THE INTERACTION BETWEEN CORRUPTION, POLLUTION AND OPENNESS: A PANEL DATA STUDY

by

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Abstract

We try to extend the environment, corruption, trade (openness) literature by endogenizing corruption and openness. Most papers on this brand new literature have assumed corruption and openness to be exogenous and therefore they have ignored the possibility of the joint determination of these three variables. In general, those papers looked at the impact of openness and corruption on environmental policy/quality treating openness and corruption to be determined outside the system. However, in reality, there are a plethora of variables that impact both corruption and openness of a nation. Therefore, ignoring such variables will cause endogeneity problem. We try to correct this problem in the existing literature by carrying out a simultaneous determination of these variables through a system of equations.

1. Introduction

The incidence of corruption dates back to the ancient days of human civilization. Since then corruption has remained as an inseparable feature of human lifestyle and the diverse nature and pervasiveness of corruption have resulted in diverse damaging consequences to human society. There is no unique nature or impact of corruption. Therefore, in common parlance, the word ‘corruption’ is reflective of various incidences in various situations. However, for the present purpose, we shall confine the analysis to political corruption and economic corruption. According to Pranab Bardhan (1997), political corruptions are those “where the ill-gotten gains are primarily in terms of political power”. On the other hand, economic corruption, in his opinion, is the use of a public office for private gains, “where an official (the agent) entrusted with carrying out a task by the public (the principal) engages in some sort of malfeasance for private enrichment which is difficult to monitor for the principal”. Economic corruption resembles what is commonly known as the principal agent problem in the economic literature. Bardhan also notes that “there are, of course, many everyday cases of other kinds of corruption some of which may take place entirely in the private sector”.

In a typically corrupt society, corruption encompasses both public and private sectors and hence it affects economic growth and distribution of income. Environmental laws and legislations in any country are formed in the ‘bureaucratic public sphere’ (or the government) and these laws are designed to be followed by both public and private institutions. The fact that bureaucratic public sphere is prone to be corrupt in a developing country leads to the suspicion that corruption might impact environmental laws and legislations as well. There are several ways (like favor for favor policy, special payments, rent seeking activities) through which public officials could compromise environmental quality for their own interest. On the other hand, corrupt private institutions, lobby groups and individuals from the private sphere, always have an incentive to escape environmental laws, standards, or pollution taxes for personal economic gains. Thus, both from public and private sectors' perspectives, environmental quality is dependent on the level of corruption in any country. In a corrupt society, the magnitude of loss of environmental quality critically hinges on the relative importance of corruption vis-à-vis social welfare.

Another aspect that can impact the environmental quality in a country is its openness. By 'openness', economists generally try to refer to the question how liberal a country is in terms of trading with the rest of the world. Often times they consider the volume of trade a country engages in, and its relative importance with respect to that country's national income. Numerous measures of openness have been put forward in the macroeconomic/trade literature. However, the most common measure of openness is probably the simplest of all, and it expresses the volume of trade (export plus import) as a proportion of Gross Domestic Product (GDP) of a country. The reason some economists and environmentalists believe that openness affects environmental quality emerges from the swift structural changes that have been taking place in the world economy over the last two-decades. The environmentalists are focusing on the way the environment; both at local and global level, is affected by the massive expansion of international trade, which has resulted from a significant increase in 'openness' of various nations worldwide over the last two decades. The environmentalists are mostly concerned whether or not trade between two counties results in the relocation of dirty industries from one country to another, and if so; they propose some changes in the environmental laws in order to address the issue. Economists, on the other hand, are investigating how environmental laws and regulations impinge on the pattern of international division of labor and capital and also the quantum and distribution of the gains, if any, accruing from such division. Thus, there is a two-way relationship between trade openness and environmental quality.

The other aspect we shall try to focus in this paper is the interrelation between corruption and openness. Not much work has been done on this area. Almost all studies that dealt with corruption, openness and environment have safely assumed corruption and openness to be exogenous and thus they precluded the possibility that corruption and openness might impact each other. In reality, corruption in a country can not be exogenous. It depends on several factors; including the extent of poverty, average income levels, unemployment, education, lack of accountability, monopoly power and openness. It is argued that the corrupt lobby groups in developing countries have an incentive to exert influence on the government to remain closed to the outer world and thus safe from foreign competition. Hence, we cannot ignore the possibility that corruption might impact the openness of a nation. On the other hand, as a country becomes more and more open (maybe due to internal or international pressure), the domestic producers and the lobby groups start facing more and more competition from the outer world and gradually things start moving beyond their control and this might result in a reduction in their level of corruption. Thus, there is a need to study the trade off, if any, between corruption and openness.

In the present paper we shall try to examine the complex relation between corruption, openness and environmental quality accounting for the real life phenomenon where all of these three variables are endogenous. This paper is organized as follows. The second part covers the literature survey; the third part covers the objective of study, the fourth part describes the data; the fifth part talks about the estimation, the sixth part explains the results and the seventh part concludes.

2. Literature Survey

The literature on the interaction between corruption, environment and openness is **rather new and is not integrated**. Most papers talk about the impact of corruption on growth and environmental quality and only a few discuss about the impact of corruption and openness on environment.

Among papers describing the impact of corruption, Lopez and Mitra (2000) analyze the significance of governmental corruption and rent seeking behavior on the level of pollution in an economy and how these levels behave as the economy grows. The authors come up with three major conclusions. First, in the presence of corruption, the pollution levels are always higher than the socially optimal level. Second, corruption is not likely to rule out the existence of Environmental Kuznets' Curve (EKC)[1]. Third, the turning point or the peak of the EKC corresponds to a situation where both income and pollution are more than their corresponding socially optimal level. This study has profound implications for large developing countries like China, India and Indonesia where corruption is pervasive. The authors conclude that unless these developing nations succeed in reducing corruption, they will experience a level of pollution much higher than the pollution level for developed nations when the latter group of nations was at comparable levels of per capita income. The EKC for the developing nations would be an upward (and shifted to the right) version of the EKC for the developed nations.

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[1] According to EKC some pollutants follow an inverse-U-shaped relation with respect to the relevant country's per capita income. This means that when a country is in its initial stage of development, pollution will increase with the increase in per capita income. Then pollution will reach a maximum when the country in question will attain a certain level of per capita income. Since then with further increment in per capita income, pollution will decline.

Paulo Mauro (2004) analyzes the nature and causes of widespread corruption and the "bad equilibrium" characterized by both widespread corruption and slow economic growth. He presents two models that rely on strategic complementarities to obtain multiple equilibria. The first model shows that when others are stealing from the government, an individual will decide his actions based on the low marginal product of working in legal activities and high marginal product of stealing as the chances of getting caught are low. Thus the individual will allocate more time to rent seeking, and less time to productive activities and this will generate multiple equilibria in corruption and growth. The second model analyzes the impact of one politician's corruption on another through the probability of reelection of the government. The second model also obtains multiple equilibria in political instability, corruption and economic growth. Mauro argues that widespread corruption can arise in these situations because individual incentives to fight corruption vanish despite everyone being better off without it.

Rock and Bonnet (2004) examine the robustness of the relation between corruption and investment and economic growth using cross-country regressions with four different types of corruption data. Their empirical results support two main conjectures. First, the impact of corruption on investment and growth is more severe in developing countries when compared with the same for developed countries. The key exceptions are the newly industrialized East Asian countries where corruption tends to be positively associated with economic growth. A positive association of corruption with growth for the East Asian countries (mainly Indonesia, Malaysia and Thailand) has been termed by the authors as "East Asian paradox", which entails further countrywise study. The authors conclude by saying that the small developing countries, where corruption is definitely a hindrance to growth, are more vulnerable to corruption than their developed counterparts. As a result, the international institutions, regional development banks and bilateral aid donors might have more to gain by focusing their anti-corruption programs in developing countries.

While the papers discussed above consider the role of corruption in a ***closed economy***, recently there have been some systematic attempts to introduce *international trade* in the corruption-growth-environment framework. Damania, Fredriksson and List (2003) examine the interaction between international trade policy, corruption and environmental policy. They present a three-stage common agency model to analyze if trade liberalization is correlated with the stringency of environmental policies and if governmental corruption is associated with environmental policy formation. They focus on the political economy effects of trade liberalization; for example, whether the incentives of the lobby groups to shape environmental policies in their favor, change as a result of trade reform. The model highlights the objective function of a typically corrupt government where it faces the ***twin conflicting objectives*** of social welfare and payments from the lobby groups. The rate of trade off between these two objectives defines the level of corruption and the final environmental policy depends on the relative strengths of the welfare motive and the political motive. The authors find that when trade policy is protective and the level of corruption is high (low), trade liberalization induces a decline in bribery that dominates (is dominated by) second-best welfare considerations. The second prediction implies a reduction in corruption leads to an improvement in the environmental standards as less corruption signifies more relative weight on social welfare that pushes the pollution tax towards the socially optimal level. The last conjecture is, an upsurge in the demand for environmental quality will indeed improve environmental quality but the magnitude of improvement will shrink as the level of corruption rises.

Fredriksson and Svensson (2003) try to bridge the gap between the two parallel literatures of (i) political instability, corruption and governmental policy & (ii) political instability, corruption & investment and growth. The novelty of their paper is the *interaction* between corruption and political instability, and in particular their joint effects on policy formation, which was hitherto unexplored. The authors treat environmental policymaking as representative of many other forms of governmental decision making. They highlight the fact that "special interests" affect environmental policies at the expense of the electorate's interest or social welfare, just like most other policies, and hence the predictions of the model are not applicable to the case of environmental policy only, but they have a *general acceptability*. In their findings, corruption influences the relation between political instability and environmental regulation. In particular, political instability reduces (increases) environmental policy stringency at low (high) level of corruption. They also find that corruption, as well, diminishes environmental policy stringency but the effect disappears as political instability increases.

Cole and Elliott (2003) investigate the composition effect of trade liberalization on the environment in further detail. The conventional approach divides the effect of trade liberalization into scale, technique and composition effects. While the scale effect is likely to damage the environment because of increase in overall economic activities, the technique effect is likely to benefit environment because of the introduction of better techniques is likely to improve environmental quality because of the introduction of better techniques in production process. Since trade liberalization is likely to change the industrial structure of an economy and will make it increasingly specialized in activities in which it has a comparative advantage, the final outcome of the composition effect will critically hinge on what determine the comparative advantage of the economy. The authors try to find out whether the compositional effect arises from the differences in capital-labor ratios or in the differences in environmental regulations or both. They find that both factors impact the compositional effect and in the opposite direction. High capital intensive sectors are more prone to pollution, yet the least capital intensive regions are those that have a laxity in environmental regulations. The authors conclude by saying that these opposing effects might cancel each other and that could be one possible reason why many empirical studies have failed to establish the case for pollution haven hypothesis.

Damania, Fredriksson and List (2004) further generalize their previous model by introducing an imperfect market setting in a theoretical framework. The authors examine whether or not the incentives of bribery for a favorable environmental policy on the part of lobby groups vary as the country enters a liberalized trade regime. The theoretical model finds that when trade policy is protective, trade liberalization leads to an increase (decrease) in the pollution tax if governmental corruption is high (low.) On the other hand if the trade is anti-protective, then trade liberalization results in an increase (decrease) in the pollution tax when governmental corruption is low (high). The intuition of the theory again hinges on the rate at which the government trades off social welfare and bribe. The conclusion of the model is paramount for developing nations. The model predicts that in a typically corrupt developing country, trade openness results in stricter environmental regulations and the interaction between openness and the level of corruption generate a “multiplier effect”, raising economic growth and improving environmental quality.

Economists have tried to address the issue of corruption-openness-environment both from theoretical and empirical point of view. Most often, they considered any two of these three issues and only on a few occasions they considered all the three issues in tandem. However, in summary, the literature on corruption-openness-environment has neither reached any consensus nor has it taken any specific direction. There is no explanation offered whether and how all these three issues influence each other and get influenced. We try to address this issue in this paper.

3. Objective and Relevance of Study

The phenomenon of corruption has taken an important place in economic literature for a long period of time. However, a severe dearth of reliable data on the level of corruption has restricted economists from verifying the validity of their theoretical understanding of the issue. In recent times, however, the situation has improved and some data on corruption started becoming available. Most of the studies above have revealed that, ceteris paribus, more corruption is bad for both economic growth and environment. In a real world scenario, the government in a corrupt country often focuses on its political aspirations at the cost of declining environmental quality. Meanwhile, the level of corruption determines the slackness in the environmental policy. The concern is paramount for a number of liberalizing developing countries that are convincingly corrupt. Will these countries fail to acquire the benefit of trade, if any, on environment because of corruption? Most research in the *brand new* literature on corruption, trade liberalization and environment assumes corruption and openness to be exogenous. In fact, there is reason to believe that corruption and openness, besides affecting each other, are also influenced by a plethora of reasons such as poverty, income, monopoly power, little accountability, dispersion in livelihood etc. Thus, almost all these studies suffer from the severe drawback of endogeneity problem and therefore they are partial in their approach to analyze the real world situation.

4. Data

In this study, country level data have been used for 54 countries across the globe, for which appropriate data were available. Typically, we tried to include as many countries as possible but due to lack of availability and reliability of data; we had to restrict our study to these 54 countries. We included almost all developed nations for which we had a more or less continuous reporting of data. However, for the small developing countries with a population of less than 10 million in 1995, we observed a severe paucity of appropriate data. Moreover, there had been instances where previous papers on similar topics have excluded very small developing countries owing to lack of reliability of data. In our study we use all developed countries regardless of their population and all developing countries with a population of more than 10 million in 1995 for which data were available. The study years are 1987-1998. Because of time and cross sectional dimensions, this is a panel data study.

(4.1) Sources of Data

Environmental Data (National SO_2 emissions): Emission Database for Global Atmospheric Research (EDGAR).

Corruption & Related Variables: International Country Risk Guide (ICRG, 2004).

All other Exogenous Variables: World Development Indicators (WDI) 2001.

(4.2) Dependent Variables

As we have discussed earlier, there are three dependent variables in our model. These are (1) air/environmental quality (pollution), (2) corruption and (3) openness. Below we describe each of these 3 variables separately.

(4.2.1) Air/Environmental Quality (Pollution)

Presence of Sulfur-Di-Oxide (SO_2) beyond an appropriate level in air is an indicator of air pollution. Therefore, it serves as one of the major indicators of environmental quality. Emissions of SO_2 beyond a scientifically justified level can have serious consequences. The main source of SO_2 in air are the industrial activities that process materials that contain Sulfur, eg the generation of electricity from coal, oil or gas that contains Sulfur. Some mineral ores also contain Sulfur, and SO_2 is released when they are processed. In addition, industrial activities that burn fossil fuels containing Sulfur can be important sources of SO_2. It is also present in motor vehicle emissions, as a result of fuel combustion. Therefore two important sources of SO_2 in air are automobiles (transportation) and industrial activities that use energy for commercial purposes. We collected data on SO_2 emissions at the *country level* from Emission Database for Global Atmospheric Research (EDGAR, version 3.2). Only two years' (1990 and 1995) data were available. Therefore, we had to estimate the emissions figure for the remaining 10 years i.e., 1987-1989, 1991-1994 and 1996-1998. Let us now explain the estimation procedure for these 10 years.

Given the technology of production, SO_2 emissions (denoted by P) predominantly depend on commercial energy use (denoted by E). Thus, for example, if two countries use the same technology, then the country with more commercial energy use will emit more SO_2. On the other hand, if two countries have the same amount of commercial energy use (E), then the country with a superior technology will emit (P) less SO_2. The ratio of emissions (P) and commercial energy (E) use, i.e., (P/E), is known as the emissions factor, F = P/E. Given the state of technology and the commercial energy use for each year, one could use the emissions factor (F) to calculate the emissions (P) figure for a country. However, there are two problems if we want to apply this principle over the years. First, the state of technology is not observable and therefore there is no measurement available for this. Second, even for one particular country, the state of technology does not remain the same over time. If a country has the same amount of commercial energy use over the years, then any improvement in technology will be reflected by a reduction in the emissions factor. It appeared that almost all countries in our sample had registered a *decline* in their emissions in 1995 over 1990, but at the same time, their use of commercial energy *increased* in 1995 over 1990. Thus, a typical country's emissions factor was lower in 1995 than in 1990; therefore, in our calculation of emissions, we needed to consider the joint impact of changing (improving) technology and commercial energy use. We had data on commercial energy use for all years (from WDI 2001) for each country. First we calculate the following.

$$F_{1990} = P_{1990} / E_{1990} \quad \text{and} \quad F_{1995} = P_{1995} / E_{1995}$$

These two are the emissions factor for the years 1990 and 1995 respectively for each country. The emissions factor for a country does not change drastically over a short period of time and the emissions factor follows more or less a linear trend over years. We define the per year change in the emissions factor for a country as

$$\Delta = \frac{1}{5}(F_{1995} - F_{1990})$$

It is clear that each country will have a separate Δ. We calculate the emissions factor for all the other years using Δ. These are given by

$F_{1990-i} = F_{1990} - i * \Delta$ where $i = 1,2,3$ and $F_{1990+j} = F_{1990} + j * \Delta$ where

$j = 1,2,3,4,6,7,8$.

For example, $F_{1987} = F_{1990-3} = F_{1990} - 3*\Delta$ and $F_{1996} = F_{1990+6} = F_{1990} + 6*\Delta$.

Having calculated the emissions factors (F), we multiply them by the amount of commercial energy use (E) to arrive at the pollution figures. Thus, for any country

$P_{1990-i} = F_{1990-i} * E_{1990-i}$ where $i = 1,2,3$ and $P_{1990+j} = F_{1990+j} * E_{1990+j}$ where

$j = 1,2,3,4,6,7,8$.

Since our environmental quality measure needs to be normalized, we divide the pollution figures for a country by its GDP and we do this for each year (the GDP figures are in 'purchasing power parity'). The unit of the measurement of environmental quality is therefore, grams of SO_2 per unit of GDP.

(4.2.2) Corruption

The source of the data on corruption is International Country Risk Guide (ICRG). It is basically a measure of political and economic corruption. Based on the level of corruption, ICRG assigns a *number* between 0, 1, 2, 3, 4, 5, 6 and in a few exceptional cases a fractional number between 0 and 6 to each country for each month. The higher is the level of corruption in a country, the lower is the number and the lower is the corruption, the higher is the number. Therefore, this is an *inverse* measure of corruption. We take the average of the monthly values over a year to arrive at an annual figure for each country. Our annual measure of corruption is, therefore, a number between 0 and 6 (inclusive of both the extreme numbers). For an overview of the descriptive statistic on corruption, look at the following table (table 1).

(4.2.3) Openness

We use the simplest measure of openness for this study. This is partly because of the fact that the simplest measure is easily understandable and partly because data on no other measure is available across countries. We define openness of a country by the ratio of its exports plus imports and GDP for each year. Therefore, the ratio gives the amount of trade per unit of GDP of a country.

Table 1: Descriptive Statistics for the Dependent Variables

Variable	Observation	Mean	Std. Dev.	Minimum	Maximum
Emissions Per Unit of GDP	648	4.19	4.43	0.0001268	30.76
Corruption (Inverse Measure)	648	3.99	1.37	0	6.00
Openness	648	0.64	0.46	0.0895935	3.03

Table 1 shows the summary statistics for our dependent variables. We can see that emissions have a wide dispersion. This is because the variation in pollution across countries is huge due to their differential preference toward environment. The maximum value of openness is more than one because there are a few countries (like Austria, Belgium, Hong Kong, Luxembourg) in our sample for which export exports plus imports are more than their GDP.

(4.3) Independent Variables

The set of explanatory variables include: per capita GDP, square of per capita GDP, cube of per capita GDP, democratic accountability, ethnic tension, external conflict, share of government in the economy, value added in the industries as a percentage of GDP (lagged by a year), internal conflict, ISD (outgoing international phone calls; minutes per subscriber), law & order, life expectancy at birth, military in politics, religion in politics, schooling (gross secondary school enrolment as a percentage of total), socioeconomic condition, stability of the government, urbanization (urban population as a percentage of total population), country dummies and year dummies. Out of these variables democratic accountability, ethnic tension, external conflict, internal conflict, law & order, military in politics, religion in politics, socioeconomic condition and stability of the government are collected from ICRG. These are all monthly figures like corruption and hence we take their yearly average into consideration. Out of these variables the *minimum and maximum possible* values of democratic accountability, ethnic tension, law & order, military in politics and religion in politics are respectively 0 and 6. However, the *minimum and maximum possible* values for external conflict, internal conflict, socioeconomic condition and stability are respectively 0 and 12. ***Out of the total 9 ICRG variables, external conflict, ethnic tension, internal conflict, military in politics and religion in politics are inverse measures, i.e., the higher are their values the better is the situation.*** The rest of the exogenous variables are collected from World Development Indicators' 2001 (WDI). The summary statistics of the WDI variables are provided in the appendix.

5. Estimation Procedure

Having described the variables let us now talk about the equations of our model. We follow 2SLS estimation techniques for panel data. We can express the estimation procedure in terms two generic equations. The first stage estimation can be expressed as:

$$Y_{it} = \sum_{k=1}^{K} \beta_k X_{it}{}^{k} + \sum_{i=1}^{53} D_i^{c} + \sum_{t=1}^{11} D_t^{y} + error \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where,

Y_{it} = Value of the dependent/endogenous variable for the i^{th} country and t^{th} year. Y could be emissions/GDP, corruption or openness.

K = Total number of exogenous variables in the system.

β_k = Coefficient of the k^{th} exogenous variables.

$X_{it}{}^{k}$ = Value of the k^{th} exogenous variable for i^{th} country and for the j^{th} year (and $(j-1)^{th}$ year for value added in the industries as a proportion of GDP).

D_i^{c} = Dummy variable for the i^{th} country and

D_i^{y} = Dummy variable for the j^{th} year.

Equation (1) expresses the first stage estimation procedure for an endogenous variable. It shows that in the first stage an endogenous variable is regressed on *all* exogenous variables.

The second stage estimation can be expressed as:

$$Y_{it} = \sum_{l=1}^{L} \gamma_l \hat{Y}_{it}^{\,l} + \sum_{m=1}^{M} \alpha_m X_{it}^{\,m} + \sum_{i=1}^{53} D_i^c + \sum_{i=1}^{11} D_t^y + error \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

where,

$\hat{Y}_{it}^{\,l}$ = Estimated value (from equation 1) of the l^{th} endogenous variable for the country and j^{th} year.

γ_l = Coefficient of the l^{th} estimated endogenous variable.

L = Total number of endogenous variables on the right hand side, where L < 3 and

M = the total number of exogenous variables included on the right hand side in the second stage estimation with M < K. The other symbols have the same meaning as in equation (1).

(5.1) Equations

The system contains 3 equations, an environment equation, a corruption equation, and an openness equation. In the environment equation, we have emissions per unit of GDP on the left hand and on the right hand side two endogenous variables (openness and corruption) and a few exogenous variables that we think should be included in the second stage estimation. In the corruption equation, we have corruption on the left hand side and on the right hand side one endogenous variable (openness) and a few relevant exogenous variables. We don't include environment on the right hand side of the corruption equation as we don't see any reason for environment to impact corruption. Last, in the openness equation, we have openness on the left hand side and on the right hand side two endogenous variables (environment and corruption) and some relevant exogenous variables. Each of these 3 equations will be explained in detail later on.

We need to identify an endogenous variable when it is on the right hand side of an equation. In that connection, we need to remember that an instrument should be exogenous with a proper theoretical reason for being related to the endogenous variable and that the instrument should be uncorrelated with the error term on the right hand side. The key identifying instrumental variable that appears on the right-hand side of the environment equation but not in the remaining equations is value added in the industries as a percentage of GDP (lagged by a year). The identifying instrument for corruption is life expectancy at birth and for openness it is the ISD.

Emission of SO_2 is mostly an industrial phenomenon. In general, more industrial activity generates more SO_2. If all other things remain the same, then for a given technology, more industrial activity will act as a reason for more emissions. Thus it is expected that the emissions intensity of GDP will rise with the share of industry in GDP. In other words, more value addition in industries as a percentage of GDP will raise emissions per unit of GDP. There is no obvious reason as to why value addition in industries as a percentage of GDP will affect corruption and/or openness. There is apparently no theory on whether the size of industries in an economy affects corruption and openness. On the other hand share of industry in GDP does follow a systemic trend with the passing of time and is more or less independent of Emission of SO_2. Why are we claiming share of industry in GDP to be not dependent on Emission of SO_2? Let us explain this briefly. Share of industry in GDP define the structure of an economy (i.e. whether the economy is very industrial or moderately industrial or less industrial). This structure does not change overnight. In terms of the Environmental Kuznets Curve (EKC) argument, when a country is passing through the initial stage of development, share of industry rises. Even if the country experiences more pollution during this phase of development, it can not afford to reduce pollution by lowering the importance of industry in GDP. This is simply because of the fact that in the initial stages of development, a country attaches more importance to basic needs like food, shelter, employment and as a result environment becomes a secondary concern. Thus, despite experiencing pollution, these developing countries can not change its industrial structure because of its income and employment associated with the industry. Two classic examples of this type of countries are India and China. Over the last decade and half or so, these two countries were polluting enormously (since they were passing through the initial phases of development), however, they could not reduce industrial activity (to lower pollution) in order to avoid loss of employment and income. When a country is passing through a developed phase, we would still argue that the country does not reduce industrial activity to lower pollution. Instead, the developed country increases its expenditure on research and development in order to improve the technology of production. Thus, by and large, rather than closing down industries, a developed country tries to use more environmentally friendly technology of production (with a few exceptions).

Other than pure economic factors and international trade agreements, openness of a nation depends on its citizen's inclination to interact with the outer world. For example, citizens in some countries are more liberal in their approach to interact with foreigners as compared to the citizens of other countries. One reflection of such inclination could be the citizens' willingness to talk to foreigners and their own citizens in foreign countries.

Thus ISD (international phone calls, minutes per subscriber) could be a good instrument for openness. We would like to clarify against a potential objection to the validity of ISD as an instrumental variable for openness. There could be a belief that more openness causes more ISD. More openness means more business activities (in our definition) with the outer world. However, these business contracts/deals are done on paper and with sufficient amount of caution and proof. In other words, the belief that more business activity causes more international phone calls could be wrong since telephone is a risky medium to carry out such confidential deals. Therefore, it can be argued that ISD is an exogenous variable that depends on sociological factors like culture, outlook toward foreigners etc. ISD is just a reflection of people's willingness to integrate to the rest of the word and therefore it carries the sense of openness in it.

Life expectancy at birth is a reflection of the status of health in a country and health affects citizens' mentality. There are significant amount of literature in health economics and psychology that support this idea. More healthy people could be more productive and mentally strong and therefore they could be more righteous than people with poor health condition and less productive capacity. This righteousness affects the level of corruption in a country. Thus, we believe life expectancy at birth could serve as a good instrument for corruption. We could support the validity of this instrumental variable from another angle. Public health investments are often a public good where there are significant spillovers. In a society with a significant amount of health expenditure, this spillover would ideally operate on the citizen's righteousness thereby resulting in a low level of corruption.

To examine the robustness of our instrument, we run three regressions. These are:

(a) Emissions per unit of GDP on (solely) value added in industry as a proportion of GDP

(b) Openness on (solely) ISD

(c) Corruption on (solely) life expectancy at birth.

Table 2: First Stage Regression Results (Robustness of the Instruments)

	Dependent Variable	Instrumental Variable	t-Statistic	Standard Error	% of Variation Explained
(a)	Emissions per unit of GDP	Lagged Value Added in Industry as a Proportion of GDP	7.28	0.025	0.10
(b)	Openness	ISD	13.50	0.00018	0.54
(c)	Corruption	Life Expectancy at Birth	17.23	0.0069	0.43

Table 2 summarizes the robustness of the instruments. In each of the three cases, our respective instrument explains a significant proportion of the variation in the dependent variable.

6. Results and Explanation

We can support our claim for the instrumental variables by the full set of first stage regression results as well. In a 2SLS regression procedure, the first stage is important mainly for two reasons. The first consideration is whether our model has *any explanatory power (R^2)* and the second consideration is whether the *coefficients of our main instrumental variables for each equation are significant or not*. Thus, we refrain from an elaborate discussion of the first stage regression results. In each regression, the main instrumental variable and its coefficients are *colored*. The reasons why each of the instrumental variables is significant in their respective equation are something that we just explained in the above paragraphs. The (R^2) in each first stage analysis is very high because of the presence of the country dummies (53 in total) and year dummies (11 in total). With a few exceptions the coefficients of the country dummies are all significant and this is the reason for a high (R^2). We, however, do not show the country and year dummies to make the results succinct. The following three pages display the first stage regression results of each equation.

Table 3: Environment (Pollution) Equation (1st Stage Regression)

Variable	Coefficient	Standard Error	t-Statistic
Value Added in Industries as a % of GDP (lagged 1 year) ***	0.0411	0.0134	3.06
Democratic Accountability	0.0511	0.0518	0.99
Ethnic Tension***	-0.4071	0.0593	-6.86
External Conflict	0.0250	0.0291	0.86
Internal Conflict***	0.1263	0.0368	3.44
ISD	0.0003	0.0010	0.28
Law & Order	0.0216	0.0677	0.32
Life Expectancy***	-0.1243	0.0227	-5.49
Military in Politics	-0.0522	0.0560	-0.93
Per Capita GDP*	-0.00027	0.00017	-1.63
Square of Per Capita GDP	-5.13e-09	9.48e-09	-0.54
Cube of Per Capita GDP	1.34e-13	1.61e-13	0.83
Religion in Politics	0.0447	0.0685	0.65
Schooling	-0.0033	0.0041	-0.80
Share of Govt. in the Economy	-0.0033	0.0194	-0.17
Socioeconomic Condition	-0.0515	0.0324	-1.59
Stability***	0.0812	0.0305	2.66
Urbanization***	0.0807	0.0235	3.44
Country Dummies	•	•	•
Year Dummies	•	•	•

Note: N = 648, $R^2 = 0.9742$

* **Variables are significant at 10 % level of significance.**
** **Variables are significant at 5 % level of significance.**
*** **Variables are significant at 1 % level of significance.**

Table 4: Corruption Equation (1st Stage Regression)

Variable	Coefficient	Standard Error	t-Statistic
Life Expectancy***	0.0911	0.0181	5.03
Democratic Accountability***	0.2089	0.0308	6.78
Ethnic Tension	0.0223	0.0358	0.62
External Conflict**	0.0401	0.0174	2.30
Internal Conflict	-0.0338	0.0217	-1.55
ISD***	0.0018	0.0007	2.73
Law & Order***	0.1946	0.0399	4.87
Military in Politics***	0.1435	0.0330	4.35
Per Capita GDP**	-0.0002	0.0001	-1.91
Square of Per Capita GDP	4.84e-09	5.90e-09	0.82
Religion in Politics***	0.1161	0.0405	2.87
Schooling**	-0.0057	0.0024	-2.34
Share of Govt. in the Economy**	-0.0260	0.0124	-2.10
Socioeconomic Condition	0.0143	0.0192	0.74
Cube of Per Capita GDP	-5.22e-14	9.95e-14	-0.52
Stability	-0.0203	0.0181	-1.12
Urbanization***	0.0672	0.0144	4.66
Value Added in Industries as a % of GDP (lagged 1 year)***	0.0235	0.0085	2.77
Country Dummies	•	•	•
Year Dummies	•	•	•

Note: N = 648, $R^2 = 0.9068$

* **Variables are significant at 10 % level of significance.**
** **Variables are significant at 5 % level of significance.**
*** **Variables are significant at 1 % level of significance.**

Table 5: Openness Equation (1st Stage Regression)

Variable	Coefficient	Standard Error	t-Statistic
ISD**	0.0002	0.0001	2.14
Democratic Accountability**	-0.0117	0.0053	-2.19
Ethnic Tension***	0.0278	0.0062	4.50
External Conflict**	-0.0058	0.0030	-1.93
Internal Conflict	0.0015	0.0038	0.41
Law & Order	-0.0023	0.0070	-0.33
Life Expectancy*	-0.0052	0.0031	-1.65
Military in Politics	-0.0027	0.0057	-0.48
Per Capita GDP**	0.000043	0.000018	2.37
Square of Per Capita GDP	-1.16e-09	1.02e-09	-1.14
Cube of Per Capita GDP	1.55e-15	1.72e-14	0.09
Religion in Politics	0.0097	0.0070	1.39
Schooling*	-0.0008	0.0004	-1.91
Share of Govt. in the Economy	-0.0027	0.0021	-1.26
Socioeconomic Condition	0.0005	0.0033	0.16
Stability***	0.0091	0.0031	2.92
Urbanization	4.15e-06	0.0025	0.00
Value Added in Industries as a % of GDP (lagged 1 year)	0.0004	0.0015	0.27
Country Dummies	•	•	•
Year Dummies	•	•	•

Note: N = 648, R^2 = 0.9751

* **Variables are significant at 10 % level of significance.**
** **Variables are significant at 5 % level of significance.**
*** **Variables are significant at 1 % level of significance.**

The coefficient of ISD is very small because the regressand (openness) is itself a very small number.

Let us now focus our attention on the second stage results. In the second stage, we do not include all the exogenous variables because some of the exogenous variables do not have apriori theoretical reason to impact the dependent variable. To give this idea an econometric basis, we conduct the overidentifying restrictions tests (Sargan test) for each equation that we shall describe after the description of the second stage results.

Table 6: Environment (Pollution) Equation (2nd Stage Regression)

	Variable	Coefficient	Standard Error	t-Statistic
Endogenous Variables	Corruption*	-0.4562	0.2507	-1.85
	Openness***	-10.8729	2.3471	-4.63
Exogenous Variables	Value Added in Industries as a % of GDP (lagged 1 year)	0.0186	0.0194	0.96
	Internal Conflict**	0.0990	0.0482	2.05
	Law & Order	0.0945	0.1095	0.86
	Per Capita GDP	-0.0004	0.0003	-1.33
	Square of Per Capita GDP	1.22e-08	1.46e-08	0.84
	Cube of Per Capita GDP	-3.15e-13	2.46e-13	-1.28
	Religion in Politics*	0.1815	0.1051	1.73
	Schooling**	-0.0145	0.0066	-2.20
	Share of Govt. in the Economy***	-0.1135	0.0327	-3.47
	Stability***	0.1282	0.0439	2.92
	Urbanization	0.0484	0.0381	1.27
	Country Dummies	.	.	.
	Year Dummies	.	.	.

In the environment (pollution) equation, the coefficient of corruption (inverse measure) is statistically significant at the 10% level. This is what we expected. As corruption goes up, the environmental policymakers are more attracted by bribes and are willing to let social welfare and/or environment become a secondary concern. Therefore, under pressure from polluting lobby groups, the policymakers design lax environmental policies that raise pollution in the country.

Openness of a country brings pollution down. This is because more open economies are characterized by more competitive industries and hence more efficient production techniques. Efficient production techniques reduce the emissions factor, which in turn reduces pollution.

In the environment equation, the coefficient of internal conflict (inverse measure) is statistically significant at the 10% level. It implies that the less is the internal conflict, the less would be the number of strike or disruptive activities in industries in any country. These disruptive activities stop/reduce industrial production. Thus less internal conflict implies more industrial production as a proportion of GDP and hence more pollution. The coefficient of religion in politics (inverse measure) is also significant at the 10% level. Almost all religion, to some extent, attaches some value to environment and therefore if the policymakers are religious, it gets reflected by their concern of environment that in turn reduces pollution.

Schooling negatively impacts pollution. More schooling implies more learned citizens and laborers who, using their technical knowledge can handle industrial production processes efficiently. Thus schooling increases technical skill, which in turn reduces pollution.

The share of government in a country's economy negatively impacts pollution. The larger is the share, the large is the government's control in the economy and stricter is the environmental laws and regulation and this reduces pollution. The coefficient of stability is significant at the 1% level.

More stable government, at times; exploit their stability by taking bribes from corrupt polluting industries. This kind of government does not need to worry about staying in power (since they are stable) and therefore the government officials try to increase their personal gains by taking bribes from lobby groups.

Table 7: Corruption Equation (2nd Stage Regression)

	Variable	Coefficient	Standard Error	t-Statistic
Endogenous Variable	Openness*	7.5688	4.471951	1.69
Exogenous Variables	Democratic Accountability***	0.2793	0.0722	3.87
	Ethnic Tension	-0.1840	0.1423	-1.29
	External Conflict**	0.0907	0.0394	2.30
	Internal Conflict	-0.0432	0.0363	-1.19
	Law & Order***	0.2213	0.0686	3.23
	Life Expectancy***	0.1457	0.0379	3.84
	Military in Politics***	0.1663	0.0566	2.94
	Per Capita GDP*	-0.0004	0.0002	-1.95
	Religion in Politics	0.0305	0.0787	0.39
	Schooling	0.0008	0.0056	0.14
	Share of Govt. in the Economy	-0.0151	0.0239	-0.63
	Socioeconomic Condition	0.0099	0.0324	0.30
	Square of Per Capita GDP*	9.04e-09	5.09e-09	1.78
	Stability*	-0.0915	0.0485	-1.88
	Urbanization***	0.0714463	0.0240153	2.98
	Country Dummies	.	.	.
	Year Dummies	.	.	.

With regard to the corruption equation, ***let us recall that the measure of corruption is inversely related with corruption; therefore a higher value implies less corruption and more honesty.*** The coefficient of openness is positive and statistically significant at the 10% level as predicted. This is due to the fact that more openness implies lesser influence of the domestic lobby groups on any policymaking as the lobby groups have less monopoly power in the domestic economy. Therefore, the possibility of prospective bribes goes down and the policymakers become less corrupt.

The coefficient of democratic accountability is positive and significant at the 1% level. More accountability in ICRG's terms implies "free and fair elections for the legislature and executive as determined by constitution or statute; and the active presence of more than one political party." Because of this fairness and competition in the political system, the policymakers are less corrupt.

The less is the external conflict (inverse measure), the smoother is the functioning of the bureaucratic political system and this reduces corruption in the system. The coefficient of law & order in the corruption equation is positive and significant at the 1% level. This has the obvious reason that stricter law & order forces a politician to be more lawful and hence less corrupt.

In the corruption equation, life expectancy is the instrument and we have already explained how it impacts corruption.

Lesser influence of military in politics (inverse measure) implies the political system is elected more democratically and therefore the chances of the system becoming corrupt get diminished. In fact this variable has some appeal to serve as an alternative instrument for corruption.

The coefficient of per capita GDP and square of per capita GDP are significant and respectively negative and positive in the corruption equation. This implies that income reduces corruption but only at a higher level. The politicians start becoming honest only when their income goes beyond a critical level. This is an interesting result.

The coefficient of stability is negative and significant in the corruption equation. This might have the reason that a more stable government believes firmly that it will be reelected and hence the concern of the political system for public welfare diminishes. This makes the political system more corrupt.

The coefficient of urbanization is positive and significant in the corruption equation. More urban countries are more city-oriented. It could be the fact that city people are more disciplined and honest than their rural counterpart. This is also an interesting finding.

Table 8: Openness Equation (2nd Stage Regression)

	Variable	Coefficient	Standard Error	t-Statistic
Endogenous Variables	Environment***	-0.0752	0.0184	-4.08
	Corruption	0.0079	0.0172	0.46
Exogenous Variables	Democratic Accountability**	-0.0149	0.0070	-2.14
	Internal Conflict***	0.0094	0.0036	2.64
	ISD	0.000027	0.00014	0.19
	Per Capita GDP	8.11e-06	0.000014	0.58
	Square of Per Capita GDP***	-7.45e-10	2.48e-10	-3.01
	Share of Govt. in the Economy***	-0.0085	0.0025	-3.44
	Stability***	0.0142	0.0038	3.79
	Schooling**	-0.0010754	0.0005108	-2.11
	Socioeconomic Condition	-0.0060	0.0040	-1.49
	Country Dummies	•	•	•
	Year Dummies	•	•	•

It is indeed very difficult to explain the openness of a nation. The number of research papers that tried to explain openness is very few. Therefore, there is no well accepted reason as to why a country is more open than others. We, however, try to shed some light on this aspect. In the openness equation, the coefficient of pollution is negative and statistically significant at the 1% level. Pollution policy in a country is representative of a whole bunch of other governmental policy. Therefore, lax pollution policy acts as a negatives signal to foreign exporters and at times, to domestic importers. As such, we do not find any evidence for the contentious pollution haven hypothesis that says a high pollution index might increase activities in the polluting sectors resulting in concentration of polluting industries in countries with lax environmental policy. Thus, in our finding increase in pollution acts as a negative signal to business activities and this reduces openness.

The coefficient of democratic accountability is negative and significant. A reason for this could be the fact that at times countries with a more democratically accountable political system are inward looking (for example, the Scandinavian countries) and therefore, less open.

Internal conflict (inverse measure) in a nation acts as a hindrance to business (because of disruptive activities like strikes, violence) and this affects both imports and exports negatively. Thus, internal conflict reduces openness.

The negative coefficient of square of per capita GDP is indicative of the fact that at a higher level of income, a nation attaches more weight to self reliance and this reduces its dependence on other nations thereby reducing openness.

More government share in an economy implies more government control and less dependence on private enterprises as well as the outer world. This might impact openness negatively.

The coefficient of stability is positive and significant in the openness equation. This indicates that a stable government is more outward looking than an unstable one. Also from a foreign nation’s perspective, doing business with a country that has a stable government is more preferable than another having an unstable government. Thus stability raises openness of a country.

More schooling might teach a nation to be more self reliant and therefore it might reduce the nations openness.

The next table shows the exclusion restrictions for each equation. We did not find any obvious common sense reason for the variables that were excluded in the second stage regression for each of the equations.

Table 9: Exclusion Restrictions

All Exogenous Variables	Environment	Corruption	Openness
Country Dummies	X	X	X
Cube of Per Capita GDP	X		
Democratic Accountability		X	X
Ethnic Tension		X	
External Conflict		X	
Value Added in Industries as a % of GDP (Lagged by 1 year)	**X**		
Internal Conflict	X	X	X
ISD			**X**
Law & Order	X	X	
Life Expectancy		**X**	
Military in Politics		X	
Per Capita GDP	X	X	X
Religion in Politics	X	X	
Schooling	X	X	X
Share of Govt. in the Economy	X	X	X
Socioeconomic Condition		X	X
Square of Per Capita GDP	X	X	X
Stability	X	X	X
Urbanization	X	X	
Year Dummies	X	X	X

Note:

(a) Each column corresponds to one equation (excluding the endogenous variables on the right hand side).
(b) The colored portions under each column indicate that the variables against which the color stands for are not there in the 2nd stage regression.
(c) The X marked variables are present in the second stage regression for each column. The one bigger X under each column indicates the chief identifying instrument for the column variable.

(6.1) Tests for Overidentifying/Exclusion Restrictions

Since we have over identification in our system of equations, we needed conduct a test for overidentifying restrictions for each of the 3 equations of our system. We conduct the Sargan test in this regard. The procedure is as follows. First, we need to generate the estimated errors from the second stage regression of each equation. Then the estimated error terms should be regressed on *all* exogenous variables for each equation. This R^2 from this regression should be noted down. For each equation, the total number of observations multiplied by R^2 from its error equation follows a chi-square distribution with degrees of freedom equal to the number of excluded (exogenous) variables in the second stage regression minus the number of endogenous variables in the second stage regression. The null hypothesis here is that the correlation between the over-identifying instruments and the error is zero. We conduct this test for each of the equations. The results are summarized in the following table.

Table 10: Summary of Sargan Test

Equation	# of Endogenous Variables	# of Excluded Variables	Calculated χ^2	Tabulated χ^2 (25%)
Environment	2	7	4.0824	$\chi^2_{5,0.25} = 6.63$
Corruption	1	3	2.5272	$\chi^2_{2,\ 0..25} = 2.77$
Openness	2	9	4.9896	$\chi^2_{7,\ 0..25} = 9.04$

Comparing the 3rd and the 4th columns of the above table, we can see that the value of the calculated χ^2 is less than the tabulated χ^2 at a convincing 25% level of significance. Thus in each case, we fail to reject the null hypothesis. This implies that the correlation between the over-identifying instruments and the error is zero and overidentifying restrictions are correct in the system as a whole.

(6.2) Interaction Effects

Staying with the same set of regressors and the same system, we derived some interesting interaction effects. We produce the results below. To avoid repetition of showing the results on the same exogenous and endogenous variables that we have already talked about, we are showing only the interaction terms and their effect on the dependent variables. The estimation procedure remains the same.

Table 11: Interaction Effects in Environment Equation (2nd Stage Regression)

Interaction Variable	Coefficient	Standard Error	t-Statistic
(Honesty x Openness)*	-1.5650	0.8866	-1.77
(Openness x Per Capita GDP)***	-0.00025	0.000097	-2.55

The positive effect of openness on environment rises with increasing honesty. This implies, for example, that if two nations are at the same level of openness, the one with more honesty will have lower level of pollution. This result shows the complementarity of openness and honesty in terms of their effect on environment.

Similarly the positive effect of trade on the environment rises with GDP. This is because of the fact that influence of trade on attitudes toward the environment is greater when a country is wealthier and therefore more able to promote environmental quality as an amenity.

Table 12: Interaction Effects in Openness Equation (2nd Stage Regression)

Interaction Variable	Coefficient	Standard Error	t-Statistic
(Honesty x Per Capita GDP)**	5.24e-06	2.65e-06	1.98

The above result shows that if two countries are at the same level of income, the one with more honesty will attract more business from the outer world as a result of being more honest and therefore more reliable and less risky. This again shows that honesty and income are complements in promoting international trade.

7. Conclusion

We found evidence that environmental pollution, corruption and openness of a country are determined endogenously within the economic system and none of them is exogenous. While more corruption increases pollution, more openness reduces it. The joint impact is therefore dependent on the relative strength of openness and corruption. We also found that as a result of more openness, the political system of a typical country becomes more honest. Part of this could be due to the fact that competition from outside the country acts as a self correcting device to the domestic economy. This addresses the gap in the existing literature that ignores the endogeneity of corruption and openness. Thus while designing environmental policies; the policymakers need to consider its direct impact on openness and indirect impact on the level of corruption.

Appendix

Summary Statistics for the WDI Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Ind_VA	648	30.50921	7.79765	8.236878	57.19294
ISD	648	113.8016	135.3484	8.527068	1026.366
Life_Exp	648	70.41545	7.575438	42.3161	80.5015
PCGDP	648	11592.83	8638.152	475.2063	36931.2
S_PCGDP	648	2.09e+08	2.38e+08	225821.1	1.36e+09
C_PCGDP	648	4.41e+12	6.31e+12	1.07e+08	5.04e+13
Schooling	648	77.06722	31.13225	10.9	157.8
Share_Govt	648	14.95806	5.474102	2.975538	28.37399
Urbanization	648	61.31185	22.80536	12.38	100

Where,

Ind_VA = Value Added in Industries as a % of GDP

Life_Exp = Life Expectancy at Birth

PCGDP = Per Capita GDP

S_PCGDP = Square of Per Capita GDP

C_PCGDP = Cube of Per Capita GDP

Share_Govt = Share of Government in the Economy

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