

Nexus between corruption and regional Environmental Kuznets Curve: the case of South Asian countries

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Abstract This study attempts to investigate the presence of a regional Environmental Kuznets Curve (EKC) in selected South Asian countries, namely, Pakistan, India, Bangladesh, and Sri Lanka for the period 1984–2008. In addition, it also intends to inspect the impact of corruption on environmental degradation in this region. The Fixed Effect results confirm the existence of the regional EKC in these countries. Furthermore, the results indicate that corruption do affect environment in the manner that it delays the turning point in EKC. It is found that, in the presence of corruption, the per capita GDP at the turning point is USD 998, which is USD 128 higher from the value that would have been in the absence of corruption. Based on these results, the study suggests appropriate policy measures.

Keywords Corruption · Environmental Kuznets Curve · South Asia · Panel data · Pakistan

1 Introduction

The recent debate on global warming, air quality, and other intense environmental dilemmas has shifted the attention of policy makers from conventional issues of growth and development toward *sustainable development and Green Economy*. The disastrous environmental effects in the last two decades such as earthquakes, floods, outburst of fires, and epidemics, especially in the South Asian region, have compelled the economists and environmentalists to seriously ponder upon the environmental deterioration. It has become

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the need of hour to develop a healthier understanding of the relationship between economic growth and environment. In this regard, extensive research has long been initiated to discourse the underpinnings of growth and sustainable development. However, the pioneering work of Grossman and Krueger (1991a, b), about what is now generally known as Environmental Kuznets Curve (EKC), explicitly analyzed the relationship between economic growth and environmental degradation. A dynamic and extensive literature then developed to test EKC empirically while using different econometric techniques; various control variables relevant to country geopolitical situations; and different indicators for environmental quality. Subsequently, it has always been difficult to generalize the results of a country or region for the rest of the world. This necessitates separate studies for different regions such as South Asia.

Pertaining to the effect of governance on environment, corruption and several other institutional flaws have also been already highlighted in the literature. But how this corruption is paralyzing the economy in terms of low economic growth and substandard environment is the matter of concern. In other words, corruption is intensified in an unaccustomed domain (environmental regulation) in recent years. The environmental consequences of government corruption have been probed in the literature by Damania et al. (2003), Fredriksson and Svensson (2003), and Fredriksson et al. (2005). Nevertheless, none of these studies has focused on the insinuations of corruption for the EKC. Likewise, the consequences of bribery on the formulation and functioning of environmental policies remain one of the least-researched facets of economic behavior. It is assumed that the so-called turning point in EKC, which varies from country to country depending on country-specific characteristics, may also be affected by corruption. Empirical literature on this issue is very rare and demands further research for different regions.

This study, conducted for selected South Asian countries using panel data for the period 1984–2008 for Bangladesh, Pakistan, India, and Sri Lanka, serves two important purposes at hand. It not only attempts to proof the existence of the regional Environmental Kuznets Curve for these South Asian countries but also accounts for the significance of corruption in polluting the environment of these countries. Specifically, the study intends to investigate whether or not corruption deviate the turning point per capita GDP from its socially optimal point.¹ This region, having high level of corruption, is also encountered with acute pollution problems for the last two decades. Therefore, the study attempts to explore the nexus between corruption, pollution and economic growth having some relevance for environmental policy purposes.

The results confirm the existence of a regional EKC in the South Asia in the presence of control variables like trade openness, energy consumption, and corruption. Nevertheless, the most important outcome is the significant impact of corruption on the level of CO₂ emissions. It is due to corruption that a delay is observed in the turning point of EKC, and when this corruption is accounted for, the turning point occurs at the socially optimal level of growth. This result exhibits a positive impact of corruption on the turning point of EKC and thus contributes to environmental dilapidation.

The paper ensues as follows: Sect. 2 outlines the relevant literature briefly. In Sect. 3, theory and econometric specification of the model is explained. Section 4 defines the methodology and data for the research. Estimation results of the study are discussed in Sect. 5, while Sect. 6 concludes the paper.

¹ The socially optimal point here refers to the per capita GDP at the turning point in the absence of corruption.

2 Literature review

Over the years, economists and environmentalists have centered their attention toward a very serious issue of the economy: the issue of economic growth and environmental deterioration. In this context, extensive and dynamic theoretical and empirical work has enriched the literature in the past two decades and the investigation is still in progress.

Grossman and Krueger (1991a, b) were the first to discover the inverted U-shape relationship between per capita real income and pollution concentration, which is named Environmental Kuznets Curve hypothesis. It states that pollution increases at low level of income, but after a certain income level is reached, it starts to decrease with further rise in income, forming an inverted U-shape. In an assessment of individual countries, Deacon and Norman (2004) exhibited the consistency of the EKC predictions, regarding income-pollution relationship, for relatively wealthy economies, but for poor and middle income countries these predictions were less frequently observed. Zarzoso and Morancho (2003) examined a panel of 22 OECD countries pointing out the existence of N-shaped EKC. The study proposed that the cubic function suggests an expected decline in CO₂ emissions (when income is rising) up to a certain level, with again an increase of pollution at higher incomes. Within an endogenous growth model framework, the prevention of environmental degradation is possible if one part of the capital is allocated for the abatement activity (Dinda 2005). The model further explains that insufficient investment for abatement at an early stage results in rising degradation which can be decreased later when capital accumulation in the economy gets sufficiently large to invest relatively more for environmental upgradation.

However, Khanna and Plassmann (2004) demonstrated that even in a developed country like USA, high-income households have not yet reached the level of income where their demand for better environmental quality can cause the EKC slope downward. Nasir and Rehman (2011) explored the existence of EKC for Pakistan in the long run with a contradiction in the short run, as no such relationship was found in the short run dynamics. The study also analyzed a positive impact of foreign trade and energy consumption on carbon emissions, exploring uni-directional causality from economic growth to energy consumption and emissions. Comparably, Hwang and Gum (1991), Stern (1993), and Jalil and Mahmud (2009) investigated the relationship between energy, emissions, and economic growth using different panel of countries. It was concluded that energy consumption is an important determinant of carbon emissions. Analogously Zhang and Cheng (2009) explored uni-directional causality, where growth causes energy consumption and energy consumption fires-up carbon emissions.

An extensive theoretical and empirical analysis has been made to test the relationship between corruption, economic development and environmental policies.² Pellegrini (2003), while exploring the role of institutions in economic performance, envisaged that institutions not only determine the level of income but also play a significant role in designing the environmental policies. Moreover, countries having strong and established institutions will have more stringent economic, social and environmental policies at any given level of income. An extension of the related literature on corruption and environmental policies made by Pellegrini and Gerlagh (2006a, b) predicted that variation in environmental policies, for enlarged EU, can be explained through the level of corruption. This study further argued that not only low income levels, but low institutional quality can also imply lower environmental standards. Econometric evidences also suggested negative impact of

² However, the effect of corruption on the turning point in EKC has not been studied sufficiently.

corruption on the stringency of economic and environmental policies. However, high economic growth as a result of decrease in corruption will improve the standard environmental policies through both direct and indirect income channel. Pellegrini and Gerlagh (2006a, b) studied the combined impact of corruption and democracy on environmental stringency, pointing out corruption to be an important determinant of environmental policies relative to democracy. Albeit, democracy when used with corruption declines its size and significance but the impact still remains positive.

Rehman et al. (2007) tested empirically the relationship between corruption, trade openness and environmental quality for selected South Asian countries. The study demonstrates that trade has a positive impact on stringency of environmental quality, while corruption has a negative impact on environmental protection. Nonetheless, the effect of trade openness on environmental emissions depends on the level of government's honesty in the respective economy. Analogous relationship between corruption, income, and environment has also been studied by Cole (2007). This study incorporated both direct and indirect impact of corruption on pollution where the indirect impact operates by affecting the per capita income and resultantly the emissions. The direct impact of corruption on per capita SO₂ and CO₂ emissions appeared positive, whereas the indirect impact appeared negative but larger in absolute value than direct effects, although increasing (approaching zero and becoming positive) with the level of per capita income. However, the net impact is found to be negative. Correspondingly, Leitao (2010) investigated the influence of corruption on income level using a cross-national panel of countries, exploring support for the EKC hypothesis and the evidence of a high per capita income at the turning point when the degree of corruption is high. During a study for 106 countries, Welsch (2004) anticipated that although the indirect impact of corruption on emissions (via its effect on income) is negative, yet it is invariably dominated by the direct effect, where corruption resulted in high pollution levels.

Since the discovery of the EKC, a large literature has been developed to forecast the role of trade on environmental policies. Through theoretical and empirical modeling, Damania et al. (2003) presented evidence that support the two conjectures; firstly, trade liberalization depends on the level of corruption to affect the stringency of environmental policies, and secondly, a negative relationship exists between corruption and stringency of environmental policies. In similar literature, Birdsall and Wheeler (1993) explained through econometric evidence that trade openness, through the importation of industrialized country pollution standards, actually encourages cleaner industries. However, the pollution intensive industries are mostly favored by the protected domestic economies. The work of Antweiler et al. (2001) divided trade's impact on pollution into scale, composition, and technique effects, providing estimates that yield positive results regarding free trade, concluding that free trade is useful for the environment quality. Grether et al. (2007) estimated that the scale and technique effects cancel out the effect of each another as they both work in opposite directions; the net impact on emissions is the composition effect, which helps to reduce the environmental degradation. A study by Abler et al. (1999) on the environmental impacts of trade openness in Costa Rica, based on eight environmental indicators, examined that the impact of free trade on environmental indicators is negative but small in magnitude both when technology remains constant and when it varies. The analysis of Grossman and Krueger (1991a, b), to assess the consequences of further trade liberalization between United States and Mexico, has demonstrated that increased Mexican specialization and trade has a benefit of reduction in pollution. An empirical simulation model used by Beghin et al. (2011) for the examination of links between trade integration, emission and public health in Chile explains that taxing the air pollutants and reducing the

trade barriers result in net welfare gains by reducing health damages and increasing efficiency gains.

3 Theoretical framework

In this section, we explain the theoretical framework of the study to analyze all the possible theoretical channels and links through which explanatory variables like economic growth (GDP per capita), energy consumption, corruption, and international trade liberalization affect the emissions of carbon dioxide. Starting with the analysis of the relationship between economic growth and CO₂ emission, we will move ahead to explain the impact of energy consumption on emissions, followed by discussion about the influence of corruption and trade liberalization on environmental emissions.

The Environmental Kuznets Curve hypothesis explains the association between economic growth and environmental pollution of the economy. This hypothesis states that initially development in terms of increase in per capita income results in the degradation of the environment by increasing emissions of different pollutants in the economy, as both public and private sectors have a main focus on creating employment opportunities in the economy, which means job creation is valued more than health and other costs of environmental degradation. With the development and high growth rate of an economy over time, when the level of income gets sufficiently large, the general public starts demanding for a clean and healthier environment around them which results in the decrease of environmental degradation. Such a behavior results in the formation of an inverted U-shape curve, known as Environmental Kuznets Curve. Generally, it is observed that poorer countries avoid the investment of an unduly high share of their income in the environmental protection because of preferential differences.

In a representative economy, the relationship between energy consumption and carbon dioxide emissions can be seen with economic growth. Many studies pointed out that the causality between economic growth and energy consumption can be uni-directional or even bi-directional. Siddiqui (2004) concluded that energy consumption play a critical role in enhancing economic growth in Pakistan. Other studies like Paul and Bhattacharya (2004); Oh and Lee (2004); Ho and Siu (2007); Bowden and Payne (2009); and Belloumi (2009) demonstrated that the high level of economic growth led by energy consumption leads consequently to high level of environmental emissions. Nevertheless, the work of Akarca and Long (1980); Yu and Hwang (1984); Abosedra and Baghestani (1989); Yu and Jin (1992); Cheng (1999); Aqeel and Butt (2001); Altinay and Karagol (2004); Jobert and Karanfil (2007); Karanfil (2008); Soytaş and Sari (2009); and Nasir and Rehman (2011) explored that it is not the energy consumption that fosters economic growth. Rather it is the economic growth that leads to a rising demand for energy consumption, resulting in environmental pollution and deterioration.

Institutions and the level of corruption are also found to have a strong impact on environmental quality standards. The level of environmental protection depends on the honesty of the institutions and government. An improved quality of institutions may benefit not only the environmental quality but also the economic growth, thus rendering a double dividend of improved societal welfare (see, for example, Panayotou 1997; Torras and Boyce 1998; Bimonte 2002; Bhattarai and Hamming 2001; Pellegrini 2003; Pellegrini and Gerlagh 2006a, b; and Rehman et al. 2007).

Corruption is found to affect the emissions through both direct and indirect channels. The direct channel exhibits that as the level of corruption goes up in an economy, it causes

delayed formation and implementation of environmental policies due to bribes accepted by the corrupt officials, which resultantly enhances the environmental emissions, and thus worsening the quality of environment. This is how corruption causes environmental degradation. The indirect channel on the other hand entails a negative relationship between corruption and emissions by affecting the level of income. This channel works by reducing the pollution in the economy by plummeting productivity as a result of high level of corruption. The overall impact can be either positive or negative, depending upon which of the two channels is dominant. Evidence strongly exhibits negative relationship between corruption and economic development (Mauro 1995; Mo 2001). A decrease in corruption level will lead to cumulating high growth rates, which will improve the environmental policy through indirect channel as shown by Cole (2007), Leitao (2010), Damania et al. (2003).

Trade when taken as a control variable can either deteriorate or improve the environmental quality. A common concern among environmentalists is that trade liberalization will lead to greater exploitation of natural resources. However, many economists favor free trade despite its negative impact in developing countries. Trade liberalization can affect the environment through three channels that include scale, technique, and composition effects as mentioned by Antweiler et al. (2001) and Grether et al. (2007). The scale effect means that openness in trade leads to excessive economic growth as a result of rise in exports, which causes emission to rise, thereby having negative effects on environmental quality. The technique effect implies that improved technology can be imported from developed countries due to trade openness which would help decrease the pollution, thus having a positive impact on environment. Finally, the change in the industrial structure of the economy, known as the composition effect, can have either negative or positive impact on the environment, depending on the comparative advantage. Generally, trade is found to be good for the environmental standards.

4 Econometric methodology and data

This study aims to investigate EKC for a panel of four selected South Asian countries (Bangladesh, Pakistan, India, and Sri Lanka) in the presence of control variables like corruption, energy consumption, and trade openness. Fixed effects and random effects panel models are the two econometric specifications which treat both times series and cross-sections characteristics of the panel data set. In light of discussion given in the last section, panel econometric specification will be as follows:

$$\text{CO}_{2it} = \alpha_{it} + \beta_1 \text{GDP}_{it} + \beta_2 \text{GDP}_{it}^2 + \beta_3 \text{Corr}_{it} + \beta_3 \text{GDP}_{it} \times \text{Corr}_{it} + \beta_5 \text{EC}_{it} + \beta_6 \text{TO}_{it} + \delta_t + \mu_i + \varepsilon_{it} \quad (1)$$

where CO_2 is the per capita carbon dioxide emissions; GDP and GDP^2 are the per capita gross domestic product and its squared term, respectively. Corr is the index for corruption, whereas $\text{GDP} \times \text{Corr}$ is the interaction term which is interpreted in two different ways: (i) given the level of GDP , carbon dioxide emissions rise with a rise in corruption; (ii) given the level of corruption, carbon dioxide emissions are positively related to the level of GDP . EC is the per capita energy consumption and TO is the trade openness ratio, constructed by dividing total trade (sum of total exports and imports) by total GDP . It is used as a proxy for foreign trade. δ_t is for the time specific effects, while μ_i captures country-specific effects. ε_{it} is the regression error term. According to the EKC theory, β_1 and β_2

are expected to have positive and negative signs, respectively. β_3 and β_6 can have either positive or negative sign depending upon the dominance of the effects, so the signs are ambiguous. β_4 and β_5 are expected to have positive signs.

The selection between *Fixed effect* and *Random effect* models is based on the assumptions regarding the intercept and slope of the equation. Generally, Hausman test is used to identify the validity of Fixed Effects Model (FEM) or the Random Effects Model (REM). As our study is confined to only four countries, indicating small cross-section units, therefore, the Random Effects Model (REM) may not be the appropriate choice. Ruling out the REM, we apply FEM for the estimation of pooled regression.

It is favorable to practice the FEM even if the cross-country-specific effects have any correlation with other explicatory variables; the coefficients estimated using this technique would remain consistent. Likewise, the estimates remain stable irrespective of the assumptions regarding the model. In FEM, the constants are treated as specific group implying that the model allows for different intercepts for each group. The estimated coefficients of the fixed effect models are free from any biasness because the fixed effects model controls for all time-invariant differences between countries such as culture, religion, gender, and race. Technically, time-invariant characteristics of the countries are perfectly collinear with the cross-sectional dummies. Moreover, the fixed effect models are designed to study the causes of changes within a cross-section.

The current study is conducted for the selected South Asian countries for the period 1984–2008. The carbon dioxide emissions, a widely used indicator for environmental quality, have been taken in metric tons per capita. The explanatory variables include the per capita GDP in constant US dollars with the year 2000 taken as base year, trade openness defined by trade as percentage of GDP, energy consumption measured in kg of oil equivalent per capita, and an index of corruption. Data for all these variables, except corruption, have been obtained from the World Development Indicators (WDI) (2009). Here, the index of corruption demands a little more explanation and space. Data on this index are taken from the International Country Risk Guide (ICRG) (2009), which assigns a numerical value to each country on a scale of 0–6, where 0 shows high level of corruption and 6 symbolizes low level of corruption. But for the purpose of simplifying the interpretation, we have altered the scale to fit with the trend of data (by subtracting each value from 6). Subsequently, 0 now exemplifies low level of corruption and 6 represent a high level of corruption. Taking into consideration the limited availability of the data on corruption, we have restricted the scope of our study to Bangladesh, Pakistan, India, and Sri Lanka, from a range of South Asian countries. Table 1 presents the descriptive statistics of these variables for each country included in the analysis.

5 Estimation results and discussion

We have estimated three different models for the selected South Asian countries, as mentioned earlier, by using Fixed Effect Model of the panel data. The results are shown in Table 2. The primary purpose of our analysis is to investigate the existence of regional Environmental Kuznets Curve in South Asian countries. In addition, we also intend to find out whether corruption plays any role in damaging the environmental stringency in countries under consideration.

It is evident from the first model that the coefficient of GDP is positive and that of its squared term is negative. The significance of both these coefficients confirms the existence of regional Environmental Kuznets Curve in South Asia. This result implies that initially

Table 1 Descriptive statistics

	GDP	EC	TO	COR
Bangladesh				
Mean	342	138.20	28.66	4.77
Median	318.92	135.31	29.78	4.5
Maximum	508.56	192.08	49.10	6
Minimum	264.82	104.74	16.24	3.5
Std. dev.	73.71	25.17	9.87	0.87
Skewness	0.81	0.59	0.45	0.41
Kurtosis	2.51	2.32	2.13	1.64
Jarque–Bera	2.99	1.96	1.65	2.64
Probability	0.22	0.38	0.44	0.27
India				
Mean	417.29	421.49	25.05	3.39
Median	392.92	420.75	22.89	3
Maximum	711.90	544.73	52.40	4.5
Minimum	256.81	326.22	12.36	3
Std. dev.	133.73	61.16	11.35	0.49
Skewness	0.78	0.26	0.93	0.93
Kurtosis	2.59	2.19	2.9	2.69
Jarque–Bera	2.69	0.96	3.64	3.73
Probability	0.26	0.62	0.16	0.16
Pakistan				
Mean	498.57	419.55	34.75	4.05
Median	496.53	426.54	35.26	4
Maximum	643.89	512.64	39	5
Minimum	381.81	333.10	28.13	3
Std. dev.	71.63	49.73	2.87	0.42
Skewness	0.51	0.0029	−0.51	−0.50
Kurtosis	2.71	2.25	2.634	4.34
Jarque–Bera	1.19	0.59	1.21	2.92
Probability	0.55	0.74	0.55	0.23
Sri Lanka				
Mean	753.83	375.03	72.6	2.86
Median	722.93	366.40	73.6	3
Maximum	1180.49	456.88	88.64	3.5
Minimum	494.19	308.19	59.05	2
Std. dev.	206.13	58.02	7.92	0.48
Skewness	0.48	0.25	−0.06	−0.73
Kurtosis	2.12	1.32	1.96	2.55
Jarque–Bera	1.74	3.20	1.14	2.46
Probability	0.42	0.20	0.56	0.29

carbon emission increases with an increase in income, reaches the turning point, and then starts to decline with a further rise in income level. This result should not be startling for the reason that the single country studies conducted for the countries in this region also

Table 2 Estimation results of fixed effect models

Variables	Model 1	Model 2	Model 3
Intercept	-1.063051 (-11.075)***	-1.006781 (-10.898)***	-1.021586 (-11.813)***
GDP	0.003208 (6.195)***	0.002399 (4.323)***	0.002122 (4.003)***
GDP ²	-0.00000162 (-6.359)***	-0.00000124 (-4.573)***	-0.00000122 (-4.971)***
GDP × COR	-	-	0.0000835 (4.227)***
EC	0.002146 (6.927)***	0.002221 (7.573)***	0.002479 (8.598)***
TO	-0.005649 (-4.248)***	-0.003180 (-2.134)**	-0.002533 (-1.809)*
COR	-	0.030109 (3.069)***	-
Bangladesh	-0.733 (-10.067)***	-0.778 (-11.080) ***	-0.701 (-10.687) ***
India	-0.673 (-8.026)***	-0.655 (-8.258) ***	-0.656 (-8.733) ***
Pakistan	-1.098 (-12.198) ***	-1.081 (-12.712) ***	-1.096 (-13.602) ***
Sri Lanka	-1.329 (-14.645) ***	-1.297 (-15.028) ***	-1.306 (-16.041) ***
R ²	0.993	0.994	0.994
Observations	100	100	100
Turning point	990.12	967.33	998.629/870

t-stats are given in parenthesis. ***, ** and * denote significance at 1, 5 and 10 % levels of significance. The figures in the last cell of the table show the values of per capita GDP at turning points both in the presence and absence of corruption

confirmed the existence of EKC (see, for instance, Nasir and Rehman 2011). This is an interesting finding in the sense that it signifies the fact about common environmental concerns in these countries. Despite these similar concerns, the formulation and implementation of mutual environmental policies among these countries are yet to be observed.

The coefficient of energy consumption is positive and significant. This outcome indicates that the rise in energy consumption raises the emission of CO₂ thereby contributing significantly to environmental degradation. Since 1984, the per capita energy consumption grew by 83.383, 66.981, 48.524, and 37.711 % in Bangladesh India, Pakistan, and Sri Lanka, respectively. This high level of energy consumption can be attributed to various reasons such as rapid urbanization, change in transportation modes, and shift from less polluting agriculture sector to more polluting industrial sector in these countries. Rapid urbanization on one hand is associated with higher incomes, higher literacy and improved quality of life, whereas on the other hand, the current wave of urbanization is not only creating larger urban slums but also increasing the potential for environmental deterioration. Increase in urban population leads to increase in average per capita commercial energy consumption. However, the increasing use of public and private transport is also attributed to rapid urbanization. A major reason for CO₂ emissions is the high usage of petroleum to meet the transportation demand. The transport sector is contributing

significantly not only to regional and local level environmental problems but also to global emissions. Similarly, different modes of transportation, which are specific to this region, are also deteriorating the air quality. For example, the 2-stroke vehicles such as motorcycles and rickshaws have a major contribution in burning fuel, due to their two stroke engines. The data on transport sector show that emissions of CO₂ (major GHG) increased by a factor of seven during the twentieth century due to the burning of fossil fuels with a corresponding rise in atmospheric CO₂ levels (Strategic Review of Environment Aspects and Impacts of Indian Transportation Sector). Likewise, not only the shift from agriculture to industrial sector but also the introduction of advanced agricultural techniques is the reason for higher energy consumption. The production techniques in industries and the advanced agriculture equipment rely heavily on energy sources that are highly polluting. Coal, for instance, alone accounts for 50 % of CO₂ emissions in Pakistan. India is the major contributor among all the South Asian countries under consideration. Over the past few decades (1950–2008), India has experienced dramatic growth in fossil-fuel CO₂ emissions, thus becoming world's third largest fossil-fuel CO₂ emitting country and the third largest producer of coal where coal contributed 71 % of the emissions in 2008.

Trade openness, on the other hand, is realized to be negative and significant. This demonstrates that trade openness has a healthy impact on the stringency of environment as opposed to a general impression that open trade can be harmful for the environment. In other words it can be said that the technique effect is dominant over composition and scale effects in this region. Our results support the finding of Antweiler et al. (2001) who found that foreign trade reduces carbon dioxide emissions through technological effects. Trade openness improves the quality of environment depending on the environmental policies of the governments. This surfaces the fact that these countries have imported latest technologies (the technique effect) that are efficient in terms of high production with less input thereby reducing the emissions significantly, making trade openness environmentally beneficial for the south Asian countries.

It is obvious from the table that the country dummies are statistically significant. It means that there are country-specific characteristics, other than these explanatory variables, that have an impact on carbon dioxide emissions in these countries. Since the coefficients of all these dummies are negative, we may conclude that these country-specific characteristics are instrumental in reducing carbon dioxide emissions. We have also tested the time dummies in model. However, almost all of them appeared to be insignificant, indicating the fact that emissions in these countries are time invariant. Lastly, the turning point of per capita income in model 1 is observed at USD 990.12. In this model, corruption is assumed to exist implicitly. It connotes that corruption affects the income level thus furthering the turning point than it would have been without corruption.

There may emerge some queries regarding the implicit impact of corruption in the model as mentioned above. There can be ambiguities about the justification of the impact of corruption when it has not been modeled explicitly. The high per capita GDP value at turning point may or may not be due to corruption. There might be some other reasons for this outcome. Taking this skepticism into consideration, we have devised second specification in which corruption is modeled explicitly. It can be observed that results of the second model are almost similar to that of the first model in terms of signs, significance, and magnitudes of the coefficients. Interestingly, the country dummies exhibit the same behavior as in first model. As far as corruption is concerned, it has a positive and significant impact on carbon emission. In other words, when the level of corruption increases in these countries, emissions also expand with it. Generally, there are two channels through

which corruption can influence environment: the first is the direct channel of corruption and second is the indirect channel (via income). As was discussed in Sect. 3, through the indirect channel, corruption reduces the economic production and growth, thus reducing the emissions. This shows a negative relationship between corruption and emissions through its impact on income level. As far as our results are concerned, we observe a positive relationship between corruption and the level of GDP over the concerned period. Had the indirect channel been working, the corruption would have reduced economic growth in these countries. However, the data shows that the countries under observation have witnessed notable growth despite substantial corruption. This fact coupled with the estimated results rules out the indirect channel of corruption from South Asian region.

The other channel through which then corruption becomes influential is the direct channel. This channel may arise due to typical causes such as violation of environmental laws on part of the firms, minimal accountability and transparency, and poor enforcement of regulations by the government officials. The dominant producers, having strong financial backing, are often observed to be involved in bribery and other illegal means in their self-interest. Even if any environmental policies are formulated, hindrances are observed in their implementation. In order to avoid legal limits of emissions, these influential producers offer bribes to the officials of concerned departments. Moreover, the major producers in these countries are directly or indirectly part of political elite in this region. These people are, therefore, able to influence the formulation and implementation of environmental policies. Such influence is the result of corrupt political system. Resultantly, the delayed implementations of environmental policies take the entire region on a high level of emissions thus harming the environment immensely.

It is interesting to see that when corruption is controlled overtly from affecting the income level, the turning point of the EKC is observed at an early income level. The per capita GDP at the turning point is now reduced to USD 967.33 as shown in the Table 2. Hence, when GDP is exclusive of corruption, the point where people start to realize the importance of environmental quality arrives early.

This model is superior over the first one in terms of specification. Nonetheless, uncertainty concerning the impact of corruption on GDP may undermine the strength of these results. Corruption is assumed to affect the turning point owing its impact on GDP, whereas corruption may also affect emissions through energy and trade sectors. This issue may raise some doubts about the results. To overcome this dilemma, model 3 is designed with few modifications made in the previous model. In this specification, corruption is taken explicitly but unlike the previous model, it is taken as an interaction term with GDP. This model has not only overcome the flaws of the previous model but is compelling too. The signs, significance and magnitudes of the coefficients are almost tantamount to those observed in previous two models. Country dummies still highlight the prominence of country-specific characteristics.

Corruption taken as an interaction term has significantly positive impact on the carbon emissions. This symbolizes that at a given level of income, when the level of corruption increases, the emissions also keep growing. It can also be said the other way round; that is, at a given level of corruption, emissions increase with an increase in the level of income. This specification is very important in terms of tracing out the true impact of corruption on the turning point. It is because this model allows us to locate the turning point GDP values both inclusive and exclusive of corruption. With this specification, the formula for determining the GDP at turning point is given as follows:

$$\text{GDP}_{TP} = \frac{\alpha_1 + \alpha_3 \text{Corr}}{2\alpha_2}$$

In the above formula, if corruption is taken to be zero, the turning point per capita GDP value comes out to be USD 870. In pure economic terminology, this is the socially optimal value. However, taking mean value of corruption into account, the turning point is achieved at USD 998.62. Hence, corruption on average delays the turning point by 128.62 per capita US dollars in South Asian region. The individual deviations from the socially optimal value for Bangladesh, India, Pakistan, and Sri Lanka are 162.80, 115.85, 138.211, and 97.65, respectively.

It worth motioning here that the turning point per capita GDP value in model 3 is quiet similar to that of model 1, where we assumed an implicit impact of corruption on per capita income. This exhibits that the three of our models can quite well explain the influence of corruption on the environmental dilapidation. Corruption is a thoughtful matter to be considered seriously in these countries. Furthermore, looking across the three models, it is obvious that these results are quite robust. The coefficients of explanatory variables as well as those of the country dummies are consistent in terms of sign, significance, and magnitude across the three models. These results confirm both the negative impact of corruption on environment by delaying the positive gains from growth and the presence of a regional Environmental Kuznets Curve in South Asia.

6 Conclusion and policy implications

The underlying study has subjected the relationship of per capita income, trade openness, per capita energy consumption, and corruption with carbon dioxide emissions to a detailed empirical analysis. Data for four South Asian countries for the period 1984–2008 were exploited to discover the existence of a joint Environmental Kuznets Curve for the South Asian region. Furthermore, the study also attempted to unearth the influence of corruption on the environment by observing its influence on turning point in the EKC. The Fixed Effect Model of panel data was used for the empirical estimation of the study.

At the outset, the results confirmed the existence of an inverted U-shaped relationship between per capita income (GDP) and the CO₂ emissions. It insinuates the existence of regional Environmental Kuznets Curve for the selected South Asian countries in all three models we have estimated. As the economies progress, pollution level is found to increase with a rise in income level. Later, when the hazardous impacts of pollution on human health and environment are realized, this positive relationship starts to diminish gradually, thus reducing pollution with a further rise in income level. In other words, when the cost of reducing exposure to environmental pollution increases to a certain limit, the curve slopes downward.

Corruption is found to have a significant impact on the environmental emissions when taken implicitly, explicitly, or even as an interaction term, as enacted in the models estimated above. Corruption works through the direct channel in these South Asian countries with no evidence of its functioning through indirect channel, hence ruling it out. The degree of corruption has a positive correlation to the critical threshold level of income, beyond which the CO₂ emissions decline. It is owing to corruption that the turning point of EKC takes place above the socially optimal level of income. Higher corruption causes delays in government's concern and controls for environmental quality, resulting in postponed formulation and implementation of stringent environmental policies.

The inclusion of other control variables such as trade openness and energy consumption rendered a significantly negative and positive impact on emissions, respectively, in all of the above estimated specifications. This implies that trade openness encourages cleaner industries through importation of new technology and adoption of industrialized country pollution standards, thereby reducing the environmental pollution. On the other hand, as the level of growth and urbanization is increased, it extensively exploits energy resources in various ways, such as in the form of high industrial production, transportation, and domestic usage, which contribute significantly in environmental emissions including CO₂ emissions. Our findings also confirm the important role of country-specific characteristics in reducing carbon dioxide emissions in these countries. Significance of the coefficients of the explanatory variables throughout the three models corroborates the robustness of our results.

The existence of regional EKC in the selected South Asian countries suggests the formulation and implementation of mutual environmental policies in these countries, taking into account their common concerns about economic growth and environmental protection. Before engaging in dialogue with developed countries, these countries need to make a regional committee whose responsibilities include formulation and implementation of environmental policies such as setting and monitoring of an emission target for each country in the region. This recommendation can be generalized in the sense that the countries and regions having similar economic characteristics, and experiencing parallel obstructions in economic growth and environmental protection, should be brought under one umbrella. This suggests the formulation of collaborative policies for these countries as a solution to their common quandaries.

Furthermore, the deferment in the turning point as a result of corruption should also be taken under due consideration. Corruption is no more a pure economic issue but is also an environmental concern. Ignorance of this brooding problem will create an alarming situation not only for the existing generation but also for the future generations. In this sense, it has in fact become a problem of sustainable development. Corruption should be tackled not only through appropriate environmental legislation but also by ensuring the implementation of the environmental laws. Low level of corruption and sound institutions would help to achieve sustainable growth path through high-income growth rate and environmental protection.

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