The Effects of Economic Liberalization on the Regulation of Local Pollutants

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ABSTRACT

The effect of increasing economic liberalization on the domestic regulation of local pollutants is examined through the lens of economic literature, historical evidence, and an econometric regression modified from Copeland and Taylor (2003)'s prior work to include the possibility of slowed regulatory development from private mitigation of the local pollutant. The econometric results of 40 countries from 1980 to 1989 suggest that when the negative externality allows for the possibility of private mitigation, such as is the case with biological oxygen demand emissions, the income-related technique effect is diminished, leading to slowed (or non-existent) levels of trade-induced abatement. The impact of further economic liberalization on environmental regulatory regimes is contingent not only on existing local characteristics, but also the form and nature of the local pollutant.

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INTRODUCTION:

For the environmentalist cause, the rise of free trade through increased globalization has historically been seen as a source of great concern and worry. There is a trade-off, many advocacy groups argue, between environmental regulations and increased levels of economic openness. At the most extreme, it is the contention of these groups that trade liberalization between developed and developing nations, each with vastly different environmental regimes, can only result in a 'race-to-the-bottom' phenomenon in order to capture the job opportunities and direct investment of polluting corporations. Traditional social contracts are eroded and, as Drezner (2001, 53) describes the anti-globalization environmentalist viewpoint (albeit dismissively), "concerns about the environment... are sacrificed on the altar of commerce."

This should be no small concern, even for those that react to such claims with scepticism. It is true that technological advancement and increased efficiency may result in some environmental improvement on its own accord, however the evidence suggests the chief factor in positive environmental change is the enforcement of increasingly stringent regulations (Dasgupta et al. 2002). The real economic gains of trade for a society's welfare are significantly diminished if it comes at the expense of the erosion, or even the eventual collapse, of environmental protections.

This paper seeks to address the impacts of increased levels of economic openness on the environmental regulation of local pollutants in developed and developing nations.

Will growing economic activity from decreasing trade frictions necessarily result in a corresponding increase in environmental degradation? Or is growth from trade, when compared to growth induced purely from internal factors, a more efficient form of economic expansion that could result in increased levels of wealth and improved environmental conditions?

As is often the case, this paper finds that theory and evidence suggest the black and white trade-off perception in popular culture is a false dichotomy. There is hope for the supporter of economic liberalization, but it is tempered with significant caveats based on local context and pollutant characteristics that need to be addressed if trade liberalization is to continue apace without the fear of exacerbating already significant environmental concerns.

In examining and evaluating the arguments on both sides of the issue, this paper is divided into five main sections. Section I outlines the environmentalist critique and the pessimistic expectations of increased economic liberalization, focusing mainly on the hypothesis that economic liberalization leads to a 'race-to-the-bottom' as national governments—in both the developed and developing economies—compete for the economic gains of pollution-intensive industry by means of reduced regulations and oversight. Section II conducts a review of recent literature on the general economic theory relating to the effect of a decrease in trade frictions on local pollution levels and the development of regulations through the environmental Kuznets curve, refuting many of the concerns of the 'race-to-the-bottom' and 'pollution haven' hypotheses in the general case. Section III examines the effect on environmental regulations of the economic integration of asymmetrical environmental regimes and its relation to the theories proposed in section II as found in the historical case of the North American Free Trade Agreement (NAFTA) with a primary focus on local air pollutants. Section IV presents the estimates and interpretation of an econometric regression using a modified form of Copeland and Taylor's (2003) theoretical and empirical work on the relationship between trade openness and local sulphur dioxide pollution concentration levels to include the possibility of private mitigation. Section V then briefly evaluates the future implications of economic liberalization in developing nations by touching on the unique cases of China, India, and the under-developed parts of sub-Saharan Africa as suggested by the theories and critiques examined in the previous sections.

The econometric regression found in section IV seeks to address the role played by the nature and form of the pollutant by questioning the suitability of generalizing a positive relationship of increased trade with environmental quality based off the results of Copeland and Taylor (2003). Can the existence of private mitigation, whereby those with financial means are also able to avoid the negative effects from increased pollution, diminish the income-related environmental gains? In order to estimate the impact of this effect a modified form of Copeland and Taylor's original model is regressed against a pollutant with a disproportionately lower impact on those with the economic means to mitigate its effects: water effluent levels. The estimates of this modified regression result in conclusions that starkly contrast the generally optimistic results for levels of sulphur dioxide emissions. This further suggests that any assertions on the impact of trade liberalization in environment quality will be highly dependent the form and nature of the pollutant being examined as well as on the context of local characteristics.

SECTION I –

THE ENVIRONMENTALIST'S CRITIQUE: RACING TO THE BOTTOM

There exists a deep environmentalist suspicion towards economists, the economic discipline's perceived faith in the benefits of growth, and the expansion of economic liberalization. This confrontational attitude, and the corresponding responses of economists, has given rise to what Esty (2001) termed a "trade-environment divide": the current adversarial (and perhaps media encouraged) state in which the most vocal proponents of either cause act as partisans to aggressively champion one side of the divide to the exclusion of the other.

The rise of the 'General Agreement on Tariffs and Trade' (GATT) and then the 'World Trade Organization' (WTO) in the post-Second World War era established a period of steadily decreasing trade-related barriers around the world that has pushed the environmental movement from a state of hesitation to one of outright resistance. The image of goods, capital, and corporations moving more freely beyond traditional boundaries and borders is not a triumph of technology over obstacles, but rather the conquest of commerce over naturally-imposed limitations. The detached discussion amongst economists on the impact of environmental regulations on competitiveness and investment decisions have only heightened a sense of disconnect with the environmentalist members of the anti-globalization movement, as they are a group traditionally more inclined to consider their arguments in moralistic terms.

In the 1980s and and the 1990s, the dominant anti-globalization arguments was the "pollution haven hypothesis", the central tenet of which is that the high costs of doing business in developed economies resulting from environmental and labour restrictions induces optimizing corporations to flee overseas to the welcoming arms and lax regulations of developing nations. The removal of barriers to this cost-minimizing behaviour through trade and investment liberalization was hypothesized to result in two polar regulatory regimes: the highly regulated developing nations would have increasingly stringent environmental regulations, whereas the already low regulation levels in developing nations would steadily decline. Developing nations, desiring the employment and economic benefits of capturing foreign investment, would seek to induce pollution-intensive production through low regulatory levels relative not only to the developed economies, but also in relation to the other developing nations seeking to attract multinational firms.

In the pollution haven hypothesis, comparative advantage in the production of pollution-intensive goods is gained through the discrepancy in the strictness of regulations between developed and developing nations. The strong regulatory regimes of developed economies result in the specialization of the production of clean goods, whereas pollution-intensive good production relocates almost entirely to the developing nations of the world. The rich economies would realise the benefits of a clean local environment and continue to consume the inexpensive goods it thrives upon, whereas these gains are offset globally as poor nations become an environmental dumping ground to meet the consumer demand for pollution-intensive goods. This argument of diverging environmental policies has since been largely refined into an altered form with more dire consequences for total global pollution: a converging, or harmonizing, regulatory 'race to the bottom'.

The race-to-the-bottom hypothesis is based on the economic pressure for a converging policy of environmental regulations that stems from the increasing mobility of trade and capital that is an essential part of economic globalization. Seeking the highest rates of return, as is the case in the pollution haven hypothesis, firms will take part in "regulatory arbitrage" either through importation, outsourcing, or relocation (Drezner 2001). The elevated costs associated with the higher regulations in developed countries create a flight to developing nations who are desperate for jobs and investment and where the environmental standards are weak. Unlike in the case of the pollution haven hypothesis, this threat of regulatory arbitrage leading the lowest regulatory regime does not result in two divergent environmental regulatory standards. Developed nations, instead, relax environmental and labour standards in an attempt to recapture or retain capital (Dasgupta et al. 2002). Recently, it is this argument of global harmonization at the lowest level that has become dominant as the anti-globalization environmental critique.

There are some obvious expectations arising from the race-to-the-bottom hypothesis as outlined by Drezner:

> First, the more exposed a state is to global markets, such as reduced barriers to trade and controls on capital, the more likely its tax and regulatory policies will converge to other states with international exposure. Second, there should be a strong negative correlation between inward capital flows and a country's regulatory standards. Third, this policy convergence

> will be at the lowest common denominator; in any given regulatory arena, states will gravitate toward the policies of the most laissez-faire country.
>
> (Drezner 2001, 59)

It was these prospects, according to Baker Fox (1995, 53), that motivated the protests of some environmentalists in the two participating developed nations of the North American Free Trade Agreement. The weaker environmental regulations in Mexico for investment and exported products granted an unfair advantage to firms that would "endanger advances in protecting the environment already achieved in the United States and Canada."

The expected pressure for environmental policy harmonization is purely economic according to this hypothesis, and standards could be anticipated to be relaxed as non-converging states become less competitive. This is why environmentalists often call for interventionist regulatory solutions, such as the forced harmonization to the most stringent levels and the imposition of "eco-duties" to create 'fair' terms of trade, in conflict with developing nations (Esty 2001).

If this hypothesis holds true then "industrial societies face two unpalatable options" according to Dasgupta et al (2002, 149). "Protect environmental gains by moving back toward autarky, but reducing global income in the process, or accept much higher global pollution under unrestrained globalization." However, does this hypothesis hold?

The central assumption to the hypothesis is that firms will be attracted to a region by virtue of its lower environmental standards. While some recent studies that focus on the type of industry (pollution-intensive versus non-intensive) suggest that strict regulations might deter firm entry within the confines of a federated nation such as the US (List and Co 2000), the significant body of evidence in this area remains inconclusive. Many studies even suggest, counter-intuitively, that the central assumption of the race-to-the-bottom hypothesis does not exist between nation states, as firms are more chiefly concerned with other factors (Xu 1999). It is worth asking, if the race-to-the-bottom hypothesis does hold, why then do pollution-intensive industries remain primarily in the developed world (or fail to receive a relaxation of industry-related regulation in contrast to levels prior to the reduction of trade frictions), while sectors such as the less pollution-intensive garment industry relocate to developing Asian countries?

If the historical evidence does not generally bear out the race-to-the-bottom hypothesis, and cost competitiveness is instead largely the result other factors, what general expectations should we have for environmental regulations with increased economic openness? Does recent economic theory offer a more optimistic scenario in contrast to the bleak outlook of the race-to-the-bottom? The answer is, for the most part, yes, but with serious qualifications.

SECTION II –
ENVIRONMENTAL KUZNETS CURVE AND ENDOGENOUS REGULATIONS

Over the course of the last twenty years, there has been significant interest in the economic literature on the impact trade-induced economic growth plays in environmental degradation. The current dominant economic view (though itself by no means free of controversy or disagreement) views the trade-environment relationship as a two-stage process. In the first stage, trade and economic openness spur economic growth and raise national incomes. In the second stage, increased income allows for the acquisition of a more desirable quality of life, manifested through increased consumption or improved living and environmental conditions, than was previously achievable at the lower income level. The 'environmental Kuznets curve' is a theoretical path mapping the relationship between the per capita aggregated income level of a nation and the levels of pollution it is willing to accept. This curve, shown in figure 1, has the approximate shape of an inverted U, as greater prosperity leads, after an initial period of increasing pollution, to a rising demand for attention to environmental issues (Grossman and Krueger 1995) that may not have existed at lower levels of income.

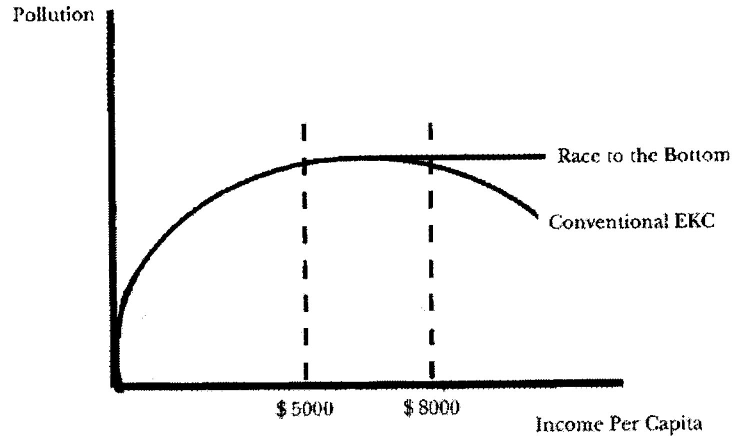

Figure 1: Environmental Kuznets Curve (Dasguta et al 2002, 148)

Dasgupta et al (2002) effectively characterizes the expected stages as a society develops economically and travels along the environmental Kuznets curve:

> "In the first stage of industrialization, pollution in the environmental Kuznets curve world grows rapidly because people are more interested in jobs and income than clean air and water, communities are too poor to pay for abatement, and environmental regulation is correspondingly weak. The balance shifts as income rises. Leading industrial sectors

> become cleaner, people value the environment more highly, and regulatory institutions become more effective. Along the curve, pollution levels off in the middle-income range and then falls toward pre-industrial levels in wealthy societies."
> (Dasgupta et al 2002, 147)

At the lower levels of income, on the left hand side of the curve, the impoverished nation is willing to accept environmental degradation in exchange for economic benefits. Growth leads to an initial environmental degradation, but it is paired with increasingly stringent environmental regulations and standards. As necessities are increasingly met, the populace becomes more willing to demand laws addressing the pressing environmental problems. If the environment is a normal good then it is not surprising that "richer countries, which tend to have relatively cleaner urban air and relatively cleaner river basins, also have relatively stronger environmental standards and stricter enforcement of their environmental laws" (Grossman and Krueger 1995, 372).

Copeland and Taylor (2004) posit that a threshold effect may exist in policy development that helps to account for the shape of the environmental Kuznets curve. While a desire for environmental improvement should come about as a response to the income effect at all levels of income, the effect is sufficiently small when national income is low such that the government does not perceive the existence of gains from environmental protection to be great enough to justify the cost of establishing a means of regulation. This suggests that until a sufficient transition point is reached, there will be no policy or, at the very least, the non-enforcement of existing policy. After the nation has moved beyond this threshold, environmental regulations should come into place and a "discrete drop" in pollution should occur.

The environmentalist critique of a 'race-to-the-bottom' would suggest a plateau-effect on the environmental Kuznets curve (Dasgupta et al 2002). At the apex of acceptable pollution levels, where environmental conditions are at their worst and where the normal curve begins to slope downward, societies are forced to safeguard their economic gains and will maintain this level of pollution. The perceived marginal cost of pollution abatement exceeds the marginal benefit, leading to a convergence of policy enforcement levels at the lowest point of acceptable environmental degradation.

There is a rising sense that the theory behind the environmental Kuznets curve is fundamentally flawed due to its reliance on economic incentives that fail to capture the socio-political institutions and characteristics within a state. Fazrin and Bond (2006) find, based on econometric analysis, that it is the interactions of socio-political characteristics that result in the observed inverted-u shape of the environmental Kuznets curve. Drezner (2001) also suggests the possibility that conceptual, or 'ideational', pressures—not economic pressures—could result in a different sort of regulatory policy convergence. The normative power of increased environmental policy is strong enough that the fear of being seen as a 'laggard' leads governing institutions to the adoption of the strict standards and regulations. This would imply a policy convergence at the highest level, with an ever-increasing standard.

The intuitive logic is that the pressures are not mutually exclusive, and may result in a convergence point resting at neither extreme. Social, political and economic characteristics interact and compete, with each in turn holding more sway at different stages of development. The results of these interactions correspond to "an initial phase of deterioration followed by a subsequent phase of improvement" with stagnant regulations until there is "an increased demand for (and supply of) environmental protection at higher levels of national income" (Grossman and Krueger 1995, 369).

Could increased trade then suggest the improvement of regulations in developing nations? The work by Antweiler, Copeland, and Taylor (2001) certainly suggested as much. In their empirical research based on local concentrations of air pollutants, it was revealed that "greater trade intensity creates only relatively small changes in pollution [...], economic theory and numerous empirical studies demonstrate that trade also raises the value of national output and income. These associated increases in output and incomes will then exert an impact on pollution concentrations" (Antweiler et al 2001, 903). The implication is that increased trade, as a source of economic growth, encourages higher levels of production efficiency, and that any increases in pollution levels resulting from the overall growth of the economy is counteracted by the associated desire for improved environmental conditions via an income effect. While there continues to be evidence of this trend with regards to pollutants that resemble sulphur dioxide, this may not be the case for all forms of environmental degradation. Using a single type of pollution as a proxy for environmental degradation without regard to the context of the environment, the form of its impact, and ability to privately mitigate the negative externality—as will be seen in section IV—diminishes the power of this finding to make sweeping generalized statements.

It is important to note that theory does recognize that the environmental Kuznets curve is not fixed or uniform across the varied circumstances of each nation. The "relationship between growth in per capita income and environmental quality will be determined by how many parties react to economic growth and its side effects-including citizens, businesses, policy-makers, regulators, non-governmental organizations, and other market participants" (Dasgupta et al 2002, 152). It is then important to realize when faced with such diversity of circumstance and players, as Esty (2001, 119) notes, "wealth is not an environmental cure-all...institutional failures in the environmental realm often mean that the requisite strengthening of environmental performance in parallel with trade liberalization may not occur". These institutional failures, such as corruption (Damania 2002) and weak property rights (Chichilnisky 1994), when combined with market failures could result in serious environmental consequences exacerbated by increased levels of economic liberalization. In developing nations especially, it could alter the expected shape of the environmental Kuznets curve such that any income-related demands for environmental improvements become too costly to enforce (Hotte et al 2000) or go unheeded until much further in the development path.

Corruption, while beyond the scope of this paper, is perhaps the most influential and persistent institutional failure behind environmental degradation (Damania 2002) and undermines the predicted trade-related gains of the environmental Kuznets curve. Though it is popularly viewed as a problem typically endemic to developing nations, developed nations may not be immune to legal forms of corruption. Cole, Elliot, and Fredriksson (2006) modelled the impact of foreign direct investment (FDI) on endogenous environmental regulations and included the ability of firms to influence governmental regulation through their ability to bribe or lobby. "If foreign firms' rent-seeking activities affect environmental policy," they reason, "any regression model trying to discern the impact of environmental policy on foreign investment has to take into account that both variables are endogenous." (2006, 160) Corruption had an inhibiting effect on the ability of economic development to

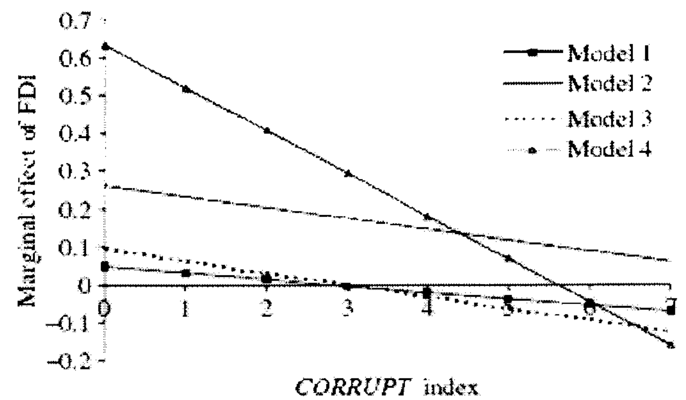

Figure 2: FDI, Corruption and the Environment
Source Cole et al (2006, 170)

translate into improved environmental regulations, as measured by lead content in gasoline, but in these models it was only when institutional corruption reached exceptionally high levels that it began to transform increased economic liberalization into decreasing levels of environmental quality (see figure 2, where the nations in their sample with the first and second highest level of corruption—Bangladesh and Nigeria—had index ratings of 5.7 and 4.2, respectively).

What of developed nations? While already at higher levels than in their developing counter-parts, regulations in developed nations are still considered sub-optimal as they fail to internalize the whole of the externalities (Bovenberg and Smulders 1996), therefore theory suggests developed nations should experience increasingly strict environmental policy as they overcome initial knowledge and political restraints. Downward economic pressures from trade with less stringent environmental regimes may slow the pace of regulation improvement, but so long as economic growth is still occurring, it seems unlikely in this general case that they would be strong enough to counteract the income effect.

In a generalized form, economic theory would suggest that most nations would experience ever-improving environmental regulations and standards, but has empirical evidence borne out this hypothesis? In recent decades, there have been at least two obvious large-scale examples of developed nations and developing nations engaging in a significant amount of economic liberalization worth examining: the North American Free Trade Agreement and the European Union. Since the EU mandates harmonization to a federal standard within the confines of its economic community (Ulph 2001), it becomes less useful in the context of the effect of economic globalization on domestic environmental regulations than the NAFTA case.

SECTION III –
THE CASE OF THE NORTH AMERICAN FREE TRADE AGREEMENT

During its formative stages and into its early implementation, the North American Free-Trade Agreement met with a fierce opposition made up of the strange and unlikely congruence of grass roots environmentalist groups and labour organizations (Baker Fox 1995). Despite its claim to being the 'greenest' trade agreement, linked as it was to the North American Agreement on Environmental Cooperation, much of the harshest criticism stemmed from fears about environmental degradation and regulatory roll back (Ederington

2007). This scepticism was only further inflamed by the sentiment among many economists at the time that NAFTA's environmental linkages did not belong within the confines of a trade agreement (Esty 2001). Relatively little was known about the relationship of a nation's stage of economic development and its pollution levels, and the fear remained that Mexico's already serious environmental situation could only be exacerbated by the further industrialization expected to result from increased trade and foreign direct investment (Grossman and Krueger 1993). Did NAFTA opponents' fears of a race-to-the-bottom materialize?

Grossman and Krueger (1993) believed, based on their econometric work, Mexico was near the peak of the environmental Kuznets curve based on its per capita GDP going into the agreement and suggested that the trade-induced economic growth from the signing of NAFTA with Canada and the United States could result in the intensification of Mexican efforts to address long-standing environmental problems. If it was true that Mexico was at the cusp of the transition point on the environmental Kuznets curve, as Grossman and Krueger predicted, improvements to the levels of environmental regulations and standards in Mexico should be readily observable.

Gilbreath and Ferretti (2004) note that prior to 1988, enforcement of Mexico's weak regulations was non-existent. In the 10 years following NAFTA, they noted several changes to the way the government approached environmental issues: In 1992 Mexico had created a federal government unit dedicated to enforcement, environmental protection was elevated to a federal cabinet position by President Salinas in 1994 and, more dramatically, in 1996 the collection of federal environmental laws were strengthened, and economic

TABLE 1:
Change in Mexican Legal Emission Levels (pounds per million BTU input)

Pollutant	*Mexico City (1994-1997)*	*Mexico City (1998)*
SO_2	1.65	1.13
NO_X	0.23	0.16
PM	0.05	0.04
	Other Critical Zones (1994-1997)	*Other Critical Zones(1998)*
SO_2	3.30	2.26
NO_X	0.41	0.16
PM	0.25	0.19

Source: Damania et al. (2002, 491)

measures were adopted as a means to achieving its policy objectives. The result has been a Mexican government accountable to the people "for a level of environmental performance that was routine the United States or Canada, but unthinkable in the Mexican political landscape of the 1980s." Table 1 demonstrates how the level of permitted emissions has changed in Mexico City and other regions deemed critical during the early part of the NAFTA period, as reported by the Commission for Environmental Cooperation.

What was not seen, counter to the Pollution Haven Hypothesis, was the regulatory arbitrage or mass flight from the relatively strict environmental regimes of the United States and Canada to Mexico in order to take advantage of the lower abatement costs associated with lax environmental regulations. That is not to say that some firms and industries did not relocate from the developed nations to Mexico, but econometric analysis suggests it was influenced by "factor endowment considerations and apparently not by differences in pollution abatement costs" (Antweiler et al 2001, 877). The cost of meeting the demands of environmental regulations is proportionally small compared to all other expenses incurred by American and Canadian firms such that it is not "sufficiently onerous to outweigh other factors keeping companies at home rather than being attracted to Mexico just to evade environmental rules" (Baker Fox 1995, 54). That pollution-intensive industries also tend to be capital intensive gives a distinct factor advantage to the capital abundant Canadian and American economies. Ederington (2007, 241) notes that studies have shown the "composition of U.S. trade has changed so that the U.S. exports have become dirtier relative to U.S. imports". The result is these 'dirty' industries, such as steel production, are subject to the more stringent environmental regulations of developed nations, and that the result should be an expected decline in the aggregated pollution level of these industries across the entire free trade area as production consolidates in the capital-intensive economies (Copeland and Taylor 2003).

Without a proper counter-factual to provide a basis of comparison, the argument cannot be that trade liberalization led to environmental gains in excess of what could have been achieved with equivalent growth under restricted trade (though it could be reasonably argued that such economic gains would not have been forthcoming without the reduction of trade barriers). Rather, it must be that liberalization between asymmetrical regimes not only did not lead to an overall regulatory collapse in Mexico, but also preceded a period of environmental regulatory tightening on the emission of air pollutants.

The case in the United States and Canada is less easily defined because both nations are located on the right-hand side of the environmental Kuznets curve with well-established regulations and higher environmental standards (Gilbreath and Ferretti 2004). Parson

(2000) refers to "mixed progress", but still perceives a forward momentum. While Nevaer (2004), speaking on Mike Harris' Conservative rule in Ontario, believes NAFTA's "unintended consequence was that Canada weakened its laws protecting the environment", Green (1997) argues that during the 1990s, emissions standards in both the US and Canada became more stringent, with Canada's regulatory tightening experiencing a six-year lag to their American counter-parts. Antweiler, Copeland, and Taylor (2001) list Canada and the United States as two of the few nations in their study that are likely see increased levels of pollution from a decrease in trade frictions, however Kirton (2002) contends that during the NAFTA period "the three North American governments have tended to find solutions that generate both higher and more convergent environmental regulations" through his analysis of the environmental regulatory protection disputes between at least two NAFTA nations. How to reconcile this contradiction?

Likely, political realities in developed nations make weakening environmental regulations an unpalatable option, giving protective policies an element of "stickiness" once instituted. Also, the seemingly inevitable utilization—however distasteful for trade advocates—of environmental restrictions as substitute tariffs (Copeland and Taylor 2004) may distort perceptions of economic liberalization or artificially improve the perception of environmental progress. That there has been slowed movement or even stagnation on regulatory improvement in Canada and the United States at various times does not seem implausible. How much of it is attributable to the cyclical nature of politics (changes in US Congressional control and Canadian parliaments) and how much to the economic pressures of free trade with Mexico seems uncertain at best.

Much of the prevailing wisdom at the time of NAFTA's inception, both the environmental concern of a regulatory race-to-the-bottom and the economic belief in diminished trade gains through environmental linkages, did not materialize (Esty 2001). Empirical evidence has suggested that the Mexican situation has improved rather than worsen; it generally appears that environmental regulations have not converged to the pre-NAFTA Mexican standard, and economic gains remain intact.

This evidence, however, largely focused on atmospheric pollutants with local impacts on a wide cross-section of the population. While both theory and some notable econometric evidence appear to be in agreement on the positive environmental impact of free trade, or at least potentially non-negative, it uses a very specific form of pollution as a proxy for all environmental degradation. This shortcoming, unless otherwise addressed, could very well lead to imperfect policy decisions.

SECTION IV –
TRADE, REGULATION, AND PRIVATE MITIGATION:
ECONOMETRIC REGRESSION

The impact of trade-induced growth can be divided into three distinct effects: scale, technique, and composition. Following the work of Grossman and Krueger (1993), Copeland and Taylor (1994, 767-770) defined the scale effect as the change in aggregate levels of pollution stemming solely from the increase in the level of economic activity, the technique effect as the change rising from the switch to cleaner production techniques and technologies, and the composition effect as the change in pollution caused by the shift in the range of goods produced in the domestic economy.

The scale effect of trade-induced growth, intuitively, has a positive relationship to pollution levels. Increased economic activity, with all else held constant, can be expected to result in increased aggregate pollution levels. The technique effect, however, acts as an opposing force to the scale effect and has a negative relationship. The inducement to move to more efficient technologies and techniques with fewer negative externalities, caused by the demand for improved environmental levels corresponding to higher levels of income, will result in a decrease in aggregate pollution levels with all else held constant. Theoretically, the relationship of the composition effect is largely ambiguous—a comparative advantage in capital-intensive industries results in a larger share of pollution-intensive production at the same level of economic activity suggesting an increase in aggregate pollution levels, whereas if the reverse is true the nation, such as a nation with a comparative advantage in service industries, will see a decline in aggregate pollution levels if all else is held constant.

In order to address the issue of how increased openness to the international market impacts local pollution levels, the empirical work of Copeland and Taylor (2003), based on the work in their earlier article with Werner Antweiler (2001), sought to estimate the consequences of different sources of income growth and separate a trade-induced composition effect from the effects induced through domestic growth, in order to understand what impact increased levels of openness had on the environment through its impact on the composition of production in the economy. Using sulphur dioxide concentration levels as the dependent variable, their regression demonstrated that the composition effect of trade was small and that the technique effect outweighed the scale effect, resulting in a net decrease in aggregate pollution levels for the "average" nation. The empirical results also suggested that the source of comparative advantage in pollution-intensive industries originated from national factor endowments rather than any disparity between the levels of environmental regulations as assumed in the pollution haven hypothesis. Therefore, this econometric regression suggests it is the existence of abundant levels of capital that will determine the directional flow of pollution-intensive industries with increased levels of economic liberalization, rather than rent-seeking through regulatory arbitrage.

Ignored in Copeland and Taylor's analysis is the possibility that the form taken by the local pollutant may in itself alter the technique effect of trade liberalization. Hotte and Winer (2007) argue that while pollution diminishes welfare for all members of society, the ability of high-income individuals to privately mitigate the personal impact of increased levels of pollution—by purchasing bottled water, living in the outskirts of the city, etc.—will alter the demand for environmental regulations addressing the resultant externalities. Their model suggests that while the rich and the poor have a preference towards a reduction in trade frictions as a result of the accrued income gains, the disparity in their incomes leads to conflicting preferences as to the strictness of environmental regulation in the event of such economic liberalization.

How resilient are Copeland and Taylor's estimated positive relationship between economic openness and environmental improvement when faced with a pollutant satisfying the essence of this critique? By running an econometric regression with a slight modification to include as the dependent variable a form of pollution that is avoidable for those with financial means, this section hopes to address the possible role of private mitigation in diminishing the trade-induced environmental gains.

DATA AND MODEL

The linear approximation adopted from the Copeland and Taylor's model (2003, 249) takes the following form:

$$Z_i^C = X_i'\beta + \varepsilon_i \qquad (1)$$

$$X_i'\beta = \beta_0 + \beta_1 SCALE_i + \beta_2 KLADJ_i + \beta_3 INC_i + \beta_4 \Psi_i OPEN_i$$

$$\Psi_i = \Psi_0 + \Psi_1 RELKL_i + \Psi_2 RELKL_i^2 + \Psi_3 RELINC_i + \Psi_4 RELINC_i^2 + \Psi_5 RELINC_i \cdot RELKL_i$$

This is a specification based of the the reduced form of the model found in Copeland and Taylor and is referred to as Model A. By combining pollution supply and demand in their theoretical model, Copeland and Taylor were able to link pollution emissions to local economic factors (X_i). As the form of their model was reduced, they linked the differences across countries in relative prices found in autarky to the difference in their relative factor abundance and real income levels, Ψ_i(RELATIVE-CAPITAL, RELATIVE-INCOME). In order to condition on these relative characteristics, they adopted a second-order Taylor series approximation and then placed it in interaction with the equivalent of this paper's OPEN variable, used by Copeland and Taylor as a measure to account for lowering trade frictions, to capture the composition effect induced by trade liberalization (Copeland and Taylor 2003, 240).

The dependent variable, Z_i^C, represents the pollution levels at location 'i'. In the theoretical form, the model predicts pollution emission levels, however in the original regression estimation by Copeland and Taylor, they used the logarithm of sulphur dioxide emission concentrations as a proxy for the overall environmental degradation.

In order to examine the impact of the argument proposed by Hotte and Winer (2007) relating to the private mitigation of pollution effects, a measure of water effluent levels was selected for the modified regression as the replacement pollution indicator. Biological oxygen demand (often referred solely to as BOD) provides a measure for a form of pollution that can be mitigated privately to a considerable degree—for example, through the purchase of purified drinking water to avoid the impact of a polluted water system—and therefore is likely to disproportionately affect lower-incomes members of a society to a greater extent than many atmospheric-related pollutants with wide-reaching effects. The benefit of this data is that they are a readily available measure of effluent levels across most nations, but it is limited in that they are not solely a measure of industrial activity. While not readily accessible from areas across a wide spectrum of economic development, an improved form of BOD measure for the purpose of this regression would be point data concentrations so as to get a more accurate picture of the degree of environmental degradation. At the most ideal, a measure of the negative health impacts for any given level of BOD concentrations would more accurately capture the role of private mitigation and an income-driven societal move towards improved environmental conditions. Data for the national daily average BOD emissions were provided by the World Resources Institute as adapted from the World Bank's 'World Development Indicators' and transformed by the natural logarithm to form the regression's dependent variable.

Table 2 summarizes the statistics used as the dependent variables and outlined below. Where possible, this information was retrieved using the same source as the original Copeland and Taylor regression so as to provide a more accurate point of comparison on the impact of the existence of mitigation on trade-induced regulatory gains.

$SCALE_i$, is an indicator of the intensity of economic activity. It is comprised of real gross domestic product (GDP) per square kilometre. It is expected that as the scale of economic activity increases, pollution levels will also intensify. This information was retrieved from the Penn World Tables, version 5.6, at constant 1985 prices.

Following the work of Copeland and Taylor, INC_i is the one-period lagged three-year moving average of per capita gross national product. The per capita gross domestic product allows for estimation of the technique effect that is separate from the scale effect. The lagged, three-year moving average is designed to smooth out some of the fluctuations in the business cycle and account for the slow response of policy to income levels. Income, as the major component of the theorized technique effect, is expected to exert downward pressures on pollution emission levels. Per capita gross national product is determined using a GNP deflator value in the Penn World Tables, version 6.2.

TABLE 2:
Summary of Statistics

Variable	Obs.	Mean	Standard Deviation	Minimum	Maximum
Scale of Economic Intensity, constant at 1985 prices ($1,000,000/km^2)	400	0.7956	1.2253	0.0081	6.4654
Capital Abundance, Adjusted ($10,000)	400	4.2585	2.0325	0.26419	8.4548
Educational Attainment [0,1]	400	0.40343	0.17263	0.14188	0.75875
GNP per capita, lagged 3-Year Moving Average ($10,000)	400	0.59305	0.42543	0.032485	1.8605
Openness [(Exports + Imports)/GDP]	400	0.56127	0.28311	0.0896	1.5645
Relative Adjusted Capital Abundance	400	2.6453	1.2711	0.14884	5.3467
Relative Income [World Average = 1.000]	400	1.4981	1.0180	0.10	3.88

$KLADJ_i$ refers to the value of national capital abundance (K / L) adjusted by national education levels. The capital abundance value was obtained from the physical capital stock per worker variable found within the Penn World Tables, version 5.6. The education value is taken from the dataset found in Barro-Lee (1993) and modified to give each nation in any given period a value between 0 and 1 inclusive based on the levels of higher education. A population with only university graduate levels of education (at least 16 years of schooling) would receive a value of 1. This value is then multiplied by the total labour force to give the adjusted capital abundance. This measure allows us to view capital accumulation in terms of the effective labour force, such that the capital-to-effective labour ratio is higher in regions with lower levels of average education than is found in the nations with high levels of average education. Capital-intensive industries generally result in high levels of pollution relative to labour-intensive industries, therefore the accumulation of capital is expected to have a positive relationship with levels of environmental degradation, such that increased levels of capital abundance would be expected to correspond to increased levels of pollution.

Relative capital abundance ($RELKL_i$) and relative income ($RELINC_i$) were obtained by dividing each country's capital abundance and income by the corresponding world average in that period and then, in the case of RELKL, modified by the education level. This world average was determined as the average of all nations in the Penn World Tables with the appropriate data, including those nations not represented in the regression. Since income and capital abundance are the key characteristics of the of the original Copeland and Taylor regression, the relative levels of these characteristics were employed to determine a comparative advantage. High levels of capital abundance will indicate a comparative advantage in capital-intensive industries and should result in an increase in production of those industries with declining trade frictions leading to higher levels of pollution. There is some ambiguity connected to the relationship of relative income—for instance, if there is a regulatory race-to-the-bottom, then higher levels of relative income will correspond to greater increases in pollution with declining trade frictions. The sign of the square of relative income may indicate that the existence of a clearly non-linear relationship, as proposed in the pollution haven hypothesis, where low relative income results in pollution increases with declining marginal pollution emissions if relative income approaches and passes the world average.

OPEN is labelled as the trade intensity variable in the original Copeland and Taylor estimation and corresponds to the Openness variable in the Penn World Tables. This value is determined by (exports + imports) / Gross Domestic Product and represents a common, if imperfect, means of measuring of economic liberalization. The relationship to pollution levels is uncertain. Though Copeland and Taylor found that declining trade frictions corresponded to declining levels of ambient air pollution levels, the question of the appropriateness of generalizing such findings is at the heart of this paper's econometric work.

Copeland and Taylor also rationalise (2003, 249-250) the need for two amended forms of the above specification for which corresponding regressions were also conducted.

Model B:

$$Z_i^C = X_i{}'\beta + \varepsilon_i \qquad (2)$$

$$X_i{}'\beta = \beta_0 + \beta_1 SCALE_i + \beta_2 KLADJ_i + \beta_3 KLADJ_i^2 + \beta_4 INC_i + \beta_5 INC_i^2 + \beta_6 KLADJ_i INC_i + \beta_7 \Psi_i OPEN_i$$

$$\Psi_i = \Psi_0 + \Psi_1 RELKL_i + \Psi_2 RELKL_i^2 + \Psi_3 RELINC_i + \Psi_4 RELINC_i^2 + \Psi_5 RELINC_i \cdot RELKL_i$$

Model B expands model A to include the square of income per capita, INC_i, which are the square of adjusted capital abundance, $KLADJ_i$, and an interaction variable between income and adjusted capital abundance. The intent was to capture the non-linear effect of capital accumulation and that the income-related gains are dependent on the pre-existing income per capita and capital-to-labour ratio. This model best corresponds to the hypothesis of environmental Kuznets curve that influences pollution levels.

And Model C:

$$Z_i^C = X_i{}'\beta + \varepsilon_i \qquad (3)$$

$$X_i{}'\beta = \beta_0 + \beta_1 SCALE_i + \beta_1 SCALE_i^2 + \beta_3 KLADJ_i + \beta_4 KLADJ_i^2 + \beta_5 INC_i + \beta_6 INC_i^2 + \beta_7 KLADJ_i INC_i + \beta_8 \Psi_i OPEN_i$$

$$\Psi_i = \Psi_0 + \Psi_1 RELKL_i + \Psi_2 RELKL_i^2 + \Psi_3 RELINC_i + \Psi_4 RELINC_i^2 + \Psi_5 RELINC_i \cdot RELKL_i$$

The only amendment made from model B to model C by Copeland and Taylor is the introduction of the square of real per capita gross domestic product, $SCALE_i^2$. This was done in the original Copeland and Taylor to add the possibility of a non-linear relationship stemming from non-homothetic elements in production and/or consumption and is reproduced in the modified regression.

As a result of the number of interaction variables and power terms in order to capture the non-linear relationship posited by Copeland and Taylor multicollinearity might have been an issue. Tests suggest that near multicollinearity between the core variables (SCALE, INC, KLADJ, and OPEN) is unlikely to be a problem, as demonstrated in table 3,

TABLE 3:
Correlation Matrix

(1) SCALE	1.00												
(2) $SCALE^2$	-0.93	1.00											
(3) KLADJ	-0.13	0.09	1.00										
(4) $KLADJ^2$	0.07	-0.05	-0.89	1.00									
(5) INC	-0.34	0.32	-0.46	0.61	1.00								
(6) INC^2	0.47	-0.39	-0.14	0.30	-0.34	1.00							
(7) INCKL	-0.00	-0.02	0.49	-0.80	-0.75	-0.35	1.00						
(8) OPEN	0.05	-0.01	0.50	-0.37	-0.20	0.03	0.11	1.00					
(9) OPRLKL	0.12	-0.06	-0.71	0.77	0.54	0.26	-0.68	-0.55	1.00				
(10) $OPRLKL^2$	-0.08	0.02	0.32	-0.62	-0.50	-0.43	0.83	0.14	-0.79	1.00			
(11) OPRLINC	-0.25	0.09	0.05	-0.18	-0.25	-0.16	0.40	-0.62	-0.22	0.45	1.00		
(12) $OPRLINC^2$	0.18	-0.11	-0.20	-0.02	-0.00	-0.27	0.20	0.35	-0.10	0.38	-0.47	1.00	
(13) OPKLINC	0.08	0.02	0.13	0.20	0.29	0.37	-0.61	0.29	0.33	-0.81	-0.60	-0.41	1.00
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

but the introduction of interaction variables does raise concerns of high pairwise correlation.

To address heteroskedasticity issues in the initial regression estimations, White's correction to standard errors and a panel-corrected covariance matrix were used in calculating the coefficient estimates.

Regression estimations were constructed using the SHAZAM econometric software, made available by the University of British Columbia. All variables prefixed with OP in the SHAZAM output refer to interaction variables with OPEN as seen in the form of the regression (1), (2), and (3).

As was the case with Copeland and Taylor, each model is presented in both the fixed and random effects estimates. Copeland and Taylor (2003, 248) note:

> While random effects estimation is in theory more efficient, it is unclear whether excluded country-specifics subsumed in our error term are uncorrelated with our regressors. And while fixed-effects estimation is preferable in just these cases, fixed effects limits the cross-sectional variation we can exploit for separating scale from technique effects.

Some limitations on the use of SHAZAM with regards to data and fixed effects models required several observations to be excluded. Therefore, to achieve a balanced panel, the data covers a period of 10 years, 1980 to 1989 inclusive, and spans 40 countries.

EMPIRICAL RESULTS

The results of the modified regression estimation, juxtaposed to the corresponding estimates from Copeland and Taylor's original estimations using SO_2 as the dependent variable, can be found in table 4 for the random effects models and table 5 for the fixed effects models. All estimations of models A, B, and C were found to be significant overall in both fixed and random effects. The Hausman test (results of which are found on table 5) suggests that for models B and C, the fixed effects specification is preferable to the use of random effects when the natural logarithm of biological oxygen demand is the dependent variable, but is unable to reject the possibility that random effects is preferable for model A.

Across all forms of the model, the intensity of economic activity (SCALE) has a significant and positive relationship with levels of BOD emissions. A rise in the intensity of economic activity leading to a corresponding increase in environmental degradation is in accordance with our expectations based on theory and evidence and is also consistent with

TABLE 4:
Comparative Regression Results, RANDOM Effects

	Mitigated Pollution Regression			Copeland and Taylor (2003, 251)		
	Model A	Model B	Model C	Model A	Model B	Model C
Intercept	17.571***	16.935***	16.978***	-2.865***	-3.279***	-3.311***
SCALE	0.077**	0.747*	3.169***	0.042***	0.058***	0.07***
SCALE²	--	--	-0.032***	--	--	-0.244
KLADJ	-0.092**	-0.081	-0.094*	0.102**	0.293**	0.286*
KLADJ²	--	-0.001**	-0.001**	--	0.014	0.013
INC	-0.034	0.092	-0.350	-0.982***	-1.248***	-1.312***
INC²	--	-0.016	0.092	--	0.708***	0.669***
INCKL	--	-0.015	0.006	--	-0.309***	-0.285***
OPEN	0.315	0.430	0.420	-0.915	-0.488	-0.51
OP(RLKL)	-0.516***	-0.531***	-0.499***	-0.462	-1.952*	-1.828*
OP(RLKL)²	0.119***	0.124***	0.125***	0.018	-0.23	-0.248
OP(RLINC)	0.415	0.293	0.237	0.47	1.056*	1.011*
OP(RLINC)²	-0.001	0.032	0.061	0.118	-0.308*	-0.285*
OP(KLINC)	-0.080	-0.095	-0.127	-0.165	0.87***	0.822***
R^2	0.1477	0.1701	0.2013	0.3395	0.3737	0.374
Overall Significance Wald X^2	32.96***	114.31***	136.85***			
Hausman (X^2)	0.63	63.78***	116.94***			

As per Copeland and Taylor, * denotes $p < 0.05$, ** denotes $p < 0.01$, and *** denotes $p < 0.001$

SCALE: Economic Intensity. Real Gross Domestic Product, in 1985 prices, per square kilometre
KLADJ: Educated adjusted Capital Abundance [K/L]
INC: Income level / 1-Period Lagged Real Gross National Product per capita, 3-year moving average
INCKL: Interaction variable between INC and KLADJ
OPEN: Openness / Trade Intensity [(Exports + Imports)/GDP]
RLKL: Relative Capital Abundance vs. the global average
RLINC: Relative Income Level vs. the global average
OP(·):Interaction variable with OPEN
OP(KLINC): Interaction variable of relative capital abundance, relative income, and openness

TABLE 5:
Comparative Regression Results, FIXED Effects

	Mitigated Pollution Regression			Copeland and Taylor (2003, 251)		
	Model A	Model B	Model C	Model A	Model B	Model C
Intercept	17.59***	16.95***	17.09***	-2.506***	-4.324***	-4.299***
SCALE	0.075**	0.601**	2.967***	0.024*	0.058***	0.089*
$SCALE^2$	--	--	-3.054***	--	--	-0.34
KLADJ	-0.094***	0.276**	0.247**	0.165***	0.461**	0.437*
$KLADJ^2$	--	-0.043***	-0.041***	--	0.006	0.008
INC	-0.050	-0.590**	-1.010***	-1.326***	-0.096	-0.228
INC^2	--	-0.101	0.011	--	0.559***	0.578***
INCKL	--	0.133**	0.149***	--	-0.381***	-0.386***
OPEN	0.572*	1.197***	1.174***	-3.677***	-3.142**	-3.216**
OPRLKL	-0.576***	-1.161***	-1.110***	0.159	-2.252*	-2.121
$OP(RLKL)^2$	0.129***	0.252***	0.248***	-0.168	-0.123	-0.176
OPRLINC	0.294	0.408	0.341	2.128**	2.687***	2.614***
$OP(RLINC)^2$	0.029	0.071	0.096*	-0.108	-0.595**	-0.584**
OP(KLINC)	-0.010	-0.194**	-0.218**	0.28	0.9*	0.924**
R^2	0.1930	0.2493	0.2825	0.2483	0.131	0.1499
Overall Significance Wald X^2	142.14***	195.14***	269.16***			

As per Copeland and Taylor, * denotes $p < 0.05$, ** denotes $p < 0.01$, and *** denotes $p < 0.001$

SCALE: Economic Intensity. Real Gross Domestic Product, in 1985 prices, per square kilometre
KLADJ: Educated adjusted Capital Abundance [K/L]
INC: Income level / 1-Period Lagged Real Gross National Product per capita, 3-year moving average
INCKL: Interaction variable between INC and KLADJ
OPEN: Openness / Trade Intensity [(Exports + Imports)/GDP]
RLKL: Relative Capital Abundance vs. the global average
RLINC: Relative Income Level vs. the global average
OP(·):Interaction variable with OPEN
OP(KLINC): Interaction variable of relative capital abundance, relative income, and openness

the findings of Copeland and Taylor with regards to sulphur dioxide concentrations. That the square of SCALE is negative and significant suggests the possibility of an efficiency gain that results in smaller corresponding increases in pollution emissions as the economy intensifies. In other words, pollution is convex in growth in real Gross Domestic Product.

The national adjusted capital abundance level, or capital-to-effective labour ratio KLADJ, represents a partial deviation from the findings in the original Copeland and Taylor regression. When sulphur dioxide emissions was used as the dependent variable, the estimated result for KLADJ was a positive relationship to pollution levels across all models of the fixed and random effects specifications. The results for the regression using BOD emission levels demonstrated a significant negative relationship to the levels of BOD pollution in random effects models A and C (with KLADJ in model B also negative, but not significant) and in fixed effects model A. The coefficient of KLADJ in the fixed effects models B and C more closely corresponded to Copeland and Taylor's results. Across all specifications, the models that included the square of KLADJ found a significant and negative relationship that stands in contrast to the results of the estimation of the original regressions.

A possible source for this deviation from Copeland and Taylor may lie in the varying sources and types of pollutants that occur at different points during a nation's economic development. The accumulation of capital may represent a move from sectors more likely to emit water pollutants, such as agricultural production, towards a more industrial/manufacturing orientation with increased emissions of air pollutants. This is also a possible explanation for the sign of KLADJ and $KLADJ^2$ in fixed effects models B and

C. It is possible that while initial increases in the accumulation of capital will occur in industries such as agriculture, the further accumulation of capital represents the development of capital-intensive industries and eventual shift in the industrial composition of the economy.

Pollution levels are also predicted to have a negative relationship with per capita income levels, INC, as would be suggested by both the theoretical economic literature and the findings of Copeland and Taylor. In the regression on biological oxygen demand this was confirmed, however the results were only significant for fixed effects models B and C. Though the sign is negative, as theory would suggest, the lack of significance across all models hints at the role of private mitigation in the diminished effectiveness of the technique effect found that was observed by Copeland and Taylor.

The openness or trade intensity variable, OPEN, was estimated as positive compared to the negative relationship theorized and found by Copeland and Taylor. The coefficient for openness, in isolation, appears to be significant only in the fixed effects models, however the joint hypothesis test of the coefficients reflecting the "trade-induced composition effect" were found to be significant across all specifications in both the modified regressions and the original SO2 regressions. While it is the overall trade-induced effect that is of interest to this paper rather than the sign of the OPEN variable, this finding of a positive relationship with BOD emission levels begins to suggest a serious potential disagreement with the optimistic results found by Copeland and Taylor.

Table 6 and table 7 compare the estimated elasticities at mean of the various effects at play for the natural logarithm of BOD emissions with the results estimated in Copeland

TABLE 6:
Random Effects Estimated Elasticities at Means Comparison

	Regression with Private Mitigation			Copeland and Taylor (2003, 252)		
	Model A	Model B	Model C	Model A	Model B	Model C
Scale Elasticity	0.061*	0.059*	0.245***	0.192***	0.265***	0.315***
Composition Elasticity	-0.391**	-0.367*	-0.401**	0.583**	0.948***	0.993***
Technique Elasticity	-0.020	-0.039	-0.190	-0.905***	-1.577***	-1.577***
Openness / Trade-Induced Composition Elasticity	0.116	0.102	0.072	-0.436***	-0.388***	-0.394***

As per Copeland and Taylor, * denotes $p < 0.05$, ** denotes $p < 0.01$, and *** denotes $p < 0.001$

TABLE 7:
Fixed Effects Estimated Elasticities at Means Comparison

	Regression with Private Mitigation			Copeland and Taylor (2003, 252)		
	Model A	Model B	Model C	Model A	Model B	Model C
Scale Elasticity	0.060**	0.048**	0.217**	0.112*	0.266***	0.398**
Composition Elasticity	-0.401***	0.741***	0.689***	0.945**	1.006**	0.975*
Technique Elasticity	-0.030	-0.050	-0.218	-1.222***	-1.153**	-1.266**
Openness / Trade-Induced Composition Elasticity	0.124*	0.120*	0.675*	-0.641***	-0.864***	-0.882***

As per Copeland and Taylor, * denotes $p < 0.05$, ** denotes $p < 0.01$, and *** denotes $p < 0.001$

and Taylor's regression of the natural logarithm of sulphur dioxide concentrations. An increase in the scale of domestic economic activity has a significant positive relationship to the level of pollution in the country for both forms of pollution and across all models and specifications.

Further contrasting the results determined in the original Copeland and Taylor paper and those found in the modified regression is the estimated composition effect. While two out of three of the fixed effects specification models bear similar results to the original regression, the random effects models and model A of the fixed effects present a negative relationship. Copeland and Taylor (2003, 250) note that based on their own results and economic theory, there is the suggestion that "less emphasis be placed on estimates from model A." Doing so still places the fixed and random effects results in opposition. As noted above, however, the possibility of opposing signs in the composition effect is not necessarily counter-intuitive when comparing a regression of a water-based pollution measure, such as BOD, and an air-based pollutant. It could be that as a society develops economically it moves away from a form of activity that contributes to increased levels of biological chemical demand, such as primary industries, and towards more industrial forms of production where air-pollutants, such as sulphur dioxide, are the dominant pollutants.

The results of the Hausman specification test, as previously noted, suggest that fixed effects models B and C are preferred due to endogeneity in the corresponding random effects models. In that case, we can determine that for the average country, an increase in capital accumulation will increase the level of pollution. The nation at the mean would not yet have reached a point where the type of pollution is likely to shift away from water effluents as suggested by the sign of the coefficients on the individual variables.

The technique effect—stemming from the stronger desire for improved environmental conditions with increasing levels of income—was not significantly different from zero for any model or specification. The possibility of diminished income-related benefits to pollution abatement relative to Copeland and Taylor's results may not be altogether surprising. If, as Hotte and Winer (2007) proposed, the income gains of increased economic activity provide the means for some groups to privately mitigate the negative aspects associated with increased levels of BOD without tighter regulations or improved government enforcement, we can expect to see the influence of income on pollution abatement levels weaken. In a case where the effects of pollution are not avoidable, we would expect the effect of an increase in income on pollution levels to be strongly negative, but the existence of possible private mitigation should diminish the strength of this relationship. This scenario becomes even further plausible if, as is intuitive, groups with economic means have a disproportionately high influence on the development and enforcement of policy relative to lower-income individuals.

Important for the purposes of this paper is the Openness or Trade-Induced Composition elasticity, (labelled in Copeland and Taylor as the Trade Intensity elasticity). The elasticity as presented above represents an "average" country—it is unlikely that the elasticity is negative or positive across all nations—but even so, the contrasting results between the two forms of pollutants is striking.

Copeland and Taylor estimated that at the mean there existed a negative trade-induced composition effect in both the random and fixed effects specifications. The results for a pollutant where there is the possibility for mitigation suggests that at the mean trade may have either a significant negative or small to no impact on water quality levels.

Copeland and Taylor (2003, 237) expressed the total change in pollution from an increase in openness as follows:

$$\frac{dz}{d\delta} \cdot \frac{\delta}{z} = [\pi_1 + \pi_3] \frac{dI}{d\delta} \cdot \frac{\delta}{I} + \pi_4 \qquad (4)$$

where "z" is the level of pollution, "δ" is trade liberalization, I is national income, π_1 is the scale effect, π_3 is the technique effect, and π_4 is the composition effect induced by openness. We expect that $dI/d\delta$ will be positive in most cases as increased economic liberalization should lead to an increase in the national income.

From the above results, we can infer that in the case of a BOD, where the possibility of privately mitigating the adverse effects of pollution are fairly strong, that the scale effect is likely larger than the opposing technique effect such that $|\pi_1| > |\pi_3|$ in the case of the average country. And since the trade-induced composition effect is non-negative on average in our econometric regression, $\pi_4 \geq 0$, we can conjecture a scenario where the removal of barriers to trade may diminish society-wide income-related gains in a good in which personal wealth allows for the alleviation of the negative impacts for a sub-section of the population, as may be the case with water effluent emissions. A reduction in trade frictions, in this model, encourages established industries to expand production and therefore increase total levels of BOD output. Any decrease in the biological oxygen demand levels arises from a change in the composition of the domestic economy, which is an effect separate from trade-induced growth.

The results suggest that regulations for pollutants that differentially impact one group over the other—especially if the gains from increased levels of pollution go towards those least affected as a result income-related mitigation—are unlikely to come into being or will do so in a reduced and weaker form. Copeland and Taylor's work still remains valid, especially for pollutants with a wide-ranging local impact, but the removal of trade restrictions for the average nation cannot by and of itself guarantee a positive environmental outcome.

This finding that the removal of trade restrictions cannot be guaranteed to have a positive relationship to environmental quality is abundantly clear in the subsequent section. The interaction of economic liberalization and local characteristics—as briefly outlined for the cases of China, India, and Sub-Saharan Africa—can carrying unintended consequences for the environmental regulatory regime and overall welfare.

SECTION V – LOOKING FORWARD

An overall model of the evolution of environmental regulation as related to economic development has academic and intellectual merit, yet any generalized proxy will fail to capture essential features that dramatically alter the expected outcomes when applied to specific circumstances. Economic theory and policy become truly interesting and practical when given application to the unique challenges and economic situations of developing countries in the real world. The diverse nature of the institutions and markets of an individual regions can be expected to result in an environmental Kuznets curves that takes on a form which may, in some cases, be outside the theorized norm.

As a result of the massive proportion of humanity living in China, India, and Sub-Saharan Africa, the impacts of changes to economic welfare and environmental conditions —even at small levels—in those regions become issues of a sizeable scale. As trade frictions continue to diminish in these relatively impoverished regions, the intertwined relationship of economic and environmental issues has moved to a higher level of prominence. It is then useful to apply theoretical work to examine the impact of this continuing trend of economic liberalization should policies be unable or unwilling to adapt to individual circumstances.

Dasgupta et al (2002, 152-153) assigned three explanations for why it is that richer countries regulate pollution more stringently than their poorer counterparts do:

> "First, pollution damage gets higher priority after society has completed basic investments in health and education. Second, higher-income societies have more plentiful technical personnel and budgets for monitoring and enforcement activities. Third, higher income and education empower local communities to enforce higher environmental standards, whatever stance is taken by the national government"

Both the second and third reasons proposed demonstrate the high reliance on the ability to enforce regulations. The institutional inability or prohibitive cost to enforce environmental regulations is likely to result in the abandonment of attempts to regulate firms into compliance (Damania 2002). This is one of the problems currently facing the People's Republic of China.

The focus of foreign direct investment and the source of the nation's famous economic boom, coastal eastern China, is a manufacturing-driven economy (while the agricultural hinterland, inland western China, is the steady source of the ever-expanding labour force in the east). China's comparative advantage appears to rest in the pollution-intensive industries (Dean 2002), such that the industrial composition of the economy facing central environmental agencies resembles those typically found in developed countries, but without the benefits of established control mechanisms.

The environmental regulations in China are considered relatively strong, but they remain impotent because of the enforcement issue. Fu et al. (2007, 7598) reports that over 60% of Chinese large lakes are eutrophic and water quality levels in over half of the rivers are decreasing. Even so, Dean (2002, 823) reports that "[c]ounterfactual simulations suggest that emissions per unit of industrial output would have grown more rapidly in the absence of trade reform." Counterintuitively, a possible reason for this finding may rest in the arrival of efficient foreign firms.

State-owned enterprises in China, being less efficient, produce higher intensity of pollution (Dean 2002) and have higher costs associated with abatement (Dasgupta et al 2002) as is noted in figure 3 reflecting econometric estimates of control costs in large factories. Among Chinese officials, there is also an increased willingness to enforce existing regulations on private industry. There is less desire, arising from local political issues, to enforce the costly environmental regulations on state-owned enterprises, and evidence suggests that pollution levies against a plant will be significantly lower if the firm is state-owned (Dean 2002) rather than privately operated.

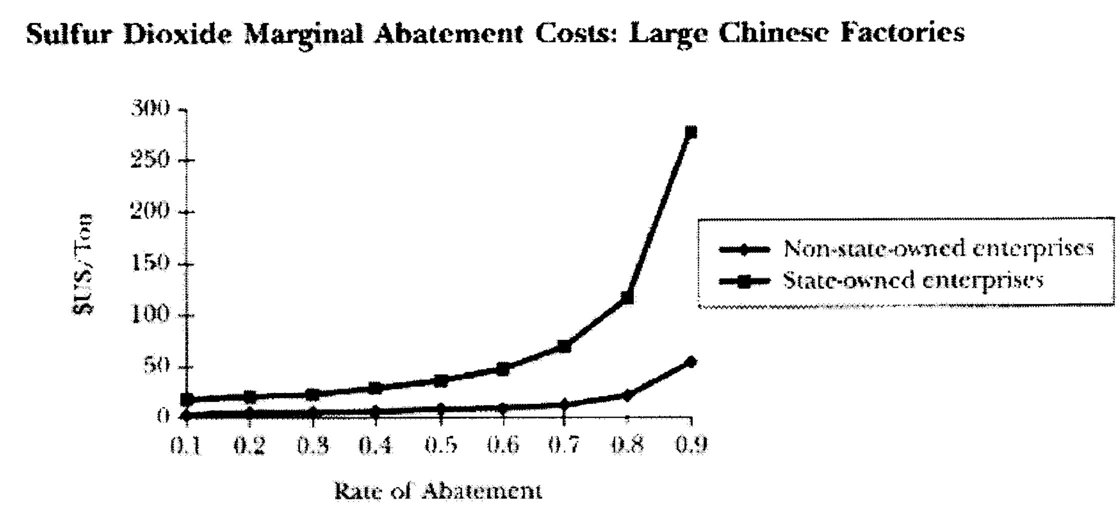

Figure 3: SO2 Marginal Abatement Costs in China (Dasgupta et al 2002, 155)

The increasing urbanization of eastern China suggests a coming breaking or transition point. In the econometric regression estimated by Cole, Elliot, and Fredriksson (2006), they found that there existed a negative relationship of regulation levels and urbanization that became positive once a majority of the population no longer lived in rural areas. The demand for increased action on the enforcement problem might become overwhelming for the governing bodies; even now Reuters reports government officials are blaming pollution as a cause behind social unrest or "mass incidents" (Buckley 2007).

Left behind in the economic expansion and relatively removed from the international trade experience, by contrast, is agricultural western China. If public unrest, buoyed by expanding personal wealth and increased urbanization, is able to bring about a tightened environmental policy in the east, it does not immediately follow that this will be the case in the west. Hotte et al (2000) demonstrated in a model with endogenous enforcement that the opening of trade may result under the right circumstances, such as where enforcement costs outweigh income gains, in a decrease of social welfare even as it undergoes the process of moving to a private property rights regime. The immense size of the nation, vast differences in economic character, focus of foreign investment in the manufacturing east, and the problem of decentralized enforcement may result in the creation of two de facto environmental regulatory regimes: strengthening along the coast and weak from lax enforcement at the frontier.

India, which by its very size and its projected emergence as an economic power invites comparison to China, has a very different road ahead. India's comparative advantages are in information services and in garment production, industries that are less pollution-intensive than the manufacturing industries of China (Dasgupta et al 2002).

Economic openness may serve India better than China in terms of combined economic and environmental welfare. Often, it is the pollution-intensive industries, such as steel, that are government protected and subsidized. The removal of protective barriers and increased openness forces either the consolidation or the reduction in the scale of these industries as more efficiently produced world goods become available in the domestic market (Dasgupta et al 2002). The social cost of this consolidation, namely the end of smaller family-held firms and the resulting unemployment, naturally creates a political impediment to rapid change.

Though the picture in India appears to be more optimistic from an environmental perspective, as it bypasses the traditional industrial path of agriculture-to-manufacturing-to-service, this not to say that the long-term economic solution will provide an acceptable short-term environmental solution. The desire for the same comforts of the developed nations, and the increased consumption associated with income growth, will create strains.

As Esty (2001, 115) writes of many developing nations, they "are living through the part of the Kuznets curve in which environmental conditions deteriorate". Pollution problems tend to become worse before they become better in the early stages of development.

Though India may be in its early stages of the environmental Kuznets curve, it has far surpassed sub-Saharan Africa. Understandably, the "acute economic despair" of the region translates into an unwillingness for improved environmental regulations "at the expense of other economic objectives" (Ukpolo 1994). In the context of environmental protection, parts of sub-Saharan Africa represent a 'perfect storm': institutional failures in the form of corruption and weak property rights, political instability, extreme poverty, an economy based on agricultural and extraction, and a fragile ecosystem unable to absorb the potential damage from the early stages of economic development.

Sub-Saharan Africa's poverty presents the possibility that the length of time it takes for economic development to reach a point where environmental concerns take priority could be disastrous. Historically, the political stability that enables the creation of more stringent regulations (Mani and Fredriksson 2004) and economic improvement has been lacking. The corruption levels suggest that even with such economic growth, environmental regulations would be slow to develop.

In Cole, Elliot, and Fredriksson (2006)'s model, they found that "in an imperfectly competitive market, the government has an incentive to lower the pollution tax below the first-best level (equal to marginal damage) in order to stimulate output and raise consumer surplus", but as more firms entered the market the government incentive to lower these standards decreases. Their model determined it is the "degree of corruptibility" that determines the "net effect of an additional foreign subsidiary". In India and China, the result of an influx of numerous foreign firms is decreased market power to dictate the level of pollution controls in place. The industries that dominate sub-Saharan African economies are resource extraction and agricultural, which by their very nature limit firm entry and therefore increases the impact of corruption on the development and enforcement of stricter environmental regulations.

The other institutional factor at play for sub-Saharan Africa is the question of weak enforcement of property rights. Chichilnisky (1994) suggests the existence of a gap between the well-defined rights in developed nations and the poorly-defined rights of developing nations will "create trade, and that trade itself can exacerbate the common-property problem." This property rights problem extends to all factors of production, including the environment, which is an "unregulated common property". The expected results are under-priced goods that lead to over-consumption in developed nations and over-production in the developing nations. Corrective taxes are ineffective at reducing this excess exploitation, Chichilnisky argues, in that they force low-income harvesters to "work harder and extract more resources to meet their consumption needs." It is worth considering that agricultural prices are artificially high, in part because of subsidization in the developed world in contrast to taxation in the developing world (Antle 1993), but free trade would deflate prices and give rise to a scenario where it would be difficult to envision the widespread economic growth required for the institution and enforcement of environmental regulatory reforms.

Agriculture and natural resource extraction is by nature environmentally sensitive. While there are evident long-run growth benefits to tighter environmental protection for an industry dependent on the health of the environment, the costs to such decision are short-term (Bovenberg and Smulders 1996), and for those in extreme poverty the trade-off may seem unacceptable. The form of agricultural pollution also lends itself to comparison with the econometric results of section IV. Increased trade is likely to result in increased levels of pollution, as those that derive gain from trade and can privately mitigate the negative effect, and resist any imposition of tougher standards and regulations. Even if such regulations were in place, as in China, the associated cost might be so prohibitive as to make them unenforceable. If nothing were to change, the short- to medium-term environmental damage of increasing economic liberalization may very well irreparably degrade the very industries in which sub-Sahara Africa has a comparative advantage and undermine any hope of trade-induced growth.

While institutional or market failures may alter the size and shape of the environmental Kuznets curve, empirical evidence suggests technology (Grossman and Kreuger 1995) and increased public information are resulting in a Kuznets curve that is shorter and steeper than previously experienced (Dasgupta et al 2002). In this manner, for pollutants that follow the general form of the environmental Kuznets curve, we can minimize the period prior to the introduction of significant environmental regulations and increase economic welfare.

CONCLUSIONS

Evidence suggests that while trade exerts a positive force on the abatement of certain forms of pollution, local pollutants with wide negative effects touching a cross-section of society, and therefore such generalizations fail to fully capture the complexity of the trade-environment relationship. The ability of high-income individuals to privately mitigate the effects of a pollutant, as demonstrated in the econometric regression of section IV, may diminish any trade-induced environmental gains. In that scenario, the results would appear to suggest decreased economic restrictions would further increase the levels of the particular pollutant, despite the gains in societal wealth.

While beyond the scope of this paper, pollutants with largely transboundary issues, such as greenhouse gases, further muddle the discussion of economic liberalization's environmental impact by introducing a free-rider problem. In advocating for trade linkages for transboundary issues, Esty (2001, 119) correctly observes that "[n]ational governments, no matter how well intended, cannot address inherently international problems such as climate change or fisheries depletion unilaterally."

It is tempting, as developed in the theory, to perceive increased levels of economic liberalization as a generalized means of attaining both economic and environmental welfare such that it takes on status as a "win-win" scenario. The application of this result as an effective counter to environmental concerns is, as is often the case with generalizations, largely confined to the artificial construct of theory. What determines the elasticities of the various effects altering environmental conditions are the individual characteristics of the region and the form and nature of the pollutant itself. These factors are vital points of consideration in the development of an effective and welfare-maximizing policy response to increased economic liberalization.

There remains, however, good cause to advocate for both increasing levels of economic liberalization and of environmental regulations. Strict environmental policies in developed nations, especially if introduced and enforced with economic incentives rather than total reliance on traditional command and control policies, spur technological innovation. The lowered tariffs from economic liberalization lead to less expensive cleaner imports and pressure builds to use more efficient, less pollution-intensive technology and techniques in order to compete. Access, partly achieved through the reduction of trade frictions, and the dispersal of that knowledge becomes essential as we move forward, especially in regions that we risk leaving behind.

Growth through economic liberalization ultimately improves environmental regulations for many serious pollutants affecting human societies, but it is not a total solution for the environmental problems in either the developing or developed world. The short-term and medium-term problems facing these nations are very real and unless care is taken to consider the characteristics of regions at the extremes and their institutional qualities, trade could exacerbate an existing problem. Drezner (2001) noted that globalization was not deterministic, but shaped by the ability of states to cooperate.

In spite of its shortcomings in universally addressing various forms of pollution, the long-term approach of the environmental Kuznets curve provides reason for optimism in an increasingly integrated world. Despite dire predictions of a race-to-the-bottom, "major urban areas in China, Brazil, Mexico and the United States have all experienced significant improvements in air quality" (Dasgupta et al. 2002) with increased economic openness. For much of the world and for many types of pollutants, the theory and evidence supports the contention that economic welfare growth through trade and openness ultimately has positive benefits on the creation, development, and enforcement of environmental regulations. Its future application, with an eye towards regulation and enforcement policies that reflect the challenges of national characteristics and the factors of individual pollutants, is likely to only continue this trend. In extreme cases, pollution havens can occur (Dasgupta et al 2002), and the unique form of the pollutant's impact can diminish trade-related gains, but these exceptions, rather than ominous and inescapable prophecy, should be treated as cautionary notes that allow nations to react and adjust in such a way as to minimize the negative effects and protect both the economic and environmental welfare gains.

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