©*The Pakistan Development Review*
46 : 4 Part II (Winter 2007) pp. 673–688

Corruption, Trade Openness, and Environmental Quality: A Panel Data Analysis of Selected South Asian Countries

FAIZ-UR-REHMAN, AMANAT ALI, and MOHAMMAD NASIR

1. INTRODUCTION

The second half of the twentieth century emerged with two important concepts of the economic world. In the start of the second half, economists, developmentalists, etc., introduced the idea of *"development"*, while; latter it was replaced by a more meaningful and attractive term "*sustainable development*". Sustainable development is defined as "balancing the fulfillment of human needs with the protection of the natural environment so that these needs can be met not only in the present, but also in the indefinite future" [Wikipedia (2007)]. Or "Sustainable development means that pattern of development that permits future generations to live at least as well as the current generation" [Todaro and Smith (2005)], eighth edition]. The field of sustainable development can be conceptually broken into four constituent parts: environmental sustainability, economic sustainability, social sustainability and political sustainability. Although, the word sustainable development is very vast and deep, but the main emphasis of our study will be on environmental sustainability.

Environmental sustainability means "the ability of the environment to continue to function properly indefinitely" [Wikipedia (2007)]. It means to fulfill the needs of present generation without endangering the demands and desires of the future generations. That is, we should satisfy our means as efficiently as possible but not at the cost of our coming generations. "*Unsustainable situation*" occurs when the natural capital (total sum of natural resources) is used at a pace faster than it can be reproduced. Thus sustainability requires that natural resources should be used at a rate at which they can be replenished naturally. Difference between sustainable and unsustainable situations can be cleared from the given Table 1.

Faiz-Ur-Rehman <faizeconomist@yahoo.com> and Mohammad Nasir <nasirawan84@yahoo.com> are both students and Amanat Ali <amanat@qau.edu.pk> is Lecturer at the Department of Economics, Quaid-i-Azam University, Islamabad.

Table 1

Differences between Sustainable and Unsustainable Environment

Consumption of Renewable Resources	State of Environment	Sustainability
More than nature's ability to replenish	Environmental degradation	Not sustainable
Equal to nature's ability to replenish	Environmental equilibrium	Steady-state sustainability
Less than nature's ability to replenish	Environmental renewal	Sustainable development

Source: Wikipedia (2007).

However, most of the countries generally and the third world specifically have unsustainable mode of production. If these developing countries have grow at this pace of un-sustainability, they will face a very dark future for their coming generations. These hot debates motivated us to conduct a study for LDCs and particularly for selected South Asian countries including Pakistan, India, Sri Lanka, and Bangladesh. Because these countries have seen a lot of climatic changes in the form of floods, heavy rainfalls, and rising temperature in the last decade or two. In addition, weak institutions and high level of corruption in these countries possess a great problem for economic development and environmental improvement [Transparency International (2006)].

The objective of this study is to address the above-mentioned issue of sustainability. That is, to explore the main economic, social, and political factors that are responsible for environmental degradation in the selected sample. Nevertheless, due to high level of integration and globalisation, the importance of trade is increased manifold. In today's globalise world, no one can live separately. One has to compete with the world and enter the world market to survive. Most of the traders support free trade for environmental improvement, while environmentalists are highly critical to their viewpoint. To compare different views about environmental protection is also one of the goals of our analysis.

The paper proceeds as follow. Section 2 outlines a review of important theoretical and empirical findings in previous studies on corruption, trade, income, and environmental standards. In Section 3, we discuss the data sets and construction of variables used in the analysis. Section 4 presents the theoretical framework of the study. In Section 5, we show our results in the context of the literature, while Section 6 concludes.

2. REVIEW OF LITERATURE

Theoretical and empirical literature related to the field of corruption, output, trade, and environmental stringency is already well developed and comprehensive. Here, the reader is referred to some important theoretical and empirical backgrounds of this issue. Some of these studies are presented to show the impact of corruption, trade liberalisation, and output level on the quality of environmental policies.

Considers six indicators of ambient air and water pollution for 106 countries to find the impact of corruption on environmental degradation, Welsch (2002) showed that even if corruption reduces pollution via its effect on income, the direct effects of corruption invariably dominate this indirect effect. While testing three predictions to explain the relationship between trade liberalisation, corruption, and environmental protection for a mix of 48 developed and developing countries, Damania, *et al*. (2003)

establish that firstly, corruption reduces the pollution tax. Secondly, pollution tax in a protected sector is high if the level of corruption is high; and pollution tax in an anti-protected sector is high if the corruption level is low. Thirdly, high level of awareness among consumers raises the pollution tax; while increase in corruption distorts this behaviour. The study supports the first two predictions, while the first part of third prediction rejected but accepts the second one.

An empirical analysis performs by Pellegrini (2003) to test the relationship between corruption, economic development, and environmental policy. The results confirm that institutions are relevant determinants of the income level of countries. It also highlights that, if environmental quality demand is increasing with income and sound institutions foster economic development, institutional quality will produce stricter environmental policies. Similar study conducted by Pellegrini and Gerlagh (2006) for the enlarged EU to analyse a statistically significant relationship between Corruption-Perception Index and Environmental Regulatory Regime Index. It also observed that corruption level is a more important determinant of environmental deterioration than income level per capita. In a related literature, Pellegrini and Gerlagh (2006) study the impact of democracy and corruption on environmental quality. The results of the study show that the corruption variable has sizeable statistically significant negative effects on environmental policy. However, democracy when used with corruption declines its size and significant, but its impact is still positive.

The relationship between corruption and environment is also examined by Cole (2007). Both the direct and indirect effects of corruption on environmental regulations were investigated. The direct effects of corruption on environment are positive, while the indirect effects are highly significant and negative. However, the net impact of corruption on air pollution is negative.

Grossman and Krueger (1991) were the first to develop the idea of Environmental Kuznets Curve (EKC); that there exists some relationship between output level and environmental quality. This relationship was called an inverted U-shaped EKC. Related to this issue, Zarzoso and Morancho (2004) present an empirical estimate for a panel of 22 OECD countries. Their results point to the existence of an N-shaped EKC for the majority of the countries under analysis. Khana and Plassmann (2004) perform a research that favours EKC for USA for the period 1990. The study suggests that even high-income households in the USA have not yet reached the income level at which their demand for better environmental quality is high enough to cause the income–pollution relationship to turn downwards for all the pollutants that have analysed. However, Deacon and Norman (2004) get the proofs for EKC within individual countries. Actually its objective is to discover whether this hypothesis is valid for individual countries of different level of income and development. The study shows that most of the observed patterns could easily have occurred by chance.

Works on the possible theoretical explanation for the EKC in the framework of endogenous growth model, Dinda (2005) suggests that each country should allocate one part of their capital for abatement activity. The model also explains that environmental degradation continues at early stage because of insufficient investment for abatement activity, but in later stage, sufficient investment prevents further degradation of environmental quality. The dynamic relationship between EKC and degree of corruption is investigated by Leitao (2006). The study confirms the existence of an inverted U-shaped relationship between per capita sulfur emissions and income.

In the present world, every economy has an access to the international market. It can integrate to import various inputs from around the globe to produce more efficiently. The reality of this globalisation is an increasingly inter-reliant world. So, as the economic world grows, free trade has become an essential for it. However, researchers concerns have been directed towards sustainable development rather than development.

Beghin, *et al.* (1999) investigates the linkages between trade integration, environmental degradation and public health. It explains that opening to world markets bring on a sizeable aggravation of pollution emissions. Similar results were also derived by Abler, *et al.* (1999) who examine the environmental impacts of trade liberalisation in Costa Rica in a CGE model. It investigate out that the impacts of trade liberalisation on the environmental indicators are generally negative in sign but small or moderate in magnitude, both when technology is constant and when technology is allowed to vary.

Grether, *et al.* (2007) investigate the decomposition of worldwide SO_2 emissions from period 1990 to 2000. Adding up the effects of technology, scale, and decomposition leaves with a total decrease in SO_2 emissions of 10 percent from 1990 to 2000. Its conclusion is that, the opening up to trade leads to an increase of roughly 10 percent in emissions in 1990 while the corresponding increase is much smaller in 2000 (3.5 percent). This idea was also supported by Birdsall and Wheeler (1992) that investigates that with trade liberalisation, higher environmental standards of industrialised countries are "imported" to developing countries: more open-economy experienced faster growth in clean industries. However, Antweiler, *et al.* (1998) performs the most comprehensive study in this literature. It also builds up the theoretical linkages of trade with environment and constructs a reduced form equation that relates the three effects of trade to pollution emissions. It also suggests the positive effect of trade on environment.

3. DATA DESCRIPTION AND CONSTRUCTION OF VARIABLES

The key independent variables of our study (trade openness, corruption, and income level) will be used to tests the interactions among institutions, economic growth and public policies. The institutional variable, i.e., corruption is constructed by International Country Risk Guide's (ICRG), a popular index for corruption in government affairs. The score of this index ranges from 0 to 6; lower scores indicate greater likelihood for government officials to demand special payments and/or bribes connected with import and export licenses, exchange controls, tax assessments, policy protection and loans. The data for corruption level is available from 1983–2006 for mix of both developed and developing countries.

We use four different measures of trade policy (i.e., for openness) to test the robustness of our results, because this approach is adopted by many researchers in their studies [for example, Damania, *et al.* (2003), and Bandyopadhyay and Roy (2006)]. These measures are: (i) Total amount of trade as a ratio of GDP, (ii) Taxes on international trade collected as proportion of total revenue, (iii) Import duties as a percentage of tax revenue, and (iv) Export duties as percent of tax revenue. The other important control variables are GDP, GDP^2, and the two interaction terms of corruption with openness and GDP. Other than the corruption variables, the rest of the data have been obtained from the *World Development Indicators* (2007) of the World Bank for various years. Due to the unavailability of corruption data, we arrive at balanced panel of 4 selected South Asian countries (Pakistan, India, Bangladesh, and Sri Lanka) over the time period 1984–2003.

There are different indexes available to measure environmental protection, stringency, and quality. Indexes like environmental protection stringency index, environmental regulatory regime index, environmental sustainability index, etc., [Pellegrini and Gerlagh (2006) and Pellegrini and Gerlagh (2006)) are very common in this respect. But most of these indexes were constructed for European Union. However, we consider emission of CO_2 and SO_2 as proxies for environmental protection, stringency, deterioration, quality, and standard. Due to their increasing effects on global warming in the second half of the twentieth century, most of the researchers are going to use these emissions as their indicators for environmental standard [Welsch (2002); Zarzoso and Morancho (2004); Cole (2007) and Grether, *et al.* (2007)]. *World Development Indicators (WDI)* is our main source of data for the emission of $CO_{2;}$ however data on SO_2 is collected from Frontier Research Center for Global Change (FRCGC).

4. THEORETICAL FRAMEWORK

We follow the model developed by [Damania, *et al.* (2003)] for our analysis. Their work mainly focuses on the interaction effect between corruption and trade openness on environmental policy stringency for a mix of 48 developed and developing countries. However, our study is an extension in the sense that we analyse this interaction effect for selected South Asian countries for the period 1984–2003.

4.1. The Model

We consider a small open economy with two perfectly competitive sectors.

(1) The numeraire sector produces good *z*, and
(2) The polluting sector produces good *x*.

There are four types of agents in the economy: consumers with and without environmental concerns, producers, and the government. There are *N* consumers, out of which a share $0<\gamma<1$ suffer disutility from pollution. The fraction γ is assumed to reflect the demand for environmental quality amongst consumers. The utility of consumers with environmental concerns is given by

$$U = z + u(x) - \theta X, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1.1)$$

Whereas consumers with out environmental concerns have utility given by

$$U = z + u(x), \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1.2)$$

Where *z* and *x* are consumption of the numeraire good and good x, respectively. θX is the total damage from pollution where θ is the per-unit damage function, *X* is the total domestic output of good *x*, and $u(x)$ is a utility function.

Trade policies may be of two types, either "protective" or "anti-protective". Our analysis applies to the case where the protected or anti-protected sector is polluting in production. Trade policy is assumed to be determined by multilateral negotiations over which this small country has negligible influence. Let p^* be the world market price of good x; consumers' domestic price is given by $P = (1+\tau)p^*$ if the sector is import competing, and $p = (1+s)p^*$ if it is exporting. But here, we focus primarily on the former one.

Since production of good x results in local pollution, the government attempts to control emissions by levying an emissions tax, t ЄTcR_+, per unit of pollution. Rewards to the sector-specific factor are denoted as $\pi(P^N)$. By Hotelling's Lemma, total output of the polluting good is given by $X(P^N) = \partial\pi(P^N)/\partial P^N$.

FOC with respect to abatement is

$$\frac{\partial\pi(P^N)}{\partial A} = -X\left(t\frac{\partial\theta}{\partial A}+1\right) = 0, \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (2)$$

Import volume of good x equal to

$$M(P^N) = Nd(P) - X(P^N). \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (3)$$

The net revenue accruing to the government from the emission tax and tariffs is thus equal to $r(t,\tau) = \tau p^*\ M(P^N) + t\theta X(P^N)$. Since rewards to the owners of the sector-specific factor depend on the trade policy and the pollution tax, they have an incentive to lobby the government for more favourable policies. But, since the trade policy is assumed exogenously determined in multilateral negotiations, lobbying is focused only on the pollution tax rate.

4.2. The Political Equilibrium

This section examines how bribery by the lobby affects the political equilibrium pollution tax. This process is proceeding as follows. In the first period, the producer lobby group offers the government a bribe schedule, $S(t)$, which is contingent on the environmental policy stance of the government. In the subsequent period, the government determines its optimal environmental policy, and collects the associated bribe. Finally, firms determine production and abatement levels taking the tariff and environmental policy as given. Since the organised producer lobby contains few individuals, and thus has a utility function given by

$$V(t,\tau) = \pi(P^N), \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (4)$$

The government is assumed to maximise a weighted sum of the bribe received and social welfare equal to

$$G(t,\tau) = S(t) + \alpha W(t,\tau), \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (5)$$

Where $W(t,\tau)$ is aggregate social welfare and $\alpha > 0$ is the weight given by the government to social welfare relative to the bribe. α represents the government's willingness to set policies that deviates from the welfare maximising level in return for bribes, and therefore is a useful measure of the level of corruption. Aggregate social welfare is given by the sum of factor rewards, labour income, consumer surplus, tariff and pollution tax revenues, minus the damage from pollution:

$$W(t,\tau) = \pi(P^N) + L + NC(P) + r(t,\tau) - \gamma N\theta X(P^N), \qquad \ldots \quad \ldots \quad \ldots \quad (6)$$

From the first order condition for (6), the welfare maximising pollution tax is given by

$$t^w = \gamma^N + \frac{\tau p^* \theta\left(\partial X \big/ \partial P^N\right)}{\theta^2\left(\partial X \big/ \partial P^N\right) - X\left(\partial\theta \big/ \partial A\right)\left(\partial A \big/ \partial t\right)} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Where the second term is positive. Note that with $\tau > 0$, the second-best tax rate t^w is set above the marginal disutility from pollution, given by γN. We assume that $\partial^2 W(t,\tau)/\partial t^2 < 0$.

The Nash equilibrium pollution tax, t^*, can be found using the following two necessary conditions:

$$t^* = \arg max_t \; S^*(t) + \alpha \, W(t,\tau) \text{ on } T, \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (C1)$$

$$t^* = \arg max_t \; [\, V(t,\tau) - S^*(t) \,] + [S^*(t) + \alpha \, W(t,\tau)] \text{ on } T. \qquad \ldots \quad \ldots \quad (C2)$$

Condition (C1) requires that the equilibrium policy, t^*, maximises the government's utility function, while by (C2) the tax also maximises the joint utility of the lobby and the government. The equilibrium characterisation is found by taking the first-order conditions of (C1) and (C2),

$$\frac{\partial S^*(t^*)}{\partial t} + \partial \frac{\partial W(t^*,\tau)}{\partial t} = 0, \text{ and} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

$$\frac{\partial V(t^*,\tau)}{\partial t} - \frac{\partial S^*(t^*)}{\partial t} + \frac{\partial S^*(t^*)}{\partial t} + \alpha \frac{\partial W(t^*,\tau)}{\partial t} = 0. \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

Substituting (8) into (9) yields

$$\frac{\partial V(t^*,\tau)}{\partial t} = \frac{\partial S^*(t^*)}{\partial t}, \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

The characterisation of the equilibrium pollution tax is found by substituting condition (10) into (8), which yields

$$\frac{\partial G}{\partial t} = \frac{\partial V(t^*,\tau)}{\partial t} + \alpha \frac{\partial W(t^*,\tau)}{\partial t} = 0. \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

In equilibrium, the government trades off bribe and social welfare at a rate of α. Expanding terms in (11) (using (4) and (6)) yields

$$\frac{\partial G(t,\tau)}{\partial t} = \underbrace{-\theta X}_{A} + \alpha \underbrace{\left[(t - \gamma N)\left(X \frac{\partial\theta}{\partial A}\frac{\partial A}{\partial t} - \theta^2 \frac{\partial X}{\partial P^N}\right) + \tau p^* \theta \frac{\partial X}{\partial P^N}\right]}_{B} = 0. \qquad \ldots \quad (12)$$

Note from (12) that the political equilibrium tax must be lower than under welfare maximisation. To see this, observe that term *A* is negative, hence term *B* must be positive which from (7) requires $t < t^{w.}$ Note also that for sufficiently smallτ, $t < \gamma N$. We make the following assumption regarding the tax rate.

Assumption. *The political equilibrium pollution tax rate is sufficiently small such that $t < \gamma N$.*

4.3. Model Specification

In this section, we study the effects of corruption, environmental concerns, and trade liberalisation on the politically determined pollution taxes and in particular their interaction effects.

Prediction 1. *In the political equilibrium, corruption reduces the pollution tax.*

Proof. Totally differentiate (12) and rearrange:

$$\frac{dt}{d\alpha} = -\frac{\left(t-\gamma N\right)\left(X\dfrac{\partial\theta}{\partial A}\dfrac{\partial A}{\partial t}-\theta^2\dfrac{\partial X}{\partial P^N}\right)+\tau p^*\theta\dfrac{\partial X}{\partial P^N}}{\dfrac{\partial^2 G}{\partial t^2}} > 0. \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

The sign follows from (a) the assumption that $\partial^2 G/\partial t^2<0$, and (b) from (12) we know that the numerator is positive ($t<t^w$).

Prediction 2. *In the political equilibrium, trade liberalisation:*

(i) Increases (decreases) the pollution tax in a protected sector if the level of corruption is high (low);

(ii) Increases (decreases) the pollution tax in an anti-protected sector if the level of corruption is low (high).

Proof. Totally differentiate (12) and yields

$$\frac{dt}{d\tau} = \frac{dt}{ds} = \frac{\overbrace{\theta p^*\dfrac{\partial X}{\partial P^N}}^{A}-\alpha p^*\left[\overbrace{\left(t-\gamma N\right)\dfrac{\partial X}{\partial P^N}\dfrac{\partial\theta}{\partial A}\dfrac{\partial A}{\partial t}+\theta\dfrac{\partial X}{\partial P^N}}^{B}\right]}{\dfrac{\partial^2 G}{\partial t^2}}, \quad \ldots \quad \ldots \quad (14)$$

Where the denominator is negative by assumption. The sign of the numerator depends on the relative size of terms *A* and *B*, which are positive under assumption 1: (a) it follows that as corruption increases (14) becomes negative since term *A* dominates and vice-versa. Hence, for sufficiently low (high) α trade liberalisation in a protected sector always increases (decreases) the pollution tax. That is, $Lim_{\alpha\to\infty}\dfrac{dt}{d\tau} = \dfrac{\vartheta p^*\dfrac{\partial X}{\partial P^N}}{\dfrac{\partial^2 G}{\partial t^2}} < 0.$ And, (b) since in an anti-protected sector the trade policy instrument has a negative sign (τ<0, s<0), trade liberalisation implies an increase in the parameter value, and the sign of (14) is reversed in this case.

Trade openness affects the pollution tax through two channels. On one hand, trade openness reduces output in the polluting sector. Due to low production, the marginal benefits from corruption fall, which induce the bribe offer to declines. Hence, the pollution tax rises through this channel (term *A*). On the other hand, if the existing level of corruption is low and an open policy is implemented, the result will be reversed (term *B*).

Prediction 3. *In the political equilibrium,*

(i) An increase in the share of the consumers with environmental concerns raises the pollution tax, and

(ii) The effect disappears as corruption increases.

Proof. Totally differentiate (12) and rearrange:

$$\frac{dt}{d\gamma} = \frac{\alpha N\left(X\dfrac{\partial\theta}{\partial A}\dfrac{\partial A}{\partial t} - \theta^2\dfrac{\partial X}{\partial P^N}\right)}{\dfrac{\partial^2 G}{\partial t^2}} > 0. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

The denominator and the numerator are unambiguously negative. The greater the share of the population suffering disutility from pollution, the greater the equilibrium pollution taxes. However, this effect on disutility from pollution only translates into policy changes to the extent that welfare matters to the government.

Thus our main equation for regression is as follow:

$$\text{Emissions of } CO_2 \text{ and } SO_2 = \alpha_0 + \alpha_1\text{Openness} + \alpha_2\text{Corruption} + \alpha_3\text{GDP} + \alpha_4\text{GDP}^2 + \alpha_5\text{Corruption*Openness} + \alpha_6\text{ Corruption*GDP} + e$$

5. ESTIMATIONS AND RESULTS

Here, we present the results of our estimation in detail. *FIXED EFFECTS MODEL* is used to estimate the impact of trade liberalisation, corruption and GDP on the stringency of environmental policies. We consider CO_2 as a dependent variable and perform some essential tests. The increased level of emissions of these gases (CO_2 and SO_2)[1] in the last decade or two, leads economists and environmentalists to increase their focus of research on these two chemicals [Grether, *et al.* (2007); Cole (2007); Zarzoso and Morancho (2004)].

5.1. CO_2 as a Measure of Environmental Protection

Table 2 summarises the findings of regressions when CO_2 is used as a proxy for environmental quality. To study the impact of openness on CO_2 emissions, the given table shows four different variables that were used as indicators of free economy; namely, trade,

[1]We have also considered SO_2 as an indicator of environmental protection and performed the required tests to show the robustness of our results (see Appendix).

Table 2

Determinants of CO_2 Regression
Estimations for Pooled Data

	Different Measures of Openness							
	Trade		Taxes		Import Duties		Export Duties	
Openness	–0.008***	–0.005***	0.001	–0.0001	0.0001	–0.0003	–0.002	0.009***
	(–7.05)	(–6.24)	(0.85)	(–0.5)	(0.1)	(–0.36)	(–0.05)	(4.49)
Corruption	–0.035***	–0.05***	0.02	–0.08***	0.01	–0.06***	–0.014*	–0.05***
	(–3.06)	(–3.31)	(1.45)	(–4.47)	(0.4)	(–4.09)	(–1.67)	(–3.28)
GDP	0.003***	0.0033***	0.002***	0.002***	0.001***	0.002***	0.002***	0.002***
	(15.84)	(16.4)	(11.3)	(12.0)	(5.6)	(12.4)	(11.2)	(13.6)
GDP^2	–0.000001***	–0.000001***	–6.21E–07**	–1.67E–06***	–5.03E–07*	–1.54E–06***	–9.69E–07***	–1.30E–06***
	(–8.4)	(–8.2)	(–2.3)	(–6.9)	(–1.76)	(–6.7)	(–5.01)	(–6.1)
Corruption*	0.001***		–0.001**		–0.002***		0.003	
Openness	(3.2)		(–1.9)		(–2.7)		(0.32)	
Corruption*		0.0001***		0.0001***		0.0001***		0.0001***
GDP		(3.34)		(3.7)		(3.4)		(2.63)
F–statistic	2958.859***	2692.826***	807.7950***	752.2259***	758.726888	753.3427***	1129.993***	1160.893***
R^2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Adjusted R^2	0.85	0.84	0.84	0.81	0.86	0.8	0.82	0.9
Country	BGD –0.53	BGD –0.53	BGD –0.30	BGD –0.3	BGD –0.2	BGD –0.34	BGD –0.51	BGD –0.5
Specific	IND 0.061	IND 0.06	IND 0.40	IND 0.3	IND 0.4	IND –0.32	IND 0.13	IND 0.1
Coefficients	PAK –0.31	PAK –0.31	PAK 0.003	PAK –0.09	PAK 0.01	PAK –0.08	PAK –0.30	PAK –0.2
	SLK –0.80	SLK –0.78	SLK –0.57	SLK –0.65	SLK –0.5	SLK –0.67	SLK –0.9	SLK –0.9

Note: Absolute value of t-statistics in parenthesis beneath coefficients estimates, ***, **, and * indicate that the coefficients are significant at 1 percent, 5 percent, and 10 percent level of significance respectively.

GLS, Fixed Effects Model (Dependent Variable = metric tons per capita of So_2 emissions).

Model type is based on which openness measure is used in the regression.

taxes on international trade, import and export tariffs. Eight separate regressions were run to test the robustness of the different openness proxies as well as of interaction terms.

5.1.1. *Trade as a Measure of Openness*

The first and second columns of Table 2 show the estimates from the regression model when trade is considered as a measure of openness. The empirical results in these two columns provide co-efficient estimates that are consistent with the theory and statistically significant at the p<0.05 level, which is associated with decrease in CO_2 emissions, signalling an increase in environmental protection. This finding suggests that as an economy becomes more open, it tends to have stringent environmental standards, which are also consistent with the results of Grether, *et al.* (2007). There are two ways through which openness affect the environmental quality. Firstly, its direct impact on CO_2 emissions and the second one is through as an interaction term with corruption (corruption* openness). The total impact of trade on environmental quality at the sample mean of corruption = ∂ CO_2/∂ Trade= –0.008+0.001(2.26) = –0.00574 (first column). This estimate suggests that as the volume of trade increases by one standard deviation (about 0.10), the level of CO_2 emission decreases by 0.00574 metric tons per capita. Result like this was also studied by Ferrantino (1997). It means that openness have a significant positive impact on environmental protection.

The effects of corruption on pollution level (CO_2 emissions) indicates that as the corruption index increases (corruption level falls) by one standard deviation point, CO_2 emissions decreased by 0.035 metric tons per capita as indicated by the significance of the corruption co-efficient at p<0.05 level. The results suggest that corruption level has a greater absolute impact on environmental protection as compared to openness, which is also analysed by Damania, *et al.* (2003), Pellegrini and Gerlagh (2006). Nevertheless, its total impact depends on its direct effects and its interaction effects with openness, ∂ CO_2/∂Corruption= –0.035+0.001(38.22) =0.0032 (first column), a one unit increase of corruption index is associated with decrease of 0.0032 per capita metric tons of CO_2.

The sign and significance of the GDP and GDP^2 (p<0.05) confirms the inverted U-shaped Environmental Kuntz Curve (EKC), that was also tested by Deacon and Norman (2004), and Khana and Plassman (2004) in their studies. This EKC relationship is not workable if an economy faces high level of corruption, that was also highlight by Leitao (2006) and Welsh (2002) in their researches. The statistically significant coefficient of the interaction variable corruption*GDP (p < 0.05 level) in the second column confirms the theory that people demand for environmental quality increases as their income level rises, but this income effect is offset by high level of corruption in the economy.

The estimates of another interaction term corruption*openness is also highly significant at the p<0.05 level support the results of the theoretical model. The sign of this interaction effect is positive shows that as the level of corruption raises, the impact of trade on the stringency of the environmental regulations increases. The interaction coefficient also provides a sense of the effects of governmental corruption level under different trade regimes that was also deliberate by Damania, *et al.* (2003). The impact of corruption level on pollution is high relatively in closed economies, which is consistent with theory that corruption and protection are complements in the creation of environmental policy distortions.

5.1.2. *Taxes as a Measure of Openness*

The third and fourth columns in Table 2 represent regression results for a model when tax on international trade considered as an indicator for openness. In these regression estimates, the co-efficient of corruption, GDP, and of the both interaction terms are statistically significant, which support the theoretical arguments of the model. However, the coefficient of openness variable is small and statistically insignificant; indicate that tax measure should be using with caution while performing such study. Because in all LDCs including our sample, data on taxes have more biased-ness in reporting and collection as compared to trade.

5.1.3. *Import Duties as a Measure of Openness*

The sign and statistical significance of the interaction variables as well as the idea of EKC are supported by the result of the regressions present in columns 5 and 6 of Table 2, when import duties are used as a liberalisation measure. The corruption coefficient is significant in one of the two regressions, signalling that highly corrupt countries have less stringent pollution policies. The coefficient of corruption*openness is negative, implying the effect of import duties on CO_2 emissions decreases as the value of the corruption index increases (i.e., corruption falls). The sign of the interaction effect is consistent across regression models and implies that distorted trade policies increase the influence of corruption on environmental policy.

5.1.4. Export Duties as a Measure of Openness

As the value of export duties is diminishing in such a globalise world, but we consider it here to check the robustness of our results. Most of the estimators in columns 7 and 8 of Table 2 are significant except a few one. These results further support the theory of the model. Export duties on trade confirm the sign of all parameters including interaction estimators.

6. CONCLUSIONS AND POLICY IMPLICATIONS

To transform theory and empirical statistics into policy implications, policy makers should consider the dynamic, complex, and technical relationships that exist in an open economy. Our objective is to analyse these technical relationships for selected South Asian countries.

6.1. Conclusions

As the impacts of trade and corruption on environmental standards are dynamic and technical in an open economy, most of the literature on trade and environment did not give much importance in the past as they are doing in the present. Due to increased importance of corruption in most of the LDC's economies in the recent past, current researchers have diverted their attention to study this side of the environmental issue.

Our findings show that there are positive effects of trade on environmental quality. It suggests that countries with more open trade regimes have stringent environmental policies and low level of emissions. Open economies may lead to import cleaner technologies and divert production from dirty to clean sectors and industries. However, the estimates suggest that these impacts are conditional upon on the level of governmental corruption. The interaction variable corruption*openness indicates that in a protected sector, the impact of trade liberalisation on environmental standards increases if the level of corruption is high while in anti-protected economy these effects become reversed. It means that corruption and close economies act like a complements for environmental policy distortions (high emissions of chemicals).

Institutional variable like corruption have negative impact on environmental protection. Its absolute value is higher than that of the estimator of openness in all-alternative specifications. Therefore, authorities should give more emphasis on institutions to correct the distortions. Moreover, the reduction in corruption has a greater effect on environmental policy in relatively closed economies.

The results of our analysis also reveal that environmental quality is a normal good, i.e., its demand increases with increase in income. Our study supports this view of environmental quality demand. But like trade, this outcome of income on environmental protection also depends on the level of corruption in the economy. The interaction effect corruption*GDP outlines that corruption distorts people's preferences to optimal policy formation. All this shows that the idea of EKC depends on the level of corruption in the economy or it is not necessary that every country should follow the path of Kuznets curve in their emissions.

In short, the effects of trade and output-level on environmental protection depend on the level of government honesty in the economy. Therefore, care should be observed while performing such studies in much complicated societies and economies.

6.2. Policy Implications

Several policy implications emerge from our analysis. Firstly, trade liberalisation reduces environmental emissions of CO_2 and SO_2 in all sectors of the economy by increasing the stringency of environmental policy. Policy makers should try to open their borders as quickly as possible to gain from double dividend of trade, i.e., high level of consumer and producer goods and clean and healthy environment. It is also a guide for environmentalists who believe that trade distorts environmental standards. Environmentalists should also design policies and pursue the authorities that trade liberalisation have more benefits to the society as compared to its costs.

However, policy makers should also keep an eye on other important variables, institutions and factors, (like corruption, democracy, etc.,) which exploit and distorts this positive relationship. That is, they should consider the effects of corruption in the economy while drawing any conclusions and making any welfare policy regarded to environmental protectionism, because the level of corruption in our sample area negatively affects these impacts of openness on emissions. Another important policy implication is that the level of governmental corruption in the economy also violates environmental protection demand. It shows that people's demand for environmental protection is not converted to optimal policy making. Therefore the authority should consider and keep an eye on their institutions while making any welfare directed policy.

APPENDIX

Appendix Table 1

Determinants of SO_2 Regression
Estimations for Pooled Data

	Different Measures of Openness							
	Trade		Taxes		Import Duties		Export Duties	
Openness	–8.64E-05***	–4.74E-05***	2.30E-05	2.52E-05*	7.40E-06	–3.29E-06	0.000663	7.05E-05***
	(–4.9)	(–3.6)	(1.47)	(1.7)	(0.4)	(–0.6)	(1.3)	(3.8)
Corruption	–0.000308***	–0.000584***	–0.000752***	–0.000809***	0.000928	–0.000326**	6.58E-05	–0.000526***
	(–2.9)	(–3.95)	(–3.4)	(–4.7)	(1.4)	(–2.1)	(0.7)	(–3.7)
GDP	1.40E-05***	1.11E-05***	7.87E-06***	5.49E-06***	5.61E-06***	3.37E-06**	6.80E-06***	5.08E-06***
	(5.4)	(5.02)	(4.59)	(3.5)	(3.2)	(2.3)	(4.4)	(3.9)
GDP^2	–3.71E-09*	–5.27E-09**	–2.88E-09	–4.42E-09**	–1.22E-09	–2.93E-09*	–2.25E-09*	–8.12E-11
	(–1.86)	(–2.5)	(–1.5)	(–2.4)	(–0.8)	(–1.7)	(1.7)	(–0.05)
Corruption* Openness	1.56E-05***		–3.29E-05***		–3.16E-05***		–0.000198	
	(3.78)		(–4.02)		(–3.8)		(–1.23)	
Corruption* GDP		1.84E-06***		2.07E-06***		1.85E-06***		1.33E-06***
		(4.35)		(4.7)		(4.8)		(3.8)
F-statistic	600***	764***	1123***	1635***	654***	908***	1117***	1426***
R^2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Adjusted R^2	0.85	0.83	0.86	0.85	0.84	0.87	0.83	0.88
Country Specific Coefficients	BGD –0.001	BGD –0.001	BGD –0.001	BGD 0.002	BGD –0.001	BGD 0.001	BGD –0.001	BGD –0.0008
	IND 0.002	IND 0.002	IND 0.002	IND 0.004	IND 0.003	IND 0.005	IND 0.002	IND 0.003
	PAK 0.003	PAK 0.003	PAK 0.003	PAK 0.005	PAK 0.004	PAK 0.007	PAK 0.002	PAK 0.004
	SLK –0.001	SLK –0.001	SLK –0.001	SLK –0.002	SLK –0.001	SLK 0.001	SLK –0.003	SLK –0.002

Note: Absolute value of t-statistics in parenthesis beneath coefficients estimates, ***, **, and * indicate that the coefficients are significant at 1 percent, 5 percent, and 10 percent level of significance respectively.
GLS, Fixed Effects Model (Dependent Variable = metric tons per capita of So_2 emissions).
Model type is based on which openness measure is used in the regression.

REFERENCES

Abler, D. G., A. G. Rodriguez, and J. S. Shortle (1999) Trade Liberalisation and the Environment in Costa Rica. *Environment and Development Economics* 4, 357–73.

Antweiler, Werner, M. S. Taylor and B. R. Copeland (1998) Is Free Trade Good for the Environment. *The American Economic Review* 91:4, 877–908.

Bandyopadhyay, Subhayu, and Suryadipta Roy (2006) Corruption and Trade Protection: Evidence from Panel Data. West Virginia University. (Working Paper Series).

Bank, World (2007) World Development Indicators. http://web.worldbank.org

Beghin, J., B. Bowland, S. Dessus, D. Roland-Holst, and D. Van-der-Mensbrugghe (1999) Trade Integration, Environmental Degradation, and Public Health in Chile: Assessing the Linkages. *Trade, Global Policy and the Environment.* The World Bank, Washington, DC.

Birdsall, N., and D. Wheeler (1992) Trade Policy and Industrial Pollution in Latin America: Where are the Pollution Havens? *International Trade and the Environment.* World Bank, Washington, DC.

Cole, M.A. (2007) Corruption, Income and the Environment: An Empirical Analysis. *Ecological Economics* 62: 637–647.

Damania, Richard, P. G. Fredriksson, and J. A. List (2003) Trade Liberalisation, Corruption, and Environmental Policy Formation: Theory and Evidence. *Journal of Environmental Economics and Management* 46, 490–512.

Deacon, R. T. and C. S. Norman (2004) Does the Environmental Kuznets Curve Describe How Individual Countries Behave? 7th Occasional Workshop on Environmental and Resource Economics at the University of California.

Dinda, Soumyananda (2005) A Theoretical Basis for the Environmental Kuznets Curve. *Ecological Economics* 53, 403–413.

Ferrantino, M. J. (1997) International Trade, Environmental Quality and Public Policy. *The World Economy* 20, 43–72.

Frontier Research Centre for Global Change (FRCGC) (2007) Regional Emission Inventory in Asia <http://www.jamstec.go.jp/frcgc/research/p3/emission.htm>

Grether, J. M., A. Nicole, and J. D. Melo (2007) Is Trade Bad for the Environment? Decomposing Worldwide SO_2 Emissions 1990-2000. University of Geneva. (Discussion Paper)

Grossman, G. M., and A. B. Krueger (1991) Environmental Impacts of North American Free Trade Agreement. Woodrow Wilson School of Public and International Affairs, Princeton, NJ. (Discussion Papers in Economics No.158.)

International Country Risk Guide (2004) Country Rankings. <http://www.countryrisk.com>

International T. (2006) Corruption and the Environment. Environmental Science and Policy Workshop, Columbia University.

Khanna, Neha, and Florenz Plassmann (2004) The Demand for Environmental quality and Environmental Kuznets Curve Hypothesis. *Ecological Economics* 51, 225–36.

Leitao, Alexandra (2006) Corruption and Environmental Kuznets Curve: Empirical Evidence for Sulfur. (Working Paper for FCT, 2010).

Pellegrini, Lorenzo (2003) Corruption, Economic Development and Environmental Policy. A Conference on Political Economy of the Environment, September 1st to 6th.

Pellegrini, Lorenzo, and Reyer Gerlagh (2006a) Corruption and Environmental Policies: What are the Implications for the Enlarged EU? *European Environment* 16, 139–154.

Pellegrini, Lorenzo, and Reyer Gerlagh (2006b) An Empirical Contribution to the Debate on Corruption, Democracy and Environmental Policy. *Journal of Environment and Development* 15, 332–354.

Todaro, M. P. and S. C. Smith (2005) Economic Development. Pearson Education. *Eighth Edition.*

Welsch, Heinz, (2002) Corruption, Growth, and the Environment: A Cross-Country Analysis. German Institute for Economic Research. (Discussion Papers 357).

Wikipedia (2007) The Free Encyclopedia. <http://en.wikipedia.org/wiki/Sustainable_development>

Zarzoso, I.M., and A. B. Morancho (2004) Pooled Mean Group Estimation of an Environmental Kuznets Curve for CO_2 *Economic Letters Elsevier* 82, 121–126.