)	5.798*** (0.055)	13.841* (0.001)	2.352 (0.309)	2.762 (0.251)	2.741 (0.254)	-	-0.004 (0.178)
Sources of Causation for Asian Subpanel								
Dep. Var.	**Short Run**							**Long Run**
	D(CO_2)	D(CPI)	D(GDP)	D(GOV)	D(FAID)	D(FDI)	D(TR)	ECT
D(CO_2)	-	6.894** (0.032)	8.751** (0.013)	0.808 (0.668)	0.335 (0.846)	1.552 (0.460)	14.749* (0.001)	0.065* (0.000)
D(CPI)	6.995** (0.030)	-	3.210 (0.201)	0.288 (0.866)	0.684 (0.710)	4.104 (0.129)	1.486 (0.476)	-0.099* (0.000)
D(GDP)	2.199 (0.333)	5.103*** (0.078)	-	2.936 (0.230)	1.029 (0.598)	3.452 (0.178)	3.253 (0.197)	-0.022 (0.132)
D(GOV)	0.097 (0.953)	0.546 (0.761)	0.935 (0.627)	-	3.340 (0.188)	0.559 (0.756)	1.770 (0.413)	0.001 (0.982)
D(FAID)	1.718 (0.424)	0.233 (0.890)	1.544 (0.462)	0.760 (0.684)	-	2.251 (0.324)	0.897 (0.639)	0.007 (0.400)
D(FDI)	0.382 (0.683)	0.182 (0.913)	6.900** (0.032)	0.299 0.861	1.731 (0.421)	-	2.763 (0.251)	-0.046** (0.025)
D(TR)	5.003*** (0.082)	0.550 (0.760)	10.810* (0.005)	3.342 (0.188)	0.043 (0.979)	0.957 (0.620)	-	-0.006 (0.439)
Sources of Causation for African Subpanel								
Dep. Var.	**Short Run**							**Long Run**
	D(CO_2)	D(CPI)	D(GDP)	D(GOV)	D(FAID)	D(FDI)	D(TR)	ECT
D(CO_2)	-	1.004 (0.605)	0.514 (0.774)	3.277 (0.194)	2.324 (0.313)	5.125*** (0.077)	1.276 (0.528)	-0.002** (0.031)
D(CPI)	0.591 (0.744)	-	0.583 (0.747)	11.417* (0.003)	1.452 (0.484)	0.324 (0.850)	1.794 (0.408)	-0.007 (0.330)
D(GDP)	2.204 (0.332)	1.003 (0.606)	-	0.104 (0.949)	4.465 (0.107)	4.595 (0.101)	0.534 (0.766)	0.000 (0.364)

D(GOV)	1.002 (0.607)	1.013 (0.603)	0.929 (0.628)	-	8.123** (0.017)	6.662** (0.036)	2.209 (0.331)	-0.001 (0.281)
D(FAID)	0.024 (0.988)	0.042 (0.979)	4.681*** (0.096)	3.811 (0.149)	-	16.557* (0.000)	1.234 (0.540)	-0.354* (0.000)
D(FDI)	0.992 (0.609)	0.311 (0.856)	3.030 (0.220)	1.219 (0.544)	19.375* (0.000)	-	3.454 (0.178)	-0.242* (0.000)
D(TR)	1.683 (0.431)	5.697*** (0.058)	0.938 (0.626)	1.919 (0.383)	2.822 (0.244)	3.509 (0.173)	-	-0.003 (0.273)
Sources of Causation for LAC Subpanel								
Dep. Var.	**Short Run**							**Long Run**
	D(CO_2)	**D(CPI)**	**D(GDP)**	**D(GOV)**	**D(FAID)**	**D(FDI)**	**D(TR)**	**ECT**
D(CO_2)	-	1.208 (0.547)	1.416 (0.493)	5.863*** (0.053)	0.862 (0.650)	3.067 (0.216)	2.700 (0.259)	8.7E-05 (0.189)
D(CPI)	1.213 (0.545)	-	2.500 (0.287)	1.315 (0.518)	0.273 (0.872)	1.171 (0.557)	1.793 (0.408)	0.017 (0.042)
D(GDP)	5.111*** (0.078)	0.186 (0.911)	-	0.478 (0.787)	0.037 (0.982)	1.734 (0.420)	1.372 (0.504)	-0.015*** (0.094)
D(GOV)	5.072*** (0.079)	1.482 (0.477)	6.963** (0.031)	-	0.966 (0.617)	3.674 (0.159)	0.091 (0.956)	-0.007 (0.538)
D(FAID)	0.555 (0.758)	4.811*** (0.093)	0.272 (0.873)	3.521 (0.172)	-	5.371*** (0.068)	0.428 (0.807)	-0.094* (0.002)
D(FDI)	13.559* (0.001)	2.170 (0.338)	2.360 (0.307)	5.856*** (0.054)	4.154 (0.125)	-	1.103 (0.576)	-0.246* (0.000)
D(TR)	1.583 (0.453)	1.914 (0.384)	12.506* (0.002)	0.412 (0.814)	1.903 (0.386)	0.007 (0.996)	-	-0.020 (0.336)

*Notes: The Chi-square statistics for the explanatory variables are reported while the corresponding probabilities are given in the parentheses. The short run causality is determined by the statistical significance of the Chi-squares statistics. *, ** and ** denote the statistical significance of the Chi-squares statistics at 1%, 5% and 10% levels of significance.*

Finally, the Granger causality results provide evidence of possible long run causal associations between the variables considered in the paper. The Granger causality results in the context of model (i), as presented in table 9, suggest bidirectional causal associations between CPI and HDI in context of the full panel and the African subpanel while a unidirectional causality running from HDI to CPI is seen to hold in the context of the LAC subpanel. The results imply that corruption, in the long run, can effectively stimulate changes in socioeconomic development in the context of the full panel and the African subpanel only. Moreover, in context of the Asian subpanel, none of the explanatory variables are effective in influencing HDI movements in the long run.

Table 9: The Granger causality test results for model (i)

Panel/Subpanel	**Full**	**Asia**	**Africa**	**LAC**
Null Hypothesis	**F-Stat.**	**F-Stat.**	**F-Stat.**	**F-Stat.**
CPI does not Granger cause HDI	24.717 (0.000)*	1.845 (0.163)	17.912 (0.000)*	0.860 (0.425)
HDI does not Granger cause CPI	4.434 (0.012)**	1.019 (0.365)	4.586 (0.011)**	3.038 (0.050)**
GDP does not Granger cause HDI	0.465 (0.628)	0.100 (0.905)	1.066 (0.345)	0.0700 (0.932)
HDI does not Granger cause GDP	9.268 (0.000)*	3.174 (0.046)*	0.525 (0.592)	3.047 (0.05)**

GOV does not Granger cause HDI	2.753 (0.064)***	0.725 (0.487)	2.000 (0.137)	0.706 (0.495)
HDI does not Granger cause GOV	2.294 (0.100)***	0.854 (0.429)	1.945 (0.145)	2.150 (0.119)
FAID does not Granger cause HDI	1.561 (0.211)	0.103 (0.902)	1.561 (0.212)	0.074 (0.929)
HDI does not Granger cause FAID	13.287 (0.000)*	1.694 (0.189)	0.142 (0.868)	2.898 (0.058)
FDI does not Granger cause HDI	1.203 (0.301)	0.636 (0.532)	0.438 (0.646)	0.694 (0.501)
HDI does not Granger cause FDI	0.658 (0.518)	2.272 (0.108)	0.291 (0.748)	2.016 (0.136)
TR does not Granger cause HDI	2.491 (0.084)***	1.878 (0.158)	3.441 (0.033)**	0.415 (0.661)
HDI does not Granger cause TR	0.813 (0.444)	3.349 (0.039)*	0.320 (0.727)	0.178 (0.838)
CO_2 does not Granger cause HDI	0.161 (0.851)	0.809 (0.448)	0.323 (0.725)	1.132 (0.325)
HDI does not Granger cause CO_2	2.676 (0.070)***	1.036 (0.359)	1.963 (0.142)	1.123 (0.328)

*Notes: The long run causality between the variables is determined by the statistical significance of the estimated F-statistics. The p-values are given inside the parentheses. *, ** and *** denote the statistical significance of the estimated F-statistics at 1%, 5% and 10% levels of significance. The optimal lag 2 is automatically selected by the EViews 7.1 software.*

Table 10 provides the Granger causality test results in the context of model (ii)[1]. According to the estimations, a unidirectional causality running from CPI to CO_2 is found to be present in the context of the full panel. This implies that corruption influences environmental impacts in the corresponding nations as a whole. In addition, a unidirectional causality running from CO_2 to CPI is seen to exist in the context of the subpanel of the Asian countries. A possible reason behind this finding could be the fact that as the volume of CO_2 emissions increases, the parties responsible for contributing to such emissions get involved in corruptive activities offering a bribe to the environmental pollution control authorities in order to avoid possible legal actions.

Table 10: The Granger causality test results for model (ii)

Panel/Subpanel	Full	Asia	Africa	LAC
Null Hypothesis	**F-Stat.**	**F-Stat.**	**F-Stat.**	**F-Stat.**
GDP does not Granger cause CO_2	0.557 (0.573)	1.570 (0.213)	0.539 (0.584)	0.860 (0.425)
CO_2 does not Granger cause GDP	7.972 (0.000)*	5.811 (0.004)*	3.765 (0.024)**	3.038 (0.050)**
CPI does not Granger cause CO_2	2.636 (0.072)***	0.460 (0.632)	1.471 (0.231)	0.706 (0.495)
CO_2 does not Granger cause CPI	0.759 (0.469)	3.633 (0.030)*	0.272 (0.762)	2.150 (0.119)
GOV does not Granger cause CO_2	0.175 (0.839)	0.015 (0.986)	1.216 (0.298)	0.074 (0.929)
CO_2 does not Granger cause GOV	1.704	1.198	1.002	2.898

[1] The GDP squared term is excluded from model (ii) intentionally since the motive is to analyze the causal relationship between HDI and its determinants in a linear framework.

	(0.183)	(0.306)	(0.368)	(0.058)***
FAID does not Granger cause CO_2	0.886 (0.413)	0.031 (0.970)	1.149 (0.318)	0.694 (0.501)
CO_2 does not Granger cause FAID	7.022 (0.001)*	1.052 (0.353)	0.787 (0.456)	2.016 (0.136)
FDI does not Granger cause CO_2	0.220 (0.803)	1.012 (0.367)	0.671 (0.512)	0.415 (0.661)
CO_2 does not Granger cause FDI	1.141 (0.320)	10.859 (0.000)*	1.319 (0.269)	0.178 (0.838)
TR does not Granger cause CO_2	2.854 (0.058)***	1.716 (0.185)	2.371 (0.095)***	1.132 (0.325)
CO_2 does not Granger cause TR	0.056 (0.945)	1.517 (0.224)	0.003 (0.997)	1.123 (0.328)

*Notes: The long run causality between the variables is determined by the statistical significance of the estimated F-statistics. The p-values are given inside the parentheses. *, ** and *** denote the statistical significance of the estimated F-statistics at 1%, 5% and 10% levels of significance. The optimal lag 2 is automatically selected by the EViews 7.1 software.*

7. Conclusions

Corruption is believed to be a menacing factor that can hold up the SDG attainment by 2030 across the globe. Thus, the focal point of our paper was to empirically analyze the possible detrimental effects of corruption which are responsible for impeding socioeconomic and environmental sustainability across selected countries from Asian, African and the LAC regions. The results generated in this paper could potentially stimulate adoption of anti-corruption measures that can be effective in the better channeling of public service deliveries and implementation of key environmental acts as well. In light of our findings, we can conclude that incidence of corruption in the context of the three subpanels exhibit adverse impacts on the socioeconomic development in the associated countries. Thus, our results corroborate to the conclusions by Gupta *et al.* (2000) in which the authors asserted that a rise in the CPI hampers public allocations in the health and education sectors affecting human development in a panel of developed and developing countries.

Our results also revealed that corruption puts environmental sustainability into question since it triggers CO_2 emission in context of all the three subpanels. This is in line with the findings by Ünver and Koyuncu (2017). A logical explanation of this positive interconnectedness between corruption and environmental degradation would be the fact that as corruption increases, enforcement of anti-corruption laws gets stalled following acceptance of a bribe by the associated law and enforcement authorities. Moreover, our estimated results also provide evidence regarding the validity of the EKC hypothesis in the context of the full panel and the LAC panel whereby the respective threshold level of per capita GDP are 11992.62 and 12777.78 US dollars (current). Thus, it is advisable for countries with GDP per capita less than these estimated thresholds to adopt relevant policies to enhance economic growth. Our paper also finds short run bidirectional causality between corruption and socioeconomic development in the context of all the countries cumulatively which did not hold to be true in the long run. Furthermore, corruption and CO2 emissions portray short bidirectional causality in context of the selected Asian economies and a unidirectional causality running from corruption to CO2 emission for all the economies as a whole.

Data constraint was one of the main limitations faced in this study restricting incorporation of disaggregated indicators of socioeconomic development in our set of simultaneous equations model. Moreover, the aforementioned limitation was also responsible for our period of study being small compared to other empirical analyses available in the literature. As part of the future scope of research, the nexus between corruption and socioeconomic and environmental sustainability can be reexamined in the context of more countries using disaggregated data and other robust methodologies for robustness check.

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Appendix

Table 11: List of countries considered in our paper

South and South Asia	Kenya	Zimbabwe
Bangladesh	Madagascar	**Latin America and Caribbean**
India	Malawi	Argentina
Indonesia	Mali	Brazil
Malaysia	Mauritius	Chile
Pakistan	Mozambique	Costa Rica
Philippines	Namibia	Ecuador
Sri Lanka	Niger	El Salvador
Thailand	Nigeria	Haiti
Sub Saharan Africa	Republic of Congo	Jamaica
Angola	Senegal	Mexico
Botswana	Sierra Leone	Panama
Cameroon	Somalia	Paraguay
Central African Republic	South Africa	Peru
Chad	Sudan	Uruguay
Gambia	Tanzania	Venezuela
Ghana	Uganda	