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Corruption, technological innovation and environmental quality in South Asian countries: An empirical insight

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Abstract. *This paper empirically examines the relationship among corruption, technological innovation and environmental quality in select south Asian countries such as Bangladesh, India, Pakistan and Sri Lanka during the period from 1990 to 2016. The study used Panel Fisher and Kao residual cointegration & Full Modified OLS and Dynamic OLS to analyze the long run relationship among the variables. The study found that both corruption and technological innovation has positive and significant effect on CO2 emission which is taken as environmental quality. Therefore, the policy makers should incorporate innovation into reduction of CO2 emission.*

Keywords: corruption, innovation, environmental quality, panel study.

JEL Classification: D73, Q57, C21.

1. Introduction

The issue of climate change or global warming has gained greater attention among the researcher now a days. There are many studies have investigated the environmental quality like (Ang 2007; Shahbaz et al., 2012; Kanjilal and Ghosh 2013; Sabori et al., 2012; Habib et al., 2018).

A survey conducted by the organization of for Economic co-operation and Development (OECD) regarding corruption and CO_2 emission in developed and developing countries. They found that corruption has greater effect on developing countries than developed countries. The corruption will lead to the destruction of ecological system and environmental quality through its weak environmental regulations (OECD, 1999). Corruption has also induced degradation of environmental quality by trade liberalization (Damiana et al., 2003).

Similarly, the economic growth of the south Asian countries are shifted from factor driven growth to innovation driven growth. It means to meet the demand of the large people large industries or factories using machinery or efficient technology in there mass production process. So this mode of production creates serious environmental hazard.

Kumar and Managi (2009) analyzed the relationship between technological innovation and CO_2 emission in 80 countries, found that technological innovation reduce CO_2 emission in developed countries, whereas it increase CO_2 emission in developing countries. There is a strong relationship between technological innovation, trade, energy consumption, economic growth on CO_2 emission. Rapid growth leads to higher energy consumption and CO_2 emission which contributes more to the global warming and climate change.

No part in this world is immune of climate change and South Asia particularly could be the most affected in terms of CO_2 emission. Due to climate change south Asian economy faces severe damage in terms of human and financial toll, natural hazard like floods, draughts and extreme weather condition. This region is the comprise of one-fourth of world population. Transparency international (2018) states that south Asia is one of the world's corrupt region. As per the latest corruption index, the major four countries in the South Asia are India, Sri Lanka, Pakistan and Bangladesh and their ranking are 78^{th}, 91^{st}, 117^{th} and 143^{rd} respectively. Basically political parties, central and state sponsored project are more corrupted. South Asia will become a hub of technological innovation because of its young population are well connected with new global technological developments. So In this paper we are trying to analyze the effect of corruption and technological innovation on the environmental quality which is proxy of CO_2 emission.

There is a few studies on corruption; innovation and environmental quality have been studied in both time series and panel study. Here, some of these empirical studies has discusses about this issue.

Pal and Mitra (2017) conducted a survey on trade openness, CO_2 emission and economic growth in India and China applying ARDL method. They found that there is strong positive effects among the variables.

Ozturk and Almulali (2015) analyzed the effect of corruption on CO_2 emission by using GMM and 2SLS method they found that control of corruption has a significant effect on CO_2 emission.

Pellegrini and Gerlagh (2006) demonstrated the casual relationship between corruption and environmental policies in EU new member states. They argued that lower environmental standard is not necessarily for low level of income, but this is more due to weak institutional quality. Some other studies also highlighted the corruption and environmental quality like (Rock and Bonnett, 2004; Sahoo and Sahoo, 2019, Fisman and Svensson, 2007; Cole, 2007; Sekrafi and Sghaier 2016, Sahoo and Sahoo, 2020).

An empirical study by Ali et al. (2016) on technological innovation (TI) and CO_2 emission in Malaysia reveals that is no relationship found between the variables in the short run, whereas it validates the EKC hypothesis in the long run.

Jones (2002) found that investment in R&D leads to increase the efficiency of technology, so that could reduce CO_2 emissions.

A recent study by Yu and Du (2019) found that innovation has a positive impact on reducing CO_2 emission. The remaining part of this paper is organized as follow, section 2 discusses the data, methodology and empirical model, section 3 presents results and analysis and section 4 discuss about conclusion.

2. Data, methodology and empirical model

Since this paper focusing on the four South Asian countries i.e. Bangladesh, India, Pakistan and Sri Lanka, we use the panel data analysis to show the relationship among the variables. The study used data from 1990 to 2016. We have chosen this time period since the database for the variables taken into account is availability. The description of the variables are presented in Table 1.

Table 1. *Description of the variables*

Variables	Symbol	Measurement	Source
Dependent variable			
Environmental Quality	EQ	CO2 emission (Million Metric Tonnes)	EIA
Independent Variables			
Gross Domestic Product	GDP	GDP per capita (constant 2010 US$)	WDI
Technological Innovation	TI	Patents application, Resident	WDI
Trade Openness	TO	Total Trade (% of GDP)	WDI
Corruption	COR	*corruption* in the public sector rating (1=low to 6=high))	ICRG
Population	PO	*Population growth annual %*	WDI

Source: Author's calculation.

Since this paper we are looking for the effect of Corruption, technological innovation, GDP, trade openness and population on environmental quality. So the empirical model can be written as.

$$EQ = F(COR, TI, GDP, TO, POP)$$

$$EQ_{it} = \theta_0 + \theta_1 COR_{it} + \theta_2 TI_{it} + \theta_3 GDP_{it} + \theta_4 TO_{it} + \theta_5 POP_{it} + U_t \qquad (1)$$

Where, EQ is a dependent variables, Environmental Quality in country i in the year t. similarly, COR, TI, GDP, TO and POP represents Corruption, Technological Innovation, Economic growth, Trade openness and population respectively. Unit root test is done by two test Im-Pesaran-Shin, 2003 (IPS) and Levin-Lin-Chu, 2002 (LLC).

$$\Delta y_{it} = \alpha_i + \rho_i y_{i,t\ 1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{i,t\ j} + \varepsilon_{it} \quad (2)$$

To show the long run relationship among the variables, the study also employ cointegration tests suggested by Pedroni (1999 and 2004). *We applied FMOLS and DOLS technique* In order to obtain asymptotically efficient consistent estimates in panel series, non-exogeneity and serial correlation problems are tackled by employing fully modified OLS (FMOLS) introduced by Pedroni (1996).

3. Empirical results and analysis

In this section, we present the results of our empirical analysis. The statistical properties of the variables are checked before applying any panel technique to establish a dynamic relationship among the variables.

Table 2 presents the result of descriptive statistics and correlation matrix among the variables like CO_2, corruption, GDP, trade openness, technological innovation and population in four south Asian countries viz. Bangladesh, India, Pakistan and Sri Lanka during 1990 to 2016.

Table 2. *Descriptive statistics and correlation matrix*

	CO2	COR	GDP	TO	TI	POP
Mean	341.47	2.368	1031.12	42.34	1346.98	1.59
Median	69.25	2.5	866.97	37.84	92	1.677
Max	2154.76	4	3768.67	88.63	13199	2.91
Min	5.31	0.08	3.48	15.67	16	0.51
S.D	558.79	0.68	900.86	18.28	2925.43	0.62
Skewness	1.86	-0.05	1.03	0.87	2.63	-0.08
Kurtosis	5.42	3.71	3.95	2.77	9.15	1.91
CO2	1					
COR	0.04	1				
GDP	0.06	0.32	1			
INN	0.96	0.05	0.14	1		
OP	-0.11	0.63	0.56	0.02	1	
POP	-0.02	-0.59	-0.56	-0.13	-0.77	1

Source: Author's estimation.

Before going for cointegration analysis, it is prerequisite to test the stationary of the data. If we run the non-stationary data, it will give us spurious regression. Here we applied two unit root tests for the testing of stationary of the data that are Im-Pesaran-Shin and Levin-Lin-Chu. The null hypothesis of both tests is non-stationary exist in the series at the level and the alternative hypothesis is stationary.

Table 3 presents the panel unit root test; it shows that all variables are non-stationary at level and become stationary at first difference.

Table 3. *Unit root test*

Method	CO2	COR		GDP	INN	TO	POP
Im-Pesaran-Shin							
Level	7.6528	-0.9475		8.6726	5.0551	0.6986	1.0031
	(1.0000)	(0.1717)		(1.0000)	(1.0000)	(0.7576)	(0.8421)
First difference	-4.3244*	-5.3043*		-4.9314*	-7.4684*	-7.3633*	-3.0171*
	(0.0000)	(0.0000)		(0.0000)	(0.0000)	(0.0000)	(0.000)
Levin-Lin-Chu							
Level	4.9000	-0.0086		9.2573	3.9423	3.0200	-1.4686
	(1.0000)	(0.4965)		(1.0000)	(1.0000)	(0.9987)	(0.0710)
First difference	-2.8300*	-6.0311*		-4.8880*	-6.6704*	-8.3779*	-5.0929*
	(0.0023)	(0.0000)		(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: * represents the 1% level of significance.
Source: Author's estimation.

However, in this paper, we are looking to show the long relationship among the variables and we have confirmed that that all variables are stationary at first difference. Therefore, we can go for next section for the analysis of cointegration among the variables. We have applied two-panel cointegration i.e. Kao (1999) and a Fisher-type test using an underlying Johansen methodology (Maddala and Wu, 1999).

Table 4. *Fisher's cointegration test results*

Hypothesized No. of CE(s)	Fisher stat* (from trace test)	Prob.	Fisher stat* (from Max-Eigen test)	Prob.
None	209.1*	0.00	104.1*	0.00
At most 1	135.2*	0.00	83.8*	0.00
At most 2	68.45*	0.00	49.04*	0.00
At most 3	29.39*	0.00	23.34*	0.00
At most 4	13.28	0.33	9.11	0.33

Note: * represents the 1% level of significance.
Source: Authors' estimation.

Table 5. *Kao residual cointegration test*

	t-statistics	Prob.
ADF	-3.9609	0.0000

Source: Authors' estimation.

Table 4 presents the Fisher cointegration test. This states that the failure of both, the trace and the maximum eigenvalue test, to accept the null hypothesis no cointegration among the variables, means that there is a cointegration relationship between the variables.

Kao Residual cointegration also supports the co-intigrating vectors among the variables as well, which is presents in the Table 5.

We estimated the cointegrating relationship among CO_2 emission, corruption, technological innovation, economic growth, Trade openness and population. In the next step, we show the long run relationship among the variables by applying Full Modified OLS and Dynamic OLS.

In case of FMOLS, we used deterministic trend into the cointegrating relationship, while the trend in the DOLS estimation was suppressed by the dynamic terms. In both cases, we have used pooled version of the FMOLS and DOLS.

Table 6. *Results of FMOLS and DOLS*

FMOLS			DOLS	
Variables	Coefficient	Prob.	Coefficient	Prob.
COR	0.3423	0.0000	1.4202	0.0813
GDP	0.0839	0.0049	0.0463	0.0449
TO	1.0308	0.0000	0.6877	0.1263
TI	0.2535	0.0188	0.1532	0.0000
POP	0.3894	0.0000	22.553	0.0036

Source: Authors' estimation.

The result in the Table 6 shows that both corruption and technological innovation has positive and significant effect on CO_2 emission or negative on the environmental quality, the sign of coefficient is positive, it means if corruption increases by 1% environmental quality (proxy of CO_2 emission) reduce by 0.3423% in case of Full Modified OLS. Technological innovation does not add any significant effect on the reduction of CO_2 emission or increase of environmental quality in the selected south Asian countries. If the unit increase in technological innovation leads to increase CO_2 emission by 0.2535%. Similarly, other variables like GDP, Trade openness and population has positive and significant relationship with CO_2 emission or negative with environmental quality like 0.0839%, 1.0308% and 0.3894% respectively in FMOLS. The Dynamic OLS also confirmed that all variables like corruption, innovation, GDP, trade openness and population has positive significant effect on the increase of CO_2 emission.

4. Conclusion

This paper explores the relationship among corruption, technological innovation on environmental quality. We also include the other variables like GDP, Trade openness and population in the study in order to avoid systematic bias. The study used Fisher and Kao residual cointegration technique to test the cointegration among the variables like CO_2 emission, corruption, Technological Innovation, GDP, Trade openness and population in the south Asian countries during period of 1990-2016.

We have applied Full Modified OLS and Dynamic OLS to show the long run relation among the variables. The study found that both corruption and technological innovation has positive and significant effect on CO_2 emission or negative on the environmental quality. Based on the findings, the policy makers should incorporate innovation into reduction of CO_2 emission. This can be done by encouraging both private and public sector to invest in the energy efficiency and sustainable technology production process that are technology intensive.

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