Trade Liberalization, Corruption and Environmental Policy Formation: Theory and Evidence

Richard Damania, Per G. Fredriksson and John A. List

December 2000
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Executive Assistant
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Trade Liberalization, Corruption and Environmental Policy Formation: Theory and Evidence*

Richard Damania, Per G. Fredriksson and John A. List

University of Adelaide

Southern Methodist University

and

University of Arizona

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This study explores the linkages between trade policy, corruption, and environmental policy. We begin by presenting a theoretical model that produces several testable predictions: i) trade liberalization raises the stringency of environmental policy; ii) corruption reduces environmental policy stringency; and iii) the effect of trade liberalization (corruption) on environmental policy is conditional on the level of corruption (trade openness). Using panel data from a mix of 30 developed and developing countries from 1982-1992, these predictions are broadly supported.

JEL Codes: Q28, F18, D78

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Contact author:
Richard Damania
School of Economics
Adelaide University
Adelaide SA 5005
AUSTRALIA
Tel: (+61 8) 8303 4933
Fax: (+61 8) 8223 1460
richard.damania@adelaide.edu.au

Per Fredriksson
Department of Economics, SMU
PO Box 750496
Dallas, TX 75275-0496
USA
Fax: 214 768 1821
pfredrik@mail.smu.edu
I. INTRODUCTION

Recent attempts to launch the “Millennium Round” of trade talks have again thrust the relationship between trade and the environment to the forefront of policy discussions. The recurring debate is by now familiar: “free traders” argue, for example, that trade openness creates an economic surplus that can be used for environmental protection measures (see, e.g., Strutt and Anderson (1999)). Environmentalists fear, amongst other things, that greater economic integration leads to political pressure to reduce the stringency of environmental regulations in order to protect industry and employment.\(^1\) Given the entrenched positions of both sides, further progress in multilateral trade negotiations depends critically on the ability to put this issue to rest. Such progress appears particularly important since empirical evidence suggests that economy-wide growth rates hinge crucially on the openness to trade (see, e.g., Dollar (1992), Edwards (1992), Harrison (1996), Ades and Glaeser (1999)).

In this paper, we focus attention on two major issues that may eventually lead to a resolution of this debate. First, we provide insights into the relationship between trade policy and environmental protection.\(^2\) In particular, we examine if trade liberalization affects the stringency

\(^1\) See, for example, The Economist, October 9, 1999, p.17.

\(^2\) Some anecdotal evidence is available from CEC (1999, p.345), however, which provides evidence from Mexico on the effects of NAFTA on environmental standards. The table shows how emissions limits have changed subsequent to the North American Free Trade Agreement coming into effect. It indicates that the emissions standards have become tighter for the three pollutants reported.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Mexico City</th>
<th>Other Critical Zones</th>
<th>Rest of the Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO(_2)</td>
<td>1.65</td>
<td>3.30</td>
<td>5.16</td>
</tr>
<tr>
<td>NO(_x)</td>
<td>0.23</td>
<td>0.41</td>
<td>0.59</td>
</tr>
<tr>
<td>PM</td>
<td>0.05</td>
<td>0.25</td>
<td>0.39</td>
</tr>
<tr>
<td>SO(_2)</td>
<td>1.13</td>
<td>2.26</td>
<td>4.53</td>
</tr>
<tr>
<td>NO(_x)</td>
<td>0.16</td>
<td>0.16</td>
<td>0.55</td>
</tr>
<tr>
<td>PM</td>
<td>0.04</td>
<td>0.19</td>
<td>0.27</td>
</tr>
</tbody>
</table>

of environmental policies. Our attention focuses on the political economy effects of trade liberalization; for example, whether lobbying incentives on environmental issues shift as a result of trade reform. This focus appears appropriate as political economy pressures have been found to be important determinants of environmental policy in the U.S. (see, e.g., Pashigian (1985), Cropper et al. (1992), Coates (1996), and Helland (1998)). Second, we test whether governmental corruption plays an important role in environmental policy determination (in a related sense, see Mauro (1995) and Ades and Di Tella (1997; 1999)). In many countries, corruption may play an important role in policy determination, a prospect that has heretofore been ignored in the

3 Related theoretical work includes Hillman and Ursprung (1994) who study the relationship between environmental preferences and trade policy in a model of political competition. They show that the resulting trade policy depends on the nature of the externality, and whether the environmentalists’ preferences are defined over the global or only the domestic environment. Leidy and Hoekman (1994) explore the effect of the degree of inefficiency of environmental instruments on trade policy determination, and find that polluting industries prefer inefficient environmental policy instruments because they increase the level of trade barriers. Rauscher (1994) provides a model of an open economy where the polluting export sector is found to have ambiguous lobbying incentives.

Copeland and Taylor (1995) study the strategic interaction between rich and poor countries in the move from autarky to free trade, allowing for income-induced environmental policy responses. Schleich (1999) studies environmental and trade policy selection when both consumption and production involves environmental damages. Fredriksson (1999) finds that in a perfectly competitive sector, trade liberalization reduces (increases) both industry and environmental lobby groups’ incentive to influence environmental policy if the country has a comparative disadvantage (advantage) in the polluting sector. Thus, the final policy effect depends on the relative shifts in political pressures. Bommer and Schulze (1999) show that environmental policy is tightened by trade liberalization if the export sector is relatively pollution-intensive, but will be relaxed if the import competing sector is so. Although this literature is expanding quickly, the interaction between trade, governmental corruption, and environmental policies has yet to be explored.

4 Related empirical inquiries include Fredriksson and Gaston (1999) investigate empirically the “regulatory chill” hypothesis, i.e. whether openness to trade affects the propensity for governments to undertake environmental policy. They find no evidence that more open countries were less prone to cooperate on the global climate change issue. There is also some evidence of the effect of trade liberalization on environmental quality. Dean (1999) finds that in China, increased openness to trade has induced greater environmental damage. This is due to China’s specialization in polluting sectors. However, increased income levels (due to more open trade) have in turn had a negative effect on emissions growth, reducing pollution levels. The present paper is also related to Hettige et al. (1992) and Krueger and Grossman (1993) who find evidence that more open countries tend to have lower pollution levels. They do not discuss policy formation, however. Moreover, neither of the above empirical papers discuss corruption and its effect on environmental regulations.
literature.\textsuperscript{5} While examining these two major issues we also explore whether these two individual effects have a joint influence on environmental policy making.

To provide structure to our analysis, we present a three-stage common agency model that represents an extension to Bernheim and Whinston (1986) and Grossman and Helpman (1994).\textsuperscript{6} Besides providing intuition into the determination of a pollution tax in a tariff-protected sector within a framework incorporating political corruption, the model yields three clear propositions. First, trade liberalization unambiguously leads to an increase in the pollution tax. Trade liberalization perturbs the determination of the equilibrium environmental policy, and the net effect is unambiguously positive for the pollution tax. Second, a reduction of corruption unambiguously leads to an increase in the pollution tax. Less corruption implies a greater weight on social welfare and thus the pollution tax will deviate less from the Piguovian tax. Third, the effect of trade liberalization (corruption) on the pollution tax is conditional on the level of corruption (openness to trade). Whether the effect of trade liberalization (corruption) is greater or smaller in more corrupt (closed) economies depends on whether trade openness and bribery are substitutes or complements in the creation of distortions in environmental policy. Our model, however, does not enable us to predict the exact nature and magnitude of this interaction. Therefore, empirical work becomes crucial in determining how exactly trade openness and corruption interact in their impacts on the level of environmental policy stringency.

\textsuperscript{5} An exception is López and Mitra (2000), who investigate (theoretically) the effect of corruption and rent-seeking on the relationship between income and pollution levels. They do not explicitly study trade and environmental policies, however.

\textsuperscript{6} Aiddt (1998), Schleich (1999), and Eliste and Fredriksson (2000) and have previously adopted this model to environmental policy formation in sectors with perfect competition. Following Schulze and Ursprung (2000), we take the view that the model by Grossman and Helpman (1994) closely characterizes a form of high level corruption. Building on the same model, Coate and Morris (1999) also refer to the political contribution offered by a lobbying firm as a “bribe”.

8
We test our theoretical predictions using panel data from a mix of 30 developing and developed countries. Our empirical estimates support the main predictions emerging from our theoretical model. First, the empirical evidence suggests that countries with more open trade policies tend to have stricter environmental regulations. This result is robust to several alternative measures of trade policies and environmental regulations. Second, the level of governmental corruption affects environmental standards. We find that lower corruption levels are associated with stricter environmental regulations. Finally, we find important interaction effects between trade liberalization and corruption—as corruption increases, the impact of openness to trade on environmental regulations rises. Thus, governmental corruption amplifies the effect of trade policies on environmental regulations. Alternatively, distorted trade policies increase the effect of corruption: a fall in corruption has a greater effect on environmental policy in relatively closed economies. It appears that corruption and protection are complements in the creation of lax environmental policies.

The remainder of the paper is organized as follows. Section II outlines the structure of the output market and summarizes certain properties of the equilibrium. Section III presents the predictions of the model. Section IV specifies the empirical model and discusses the data. Section V presents the empirical results, while Section VI concludes. All proofs are relegated to the appendix.

**II. THE OUTPUT MARKET**

Our main aim is to explain environmental policy formation in mature polluting industries, and therefore we consider a domestic duopoly that produces an importable good and faces a
perfectly competitive world market. Typically, such industries face intense competition on the world market, which makes entry into the domestic industry unattractive. Thus, such industries are typically characterized by imperfect competition when protected by tariffs or quotas. We assume that a domestic oligopoly faces perfect competition on the world market and the domestic and foreign goods are imperfect substitutes. The duopoly may be sustainable even with free trade due to the role of product, industry, political, and “home bias” factors (see Blonigen and Wilson (1999)). The domestic price remains strongly influenced by the tariff level, however. We assume that the tariff is determined by multilateral trade negotiations on which this small country has a negligible impact; therefore it appears reasonable that the domestic oligopoly and the government take the tariff level as exogenous.

The domestic good price is given by \( p \), and the world market price by \( p^* \). The domestic market is protected by a tariff \( \tau \in T \), which implies that the foreign substitute is sold on the domestic market at a price \( P = (1 + \tau)p^* \). We assume that demand for the domestic and foreign goods is given by \( Q = Q(p, P) \) and \( Q^* = Q^*(P, p) \), respectively, where \( \partial Q / \partial p < 0, \partial^2 Q / \partial p^2 > 0, \partial Q / \partial P > 0 \), and \( \partial^2 Q / \partial p \partial P > 0 \). The inverse demand functions are given by \( p = p(Q, P) \) and \( P = P(Q^*, p) \), where \( \partial p / \partial P > 0, \partial P / \partial Q < 0 \), and \( \partial^2 p / \partial P \partial Q > 0 \). We further assume that the own price effect on demand exceeds the cross price effect, i.e. \( |\partial Q / \partial p| > |\partial Q / \partial P| \).

Domestic production of \( Q \) is associated with local pollution \( E \), where \( E = \theta Q \) and \( \theta > 0 \). Polluters have one single abatement technology available. Without loss of generality, production

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7 The results can readily be generalized to the case of an oligopoly.
8 Blonigen and Wilson (1999) find, for example, that a greater quality difference between home and foreign goods (as measured by the ratio of industry imports from developing countries) gives a lower cross-price elasticity (Armington elasticity) between home and foreign goods.
is assumed to be costless except for expenditures associated with pollution control. Following Conrad (1993), we let \( a \) equal the degree of end-of-pipe abatement per unit of pollution, and \( v(a) \) represents the cost of abating one unit of pollution, where \( \partial v(a) / \partial a > 0 \) and \( \partial^2 v(a) / \partial a^2 > 0 \). This implies that the total abatement costs are \( v(a)a \theta Q \). Unabated pollution is taxed at a rate \( t \), thus total production costs are given by

\[
TC = [(1-a)t + v(a)a] \theta Q. \tag{1}
\]

The profits of the domestic firm \( i=1,2 \) are defined as

\[
\pi_i = \left[p(Q,P) - [(1-a_i)t + v(a_i)a_i] \theta \right] q_i - S_i(t), \tag{2}
\]

where \( S_i(t) \) is the bribe given by the firm to the incumbent government which is contingent on the tax policy implemented by the government, \( q_i \) denotes output of firm \( i \), and \( Q = q_i + q_j \). The Cournot-Nash equilibrium is given by \( q_i^* \in \arg \max \pi_i \). The first-order condition of (2) is

\[
\frac{\partial \pi_i}{\partial q_i} = p + p'q_i - [(1-a_i)t - v(a_i)a_i] \theta = 0. \tag{3}
\]

Let \( q_i^* = q_j^* = q^* \) be the solution to (3). Having determined output levels, the two firms chose abatement levels to minimize total costs, i.e. each firm solves the following problem:

\[
\text{Min } TC_i = [(1-a_i)t + v(a_i)a] \theta q_i. \tag{1'}
\]

We find the intuitive result that abatement per unit of pollution is unambiguously increasing in the pollution tax, i.e. \( da_i / dt > 0 \). To see this, the first-order condition corresponding to (1') is

\[
\frac{\partial TC_i}{\partial a_i} = a_i \frac{\partial v(a_i)}{\partial a_i} + v(a_i) - t = 0. \tag{4}
\]
Total differentiation and rearranging (4) yields \( \frac{da_i}{dt} = \frac{1}{(\partial^2 TC_i / \partial a_i^2)} > 0 \), since for a cost minimum we require \( \partial^2 TC_i / \partial a_i^2 > 0 \). This result reflects the fact that higher emission taxes raise the cost of pollution and thus induce firms to abate more emissions per unit of output. Total differentiation of (3) yields \( \frac{dq_i}{dt} = (1 - a_i) / (\partial^2 \pi_i / \partial q_i^2) < 0 \), i.e. the output level of firm \( i \) is decreasing in the pollution tax since \( 1 > a \) and \( \partial^2 \pi_i / \partial q_i^2 < 0 \). Again, this occurs because the tax raises marginal costs and thus results in a decline in output levels.

It is instructive to consider the effect of trade liberalization on output levels. First, total differentiation of (3) yields

\[
\frac{dq_i}{dP} = -\frac{\partial^2 \pi}{\partial q_i^2}, \tag{5}
\]

where the denominator is negative. To sign the numerator, we note that by Young’s Theorem, \( \partial^2 \pi / (\partial q_i \partial P) = \partial^2 \pi / (\partial P \partial q_i) \). Differentiating (2) using (3) yields

\[
\frac{\partial \pi}{\partial P} = \frac{\partial P}{\partial P} q_i. \tag{6}
\]

Further differentiation of (6) yields

\[
\frac{\partial^2 \pi}{\partial P \partial q_i} = \frac{\partial P}{\partial P} + \frac{\partial^2 P}{\partial P \partial q_i} q_i, \tag{7}
\]

which is unambiguously positive\(^9\). Substituting (7) back into (5) implies that trade liberalization reduces the output of firm \( i \).

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\(^9\) This is because it assumed that \( \partial P / \partial P > 0 \) and \( \partial^2 P / \partial P \partial q_i > 0 \).
Consumers derive utility from consumption of the domestic and foreign goods. In addition, consumers suffer damage from pollution. Pollution damage is a convex function of the amount of unabated local pollution, \( D(E(1 - a)) \).

The Political Equilibrium

This section examines how bribery by firms affects the political equilibrium pollution tax. We assume the two firms are able to form a lobby group that offers the government a prospective bribe. The firms’ owners are a negligible fraction of the population. Hence, its members receive a negligible part of any tax and tariff revenues, and the lobby group’s welfare is entirely given by the aggregate profits of the two firms.

The timing of the game is as follows. In the first period, an industry lobby group offers the government a bribe schedule, \( S(t) \), contingent on the environmental policy stance of the government. In the subsequent period the government determines its environmental policy, and collects the associated bribe. Finally, firms set output and pollution abatement levels taking the tariff and environmental policy as given. We solve the model by backward induction.

The government is assumed to maximize a weighted sum of the received bribe and aggregate gross-of-contributions social welfare, such that

\[
G(t) = S(t) + \alpha W(t),
\]

where \( \alpha > 0 \) is the weight given to aggregate social welfare relative to bribes. In our view, \( \alpha \) represents the government’s willingness to set policies that deviate from the welfare maximizing level in return for bribes, and therefore is a useful measure of the level of corruption. This interpretation is similar to Schulze and Ursprung (2000), who argue that bribes are given in order to influence government policy, not the election outcome. The level of corruption in the model is reflected by the government’s willingness to allow lobby groups to influence the process of...
environmental policy formation, e.g., the propensity to sell policies for personal gains in the form of monetary transfers. This view of corruption is consonant with that of Bardhan (1997), who defines corruption as “the use of public office for private gain” (p. 1321), and to Shleifer and Vishny (1993, p. 599) who argue that corruption is “the sale by government officials of government property for personal gain”. Our formulation also closely follows the government’s objective function in López and Mitra (2000).

Social welfare gross-of-contributions is given by the sum of profits, consumer surplus from consumption of both substitutes, tariff and pollution tax revenues, minus the damage from pollution,

\[ W(t) \equiv \int_0^Q p(Q, P)dQ - v(a)Q + \int_0^Q P(\tau, \bar{P})d\bar{Q} - (P - \bar{P})Q - D(E(1-a)). \]  

(9)

We define the welfare maximizing pollution tax as

\[ t^* \in \text{Argmax } W(t). \]  

(10)

Since Bernheim and Whinston (1986) and Grossman and Helpman (1994) discuss the necessary conditions for a Nash equilibrium in detail, we do not restate these conditions. Goldberg and Maggi (1999) argue that the equilibrium in this model is simply the equilibrium emerging from a Nash bargaining game and thus maximizes the joint surplus of all parties. Therefore, the political equilibrium pollution tax supported by the bribe schedule satisfies

\[ \frac{\partial G(t)}{\partial t} = \frac{\partial \pi(Q)}{\partial t} + \alpha \frac{\partial W(t^*)}{\partial t} = 0. \]  

(11)
In equilibrium, the government trades-off firm profits and social welfare (where profits are again included) at the rate of $\alpha$. Note that since $\partial \pi(Q)/\partial t < 0$, the equilibrium pollution tax must be below the welfare maximizing rate because (11) will be satisfied only if $\partial W(t^*)/\partial t > 0$.

**III. PREDICTIONS**

In this section we explore the effects of trade liberalization and corruption on the politically determined pollution taxes. We also study how the relationship between trade regimes (corruption) and environmental policy is influenced by corruption (trade openness). We find several results that form the basis of our empirical work in the next sections. All proofs are presented in the appendix.

**Prediction 1:** *In equilibrium, trade liberalization results in an increase in the pollution tax.*

The intuition for the result is as follows. First, note that with an exogenous tariff, the pollution tax must correct both the trade and the environmental distortion, i.e. it is second-best even disregarding corruption. This need declines as the tariff is lowered. Moreover, trade liberalization has a number of conflicting effects on the welfare of all population groups. (i) Since the domestic and foreign good are substitutes, a reduction of the tariff lowers the price of the domestic good and reduces the profitability of domestic production. Welfare falls due to this effect. In political equilibrium, the bribe offer mirrors the profitability of a given policy (see Grossman and Helpman’s (1994) discussion of “local truthfulness”). Thus, as profits decline as a result of trade liberalization, the size of the bribe falls because less is at stake, and as a consequence the equilibrium tax rises. (ii) Welfare rises as consumer surplus increases. (iii) Welfare also rises as the local pollution level declines. With a lower output level following trade
liberalization, the effect of the pollution tax on profits, consumer surplus, and pollution levels therefore declines. (iv) Trade liberalization has an ambiguous effect on tariff revenues since this depends on the import demand elasticity.

It follows that trade liberalization perturbs the government’s trade-off between social welfare and the bribe. In sum, trade liberalization influences the political determination of the pollution tax in several separate ways, and the model predicts that net effect is a rise in the pollution tax.

*Corruption and Openness*

Next, we investigate how the level of corruption influences environmental policy. We find the following result.

**Prediction 2:** *In equilibrium, corruption reduces the pollution tax.*

In this model, a reduction of corruption implies a lower relative weight on bribes, and thus on firm profits. Thus, the pollution tax consequently increases, approaching the welfare-maximizing rate. In Eqn. (8), when $\alpha \to \infty$, the bribe becomes relatively less important, and the distortion of environmental policy declines.

Finally, we explore the interaction between trade policy and corruption and their joint effects on environmental policy.

**Prediction 3:** *The effect of trade liberalization (corruption) on the pollution tax is conditional on the level of corruption (openness to trade).*

The environmental policy distortion created by protectionism (corruption) will depend on the level of distortion created by corruption (trade protection), i.e. whether protection and corruption are *substitutes or complements* in the creation of distortions in environmental policy. If they are complements, an increase in protection (corruption) will cause corruption (protection) to distort
environmental policy more severely. In other words, if they are complements trade liberalization (reduced corruption) increases the stringency of environmental policy by more in the most corrupt (closed) economies. The opposite is the case if they are substitutes. In sum, we have identified an interaction between trade policy and corruption.

IV. EMPIRICAL MODEL AND DATA

To test the main assertions of the theory, our empirical analysis proceeds by examining environmental stringency levels within and between countries. When significant discrepancies exist, we analyze whether openness of the economy or corruption levels might be responsible for the differences. Amongst other things, in the empirical analysis our goal is to provide insights into policy-based questions that remain largely unresolved: First, does trade liberalization affect the stringency of environmental regulations? Second, does the level of corruption influence the stringency of environmental regulations? Third, are there interaction effects between trade liberalization and corruption that affect environmental standards?

Using country level data from 1982-1992, we implement the random effects regression model due to Balestra and Nerlove (1966):

$$\text{Env}_{it} = \beta X + \omega_{it}$$

(12)

where $\text{Env}_{it}$ represents the environmental stringency measure for country $i$ time period $t$; $\omega_{it} = u_t + \alpha_i + e_{it}$; $E[\alpha_i] = 0$, $E[u_t] = 0$, $E[\alpha_i^2] = \sigma_\alpha^2$, $E[u_t^2] = \sigma_u^2$, $E[\alpha_i\alpha_j] = 0$ for $i \neq j$, $E[u_t\alpha_i] = 0$ for $t \neq z$, and $u_t$, $\alpha_i$, $e_{it}$, are orthogonal for all $i$ and $t$. By construction, the individual random effects $\alpha_i$ capture important heterogeneity across countries that would be left uncontrolled in a standard cross-sectional model. In addition, the time effects $u_t$ capture any factors that are dynamic but affect the level of environmental stringency, such as global preference changes due to education and technology.
A few features of (12) warrant further discussion. First, finding a dynamic measure of environmental stringency to test our hypotheses is a difficult task. We restricted our search over environmental measures that have both within-country and between-country variation so we could control for important unobservable factors that may influence the level of stringency. Our choices were severely limited, as most environmental regulatory indices at the country level are cross-sectional estimates based on one year of data. In the end, we chose to use two measures, one based on the consumption of goods, the other based on the production of goods. Our consumptive proxy for the level of environmental stringency is grams of lead content per gallon of gasoline. For our purposes, such data are available annually from 1982-1992 for the 30 countries. Given that lead emissions are precursors to harmful local air pollutants, a country with relatively strict environmental policy allows lower lead content per gallon of gasoline. For example, in 1982 Germany had a lead content measure of 0.52 grams per gallon of gasoline, whereas Chile had a lead content of 3.12 grams per gallon of gasoline. During our sample period, the average country had approximately 1.77 grams of lead per gallon of gasoline. Lead content in gasoline has been used by previous authors to measure regulatory stringency for other purposes (e.g, Hilton and Levinson (1998) and Deacon (1999)), and to our knowledge represents the most viable dynamic consumptive proxy for environmental stringency at the country level. For a nice description of the lead data, which comes from Octel’s *Worldwide Gasoline Survey*, see Hilton and Levinson (1998).

Our production-based proxy for the level of environmental stringency is derived from an index originally developed by Dasgupta *et al.* (1995) for 31 countries for the agricultural, industry, energy, and urban sectors. Eliste and Fredriksson (2000) extended the index to include 62 countries. The index is based on country reports for the 1992 United Nations Conference on Environment and Development in Rio (UNCED (1992)) on existing environmental regulations.
Each country report is based on survey questions and was prepared under well-defined UNCED guidelines, making a cross-country comparison possible (see Dasgupta et al. (1995)). The reports provide specific information about the state of the environmental regulatory framework, focusing on existing environmental policies, legislation, control mechanisms, and enforcement. Using the information gathered, Dasgupta et al. (1995) developed the index by assigning the answers on each of 25 questions (with 4 parts per question) a score from 0 to 2. The questions varied considerably, ranging from issues of water pollution to biodiversity. The scores were summed to yield an index with a maximum tally of 200. Countries with relatively strict environmental policies have higher scores than those with lax policies. For example, in 1990 Germany had an index score of 182, while Chile had a score of 92.

Given that the Dasgupta et al. index is only for one year (1990), we use forecasting techniques to construct a panel data set for our 30 countries. To proceed, we model the environmental index accordingly:

\[ DAS_i = \beta^* Z + \omega_i \]  

(13)

where DAS\(_i\) is the Dasgupta et al. index for 1990, Z includes conditioning observables that influence a country’s environmental regulatory stringency and, in addition to our theory, mainly follow Henderson (1996) and Eliste and Fredriksson (2000)—for example, variables in Z include measures of governmental corruption levels, real GDP, real GDP squared, percent of population living in urban areas, percent of labor force in industry, and overall population. We then pair the estimated \( \beta \) from (13) with appropriate regressors for 1982-1992 to predict levels of environmental stringency. This provides us with an environmental index that is panel in nature.

A second feature of (12) that warrants further discussion is that the data used to estimate (12) do not form a balanced panel. We therefore use unbalanced panel data estimation techniques.
In particular, the diagonal blocks in the covariance matrix are of different sizes, which induces groupwise heteroscedasticity. Our estimation procedure adjusts for this problem, as we present feasible GLS estimates. Third, we include an overall constant in \( X \), but the restriction \( \alpha_i = u_i \) avoids violation of the rank condition. Fourth, we model \( \alpha_i \) and \( u_i \) as random country and time effects, which treats unmeasured characteristics as error components, economizes on degrees of freedom, and yields coefficients that are not conditioned on unmeasured effects.

Fifth, regressors included in \( X \) represent dynamic and static factors that are posited to influence the level of stringency of environmental standards. The first regressor of primary interest to the basic hypotheses is a trade openness measure. Given that openness of an economy is difficult to quantify, we follow Reppelin-Hill (1999) and examine several alternative measures. Our first openness measure is the basic measure of trade openness reported in standard international statistics, the share of exports and imports in GDP (Trade). These data are available in the Penn World Table (PWT) version 5.6 or the World Bank’s “World Development Indicators.” The second measure of openness is the value of taxes on international trade and transactions as a percent of total trade values (Taxes). These taxes cover items such as import and export duties, foreign exchange taxes, and profits on import or export monopolies. The final two measures are duties on imports (Import Duties) and exports (Export Duties). These regressors represent the value of import (export) duties as a percentage of total import (export) value. The final three measures are from the IMF’s “Government Finance Statistics.”

The second issue of particular interest is the effect of corruption, or alternatively, honesty in government. Our measure of governmental honesty is the index constructed by the International Country Risk Guide (Govt. Honesty). The governmental honesty variable is a corruption measure that represents an indication of the likelihood that “high government officials are likely to demand
special payments”. In addition, the data are meant to capture whether “illegal payments are generally expected throughout lower levels of government” in the form of “bribes connected with import and export licenses, exchange controls, tax assessment, policy protection, or loans” (Knack and Keefer (1995), p.225). The index is directly related to governmental honesty and ranges from 0 to 6, with 0 being the least honest and 6 being the most honest. In this index, countries such as Egypt and Ghana have Govt. Honesty values of 1 in 1982, whereas Austria and Australia have honesty values of 6.

The final result that emerges from our theory is the prediction that the effect of trade openness (corruption) is conditional on the degree of corruption (openness). We include an interaction term in the vector $X$ to test for these interaction effects, Govt. Honesty*Openness.

We also include a vector of control variables in $X$ to reduce the unexplained variation in the regressand. Given that some studies find a nonlinear relationship between a measure of output (or incomes) and environmental quality (see, e.g., Hilton and Levinson (1998)), we include real GDP per capita and higher order GDP per capita per capita terms in $X$ ($GDP; GDP^2; GDP^3$). Other regressors in $X$ include a dichotomous variable that indicates whether the country is developed or undeveloped (Developed); where Developed = 1 if the country is a developed nation, 0 otherwise.\footnote{Countries included in the developing country group are Argentina, Brazil, Chile, China, Colombia, Egypt, India, Jamaica, Korea, Mexico, Philippines, Uruguay, and Venezuela. Developed countries include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, and Sweden.} This regressor provides a control for the overall level difference in environmental policies across developed and developing countries. We control for the proportion of the population exposed to industrial pollution (marginal damage) by including urban population as a percentage of total population ($%Urban$). And, finally, to measure industry lobby group
presence and incentives, the percentage of labor force in industry is included (%LFI) (see Olson (1965)). Both the urban population variable and the labor force variable are from the World Bank’s World Development Report. Table 1 provides the summary statistics.

V. EMPIRICAL RESULTS

Empirical results from estimation of (12) are presented in Table 2. We should first note that a computed correlation coefficient of –0.78 between our two environmental stringency variables suggests that the two measures are quite consistent with one another. Coupling this result with the fact that inference from the empirical estimates are qualitatively similar across the two regressand types, we report only results using the lead measure to conserve space. Results using the computed environmental index are available upon request.

Columns 1-4 of Table 2 contain estimates from the regression model based on which openness measure was included. For example, column 1 estimates are for the model that uses Trade as the openness regressor. When considering our results, it is important to note that likelihood-ratio tests suggest that all model types are significant at the $p < .05$ level. This finding implies that our error-components model explains a significant portion of the variation in the regressand. In addition, LM statistics indicate that in all models, the null hypothesis of homogeneity of unmeasured country- and time-specific effects is rejected at the $p < .05$ level, except for the Export Duties specification, where the homogeneity null is rejected at only the $p < .12$ level. Finally, it may be the case that our regressand is jointly determined with the regressors. Our GLS estimates may appear to be particularly subject to simultaneity, because in this case the error term includes the country and time specific effects. As a robustness test, we also regressed
values of the environmental stringency measure on lagged values of the regressors. This exercise yielded results generally similar to estimates from contemporaneous specifications.\textsuperscript{12} We therefore present estimates from the contemporaneous model.

Broadly speaking, the empirical results in Table 2 provide coefficient estimates that support the theory.\textsuperscript{13} In the \textit{Trade} model, we see that increases in the share of exports and imports as a proportion of GDP is associated with decreases in gasoline lead content, signaling an increase in environmental protection. This finding implies that a more open economy will tend to have more stringent environmental standards. In the other three models, positive coefficient estimates imply that increases in \textit{Taxes}, \textit{Import Duties}, and \textit{Export Duties} are associated with increases in the level of allowable lead content per gallon of gasoline. This finding suggests again that as an economy becomes more open, it tends to have more stringent environmental standards.\textsuperscript{14}

To get a sense of the economic significance of the openness coefficient estimates, consider the parameter estimate in the \textit{Import Duties} specification measured at the sample means: $-\frac{\partial \text{Lead}}{\partial \text{Import Duties}} = 2.75 = 4.70 - 0.76(2.57)$.\textsuperscript{15} This estimate suggests that as the value of import duties as a percentage of total import value increases by one standard deviation

\textsuperscript{11} We should note however that for the latter three model types we did not find a positive estimated component for the variance of $u_t$. Nonetheless, in the first model type inclusion of time effects does not significantly alter the findings so we are comfortable presenting the one-way random effects estimates.

\textsuperscript{12} These results are available from the authors upon request.

\textsuperscript{13} Considering that Govt. Honesty and some of our openness measures are correlated to a degree, we also experimented with regression models that included each of the important variables (Govt. Honesty and trade openness) separately. Our results are robust to these changes in specification, with the most obvious change occurring in the \textit{Export Duties} model, where the coefficient of the openness measure became positive and statistically significant.

\textsuperscript{14} Hilton and Levinson (1998) point out that that in some countries the average lead content increased as income rose because consumers substituted to higher octane gasoline, with more lead, as their incomes expanded. This would suggest that as an economy opens, and incomes increase, lead content also increases. This effect would tend to preclude the data from matching theoretical predictions.

\textsuperscript{15} In this case the total effect of import duties on the regressand is the summation of its direct effect, 4.70, and its interaction effect, $-0.76 \times (\text{Govt. Honesty})$. Thus, the total effect depends on the level of Govt. Honesty. We use variable means when interpreting interaction terms.
(about 0.10), the level of allowable lead content per gallon of gasoline increases by 0.275 grams. In 1982, this change in allowable lead content in gasoline would have represented a movement from Belgian standards to Bangladeshi standards.

Concerning the effects of governmental honesty on environmental regulations, we find that a higher level of honesty tends to be associated with lower levels of allowable lead content per gallon of gasoline. Given that the Govt. Honesty index is inversely related to corruption levels at the country-level, this result suggests that more corrupt countries tend to have less stringent pollution control policies. The magnitude of the effects are relatively stable across model type—for example, a one unit increase in the government honesty index in the Taxes specification leads to a 0.18 (–0.09 – 2.31(0.04)) gram increase in the lead content of gasoline. In practice, government honesty has a standard deviation of 1.57, hence a one unit increase in the corruption index represents a little more than one-half of one standard deviation.

We also find that, consistent with our theory, there are important interaction effects between corruption and openness. The interaction term Govt. Honesty*Openness is marginally significant in the Trade specification and significant at the p < .01 level in the Taxes and Import Duties models. The inference from the interaction term is as follows. In the Import Duties model, the coefficient of Govt. Honesty*Openness is negative, implying the effect of Export Duties on lead content in gasoline decreases as the value of the government honesty index increases (i.e. corruption falls). Or, likewise, as a country becomes more corrupt, the impact of trade policies on environmental regulations increases. In this sense, governmental corruption tends to amplify the effect of trade policies on environmental regulations. As can be seen from the parameter estimates in the other three models, inference is similar across all specifications.
The interaction coefficient estimates also provide a sense of the effects of governmental corruption levels under different trade regimes. Consider again estimates from the Import Duties regression model. A negative coefficient of Govt. Honesty*Openness suggests that changes in corruption levels have a greater absolute effect on environmental policy in relatively closed economies. 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. This result suggests that corruption and protection are complements in the creation of environmental policy distortions (i.e. weak environmental policy).

Other empirical estimates in Table 2 provide a few robust results across the four specifications. For example, in each model the individual coefficients of all three GDP per capita terms are significant at conventional levels. The estimates suggest that lead content and real GDP per capita have a similar relationship to that found in other studies (see, e.g. Hilton and Levinson (1998)). In our case, the results suggest that as incomes rise, levels of lead in gasoline follow a sideways S-shape with the peak occurring in-sample, and with many countries in our sample currently on the inverted-U portion of the estimated curve. Another consistent set of coefficient estimates is that conditional on per capita income levels and the other regressors, developed nations have approximately 1 more gram of lead per gallon of gasoline than developing nations. This effect is consistently significant at the $p < .05$ level and suggests that although richer nations appear to be more environmentally aware than poorer nations, conditionally they are being outperformed by the developing nation group.\footnote{This may be due to political pressures from car and truck owners in developed countries, where reliance on these vehicles for personal and goods transportation may be greater than in developing countries (of course, motor scooters are important sources of transport and pollution in many developing countries, however). Alternatively, it may show that developed nations are transferring their technology and education to developing countries, inducing a “greener” growth than their predecessors’ growth (see Wheeler and Martin (1992) and Reppelin-Hill (1999)).}
Industry lobby group presence also has an intuitive effect on environmental standards. In the Trade and Import Duties regressions, \( \%LFI \) is positive and significant at the \( p < .01 \) level. The estimates suggest that higher lead concentrations in gasoline are associated with countries that have a larger percentage of their labor force in industry. Our measure of population exposed to pollution levels (\( \%\text{Urban} \)) generally performs sporadically. Although it gains significance in three of four models, it is positive and statistically significant in the Trade and Export Duties models, whereas it is negative and significant in the Import Duties model.

**VI. CONCLUSIONS**

Academic research in the area of trade and the environment may eventually lead to generalizations that convert theory and empirical evidence into optimal policy making, but such a conversion requires that we understand the myriad of complex relationships that exist in an open economy. In this paper, we take a first step in this direction by focusing on the interactions between trade liberalization, corruption, and environmental policy determination. We begin by developing a political economy model of the endogenous determination of environmental policy. Several testable propositions emerge. We find that both lower trade barriers and less corruption is associated with an increase in the stringency of environmental policy. We also find that the effect of trade policy changes (corruption) is conditional on the level of corruption (trade openness). The exact nature of this interaction depends on whether protectionism and corruption are complements or substitutes in the creation of environmental policy distortions.

We take our predictions to task by examining panel data from a broad mix of 30 developed and developing countries. We generally find broad support of the model’s predictions. First, countries with more open trade regimes tend to have stricter environmental regulations, and this result is robust to several alternative measures of trade openness and environmental stringency.
Second, corruption weaken the stringency of environmental policies. In addition, the effect of trade liberalization (corruption) on environmental regulations is found to be conditional on the level of corruption (trade openness): changes in trade policies have a greater impact in countries with more corrupt governments, ceteris paribus. Moreover, a reduction in corruption has a greater effect on environmental policy in relatively closed economies. In essence, distorted trade policies (corruption) increase the effect of a reduction of corruption (trade liberalization) on environmental standards. Thus, protectionism and corruption are complements in the creation of environmental policy distortions.

Several policy implications emerge. First, trade liberalization reduces the distortions in environmental policy making by inducing an increase in their stringency. We therefore believe there is little ground for arguing that multilateral trade negotiations should be delayed due to concerns about the impact on environmental regulations. In addition, we doubt that concerns about the effects of trade liberalization on the environmental policy stringency in countries with relatively stringent regulations are well founded. Second, efforts to reduce corruption will benefit efficient environmental policy-making. Finally, improvements in environmental protection (due to trade liberalization) appear particularly pronounced in countries where regulations are the most distorted; i.e. in the most corrupt countries. Therefore, we believe that the positive effects on environmental policies from fighting corruption are largest amongst heavily protected countries.
REFERENCES


**APPENDIX**

*Proof of Prediction 1:* Total differentiation of (11) yields

\[
\frac{dt}{d\tau} = \frac{\partial^2 G}{\partial t \partial \tau} / \frac{\partial^2 G}{\partial t^2},
\]  
(A1)

where the denominator is required to be negative for (11) to be a unique maximum. Using Shephards Lemma, expression (11) yields

\[
\frac{\partial G(t)}{\partial t} = -(1-a)\theta Q + \alpha \frac{\partial W(t^*)}{\partial t} = 0.
\]  
(A11')

To find the sign of expression (A1), further differentiate Eqn. (A11’) which yields

\[
\frac{\partial^2 G}{\partial \tau \partial t} = -(1+a)\theta \frac{\partial Q}{\partial \tau} + \alpha \frac{\partial^2 W(t^*)}{\partial \tau \partial t},
\]  
(A2)

where the first term is negative since it has been shown that \( \partial Q / \partial P > 0 \). To sign the second term of (A2), consider the welfare function. Let \( t^w \) and \( \tau^w \) be the welfare maximizing levels of the pollution tax and the tariff and define the corresponding maximal level of welfare as \( W(t^w, \tau^w) \). Let \( t^l < t^w \) be the tax with lobbying and let \( \tau^l > \tau^w \) be a tariff level which exceeds the welfare maximizing level. Welfare with this policy stance is defined as \( W(t^l, \tau^l) \). We assume that \( W(t, \tau) \) is strictly concave in both \( t \) and \( \tau \). Moreover in the region under consideration it is supposed that \( \partial W / \partial t > 0 \) and \( \partial W / \partial \tau < 0 \), and that \( W(t^w, \tau^w) > W(t^l, \tau^l) > 0 \). Given these assumptions we have the following inequality:

\[
W(t^w, \tau^w) > \begin{cases} W(t^l, \tau^w) > W(t^l, \tau^l), \end{cases}
\]  
(A3)

which implies (by adding a negative sign on the LHS)

\[
- W(t^l, \tau^l) - W(t^w, \tau^w) < W(t^w, \tau^l) - W(t^l, \tau^l).
\]  
(A4)

Rearranging further yields
Now since \( t^L < t^W \), inequality (A5) implies that
\[
\frac{\partial}{\partial t} \left( W(t, \tau^L) - W(t, \tau^w) \right) < 0,
\]
which holds if
\[
\frac{\partial}{\partial t} \left( W(t, \tau^L) \right) < \frac{\partial}{\partial t} \left( W(t, \tau^w) \right).
\]
Since \( \tau^L > \tau^w \), this implies that (by Young’s Theorem) \( \partial^2 W/\partial t \partial \tau = \partial^2 W/\partial \tau \partial t < 0 \), and thus (A1) and (13) are unambiguously negative.

**Proof of Prediction 2**: Total differentiation of Eqn. (A11’) yields
\[
\frac{dt}{d\alpha} = -\frac{\partial W(t^*)/\partial t}{\partial^2 G/\partial t^2}.
\]
By assumption of a maximum \( \partial^2 G/\partial t^2 < 0 \) is required, and from Eqn. (11), \( \partial W(t^*)/\partial t > 0 \).
Hence, \( dt/d\alpha > 0 \).

**Proof of Prediction 3**: Taking the derivative of (A8) with respect to the tariff yields
\[
\frac{d^2 t}{d\alpha d\tau} = \frac{(\partial^2 W/\partial t \partial \tau)(\partial^2 G/\partial \tau^2) - (\partial W/\partial t)(\partial^3 G/\partial t^2 \partial \tau))}{(\partial^2 G/\partial t^2)^2},
\]
which is indeterminate in sign and \( \neq 0 \).
### Table 1. Descriptive Statistics\textsuperscript{a}

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grams of lead per gallon of gasoline</td>
<td>1.78</td>
<td>0.98</td>
<td>0.00</td>
<td>3.98</td>
</tr>
<tr>
<td>Environmental index</td>
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<td>35.8</td>
<td>63.96</td>
<td>183.41</td>
</tr>
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<td>GDP</td>
<td>6,795</td>
<td>5,828</td>
<td>290</td>
<td>21,631</td>
</tr>
<tr>
<td>Developed</td>
<td>0.40</td>
<td>0.49</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>%Urban</td>
<td>55.6</td>
<td>24.3</td>
<td>9.00</td>
<td>97.00</td>
</tr>
<tr>
<td>%LFI</td>
<td>32.1</td>
<td>9.8</td>
<td>3.00</td>
<td>60.00</td>
</tr>
<tr>
<td>Govt. Honesty</td>
<td>2.57</td>
<td>1.57</td>
<td>0.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Openness measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade</td>
<td>48.97</td>
<td>28.06</td>
<td>6.32</td>
<td>156.00</td>
</tr>
<tr>
<td>Taxes</td>
<td>0.04</td>
<td>0.07</td>
<td>0.00</td>
<td>0.37</td>
</tr>
<tr>
<td>Import Duties</td>
<td>0.06</td>
<td>0.10</td>
<td>0.00</td>
<td>0.64</td>
</tr>
<tr>
<td>Export Duties</td>
<td>0.01</td>
<td>0.04</td>
<td>0.00</td>
<td>0.34</td>
</tr>
</tbody>
</table>

\textsuperscript{a}
Table 2: Panel Data Estimates Using Grams of Lead Per Gallon as the Regressand

<table>
<thead>
<tr>
<th>Model Type</th>
<th>Trade</th>
<th>Taxes</th>
<th>Import Duties</th>
<th>Export Duties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade</td>
<td>-0.02</td>
<td>9.66</td>
<td>4.7</td>
<td>6.86</td>
</tr>
<tr>
<td></td>
<td>(-2.4)</td>
<td>(4.7)</td>
<td>(6.2)</td>
<td>(0.9)</td>
</tr>
<tr>
<td>Govt. Honesty</td>
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<td>-0.09</td>
<td>-0.09</td>
<td>-0.36</td>
</tr>
<tr>
<td></td>
<td>(-1.8)</td>
<td>(-1.2)</td>
<td>(-2.5)</td>
<td>(-2.6)</td>
</tr>
<tr>
<td>Govt. Honesty*</td>
<td>0.003</td>
<td>-2.31</td>
<td>-0.76</td>
<td>-1.21</td>
</tr>
<tr>
<td>Openness</td>
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<td>(-3.5)</td>
<td>(-0.34)</td>
</tr>
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<td>GDP</td>
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<td>-0.6E-3</td>
<td>-0.5E-3</td>
<td>-0.9E-3</td>
</tr>
<tr>
<td></td>
<td>(-4.9)</td>
<td>(-3.5)</td>
<td>(-5.4)</td>
<td>(-3.6)</td>
</tr>
<tr>
<td>GDP²</td>
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<td>0.3E-7</td>
<td>0.3E-7</td>
<td>0.9E-7</td>
</tr>
<tr>
<td></td>
<td>(3.1)</td>
<td>(2.1)</td>
<td>(3.8)</td>
<td>(3.5)</td>
</tr>
<tr>
<td>GDP³</td>
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<td>-0.6E-12</td>
<td>-0.7E-12</td>
<td>-0.3E-11</td>
</tr>
<tr>
<td></td>
<td>(-2.3)</td>
<td>(-1.7)</td>
<td>(-3.4)</td>
<td>(-3.4)</td>
</tr>
<tr>
<td>Developed</td>
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<td>1.12</td>
<td>0.97</td>
<td>1.44</td>
</tr>
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<td></td>
<td>(2.6)</td>
<td>(2.7)</td>
<td>(2.4)</td>
<td>(2.3)</td>
</tr>
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<td>%Urban</td>
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<td>0.01</td>
<td>-0.02</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(2.8)</td>
<td>(1.1)</td>
<td>(-2.9)</td>
<td>(2.4)</td>
</tr>
<tr>
<td>%LFI</td>
<td>0.02</td>
<td>0.006</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(3.1)</td>
<td>(1.0)</td>
<td>(3.8)</td>
<td>(0.9)</td>
</tr>
<tr>
<td>N</td>
<td>294</td>
<td>185</td>
<td>151</td>
<td>96</td>
</tr>
</tbody>
</table>

Notes:
1. Dependent variable is grams of lead per gallon of gasoline.
2. Model type is based on which openness measure is used in the regression.
3. T-statistics in parentheses beneath coefficient estimates.
4. All models are significant at the p < 0.05 level.
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