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THE EFFECTS OF TRADE LIBERALIZATION ON THE ENVIRONMENT: AN EMPIRICAL STUDY

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1.0. Introduction

Extensive debate currently exists over the question of free trade's effect on the environment. A central issue in the discussion is the potential for trade liberalization to increase incomes, encouraging economic growth. Two studies by Grossman and Krueger (1993; 1995) find evidence in support of an inverse U-shaped relationship between per capita income growth and pollution levels. Referred to as the Environmental Kuznet's Curve (EKC), this relationship hypothesizes that economic growth in a country will bring an initial period of environmental deterioration, followed by a subsequent phase of improvement. The policy impacts of the EKC hypothesis could be significant, since it finds no evidence that economic growth related to free trade does unavoidable harm to the environment. (Grossman and Krueger, 1995)

According to Antweiler *et al* (2001), however, the relevant economic theory gives little reason to believe that free trade will influence all countries in the same way. Instead, when considering the relationship between openness and the environment, it is important to consider the interactions between scale, composition, and technique effects created by different national characteristics and trading opportunities (Antweiler *et al*, 2001; Copeland and Taylor, 2004). The scale effect of openness to trade increases environmental degradation through more intensive production. The technique effect reflects cleaner production processes arising from increased demands for environmental quality as income levels rise. The composition effect will shift production between environmentally beneficial or damaging goods, depending on the competitive advantages

between trading partners. The relative strength and direction of these effects will cause the environmental impact of trade liberalization to differ across countries.

Furthermore, theoretical analysis highlights the potential for government policy and environmental regulations to alter these effects. The pollution haven effect hypothesizes that the stringency of environmental regulation distorts how competitive advantages are utilized by influencing plant location decisions and trade flows (Copeland and Taylor, 2004). Deacon and Mueller (2004) argue that corrupt governance may impede the technique effect by rendering governments unresponsive to public demands for greater environmental quality. Damania *et al* (2003) and Welsch (2004) also find that corruption can cause environmental degradation by reducing the effectiveness of environmental regulations. Both the pollution haven effect and corrupt governance could thus affect the transferability of the EKC between countries.

To investigate these relationships further, panel data across countries is utilized to evaluate the environmental effects of freer trade. Models test the effect of trade liberalization to see whether an EKC is observable in all or only particular countries. Moreover, the panel nature of the data allows heterogeneity between nations to be controlled so that comparisons can be made of how national characteristics influence the impact of freer trade. This study is unique in its application of panel data to evaluate the impacts of trade liberalization on the environment while controlling for national characteristics that can distort the competing scale, technique and composition effects among countries. The approach taken is based on emerging economic theory on trade, environment and development.

2.0. Methodology

2.1. Data

All data, except for the governance index, has been obtained from the *World Development Indicators* Online Database, which is assembled by the World Bank. The dependent variables under consideration are carbon dioxide (CO2) emissions and organic water pollutant (BOD) emissions. CO2 emissions are those stemming from the burning of fossil fuels and the manufacture of cement. The dataset for CO2 is composed of measurements for 143 countries spanning the years 1970 to 2000. Emissions of organic water pollutants are measured by biochemical oxygen demand (BOD), which refers to the amount of oxygen that bacteria in water will consume when breaking down waste. BOD is a standard water-treatment test for the presence of organic pollutants. The dataset for BOD includes observations for 119 countries spanning the years 1980 to 1995.

As discussed above, income may play a strong role in determining the environmental outcomes of trade across countries. Per capita Gross Domestic Product (GDP) is therefore obtained to act as a proxy for the per capita income of a country. To estimate the effects of openness on emissions, cross-country data on trade levels is also obtained. Additional country specific data is gathered on total population levels, domestic land area and urban population levels in order to control for possible influences of these national characteristics in explaining emissions of CO2 and BOD. Data on governance is retrieved from the University of Maryland's *Polity IV* project.

Before proceeding, it should be addressed that complete panels of data could not be obtained for all countries in the dataset. This is a common problem with panel data and can be corrected by using unbalanced panel estimation methods (Greene, 2003;

Verbeek, 2004). Unbalanced panel estimation avoids losses in efficiency by using all available observations, including those for countries that are not observed in all years of the dataset.

2.2. Econometrics[1]

The use of panel data allows for the modeling of differences in behaviour across subjects. Heterogeneity across countries is therefore the central focus of the empirical analysis in this paper. According to Verbeek (2004), a random effects model is the most appropriate panel data model for focusing on differences across countries with certain characteristics. A general formulation of the random effects model can be expressed as:

$$y_{it} = \mu + x'_{it}\beta + \alpha_i + \varepsilon_{it}; \qquad \alpha_i \sim IID(0, \sigma_\alpha^2) \quad \varepsilon_{it} \sim IID(0, \sigma_\varepsilon^2) \tag{1}$$

where β measures a constant partial effect for the x_{it} across years t and countries i, μ is the intercept term and the random parameters α_i capture individual effects and are assumed independently and identically distributed (IID) over countries. The model depicted in equation (1) will be estimated twice, once with BOD emissions as the dependent variable, and again with CO2 emissions as the dependent variable. All variables included in the models are described in **Table 1**.

[1] The econometric theory depicted in this section draws largely from the works of Greene (2003) and Verbeek (2004).

Table 1: Descriptions of all Variables included in the Random Effects Models.

VARIABLE	*DESCRIPTION*
BOD	Organic Water Pollutant Emissions (kg per day).
CO2	Carbon Dioxide Emissions (kt per year).
GDP	Gross Domestic Product per Capita (Constant 1995 US$).
GDP2	Square of *GDP*. Included to capture non-linear effects of per capita income growth on emissions.
Trade	Trade (% of GDP). Included as a proxy for openness.
Polity	The degree to which a country is democratic or autocratic, as coded by the *Polity IV* index (-10 = strongly autocratic; +10 = strongly democratic).
Pop	Total population.
Land	Land area (Square km).
Urban	Urban population (as a % of total population).
Disrupt	Variable created to capture the years in which a country was coded by the *Polity IV* project as having had a disruption in governance (1 = coded for disruption; 0 = no disruption, regular polity index applies).
Respond	Interaction term capturing the specific effects of GDP per capita for countries coded as democratic (index ≥ 1) by the *Polity IV* project.
Respond2	Interaction term capturing the specific non-linear effects of GDP per capita (i.e. *GDP2*) for countries coded as democratic (index ≥ 1) by the *Polity IV* project.
ATrade	Interaction term capturing the specific effects of openness to trade (*Trade*) for countries coded as strongly autocratic (index ≤ -5) by the *Polity IV* project.
Haven	Interaction term capturing the combined effects of GDP per capita (*GDP*) and openness to trade (*Trade*).

The effect of openness on environmental quality will be given by the coefficient on the variable *Trade*. A positive coefficient on *GDP* coupled with a negative coefficient on the non-linear term *GDP2* would indicate a possible EKC relationship. The coefficient on the variable *Polity* will describe the direct effect of a country's governance on its environmental quality, but of greater interest for the purposes of this paper will be the estimators on the terms interacting governance with openness, *ATrade*, and with income; *Respond* and *Respond2*. Drawing from the economic literature discussed above, the interaction *ATrade* is included in order to test the hypothesis that openness will affect the environment differently in more autocratic countries than in more democratic ones.

Respond and *Respond2* are included in order to test the hypothesis that democratic countries will be more responsive to increased demands for environmental quality as per capita incomes grow, indicating a stronger technique effect from trade. Finally, again based on the economic theory developed earlier, a third interaction term *Haven* is included in order to test the hypothesis of a pollution haven effect between relatively rich and poor countries.

The random effects models to be estimated are therefore formulated as the following equations:

$$BOD_{it} = \mu + \beta_1 GDP_{it} + \beta_2 GDP2_{it} + \beta_3 Trade_{it} + \beta_4 Polity_{it} + \beta_5 Pop_{it} + \beta_6 Land_{it} + \beta_7 Urban_{it} + \beta_8 Disrupt_{it} + \beta_9 Respond_{it} + \beta_{10} Respond2_{it} + \beta_{11} ATrade_{it} + \beta_{12} Haven_{it} + \alpha_i + \varepsilon_{it} \quad (2)$$

$$CO2_{it} = \mu + \beta_1 GDP_{it} + \beta_2 GDP2_{it} + \beta_3 Trade_{it} + \beta_4 Polity_{it} + \beta_5 Pop_{it} + \beta_6 Land_{it} + \beta_7 Urban_{it} + \beta_8 Disrupt_{it} + \beta_9 Respond_{it} + \beta_{10} Respond2_{it} + \beta_{11} ATrade_{it} + \beta_{12} Haven_{it} + \alpha_i + \varepsilon_{it} \quad (3)$$

where *i* again represents the country and *t* the year. Initial estimates of models (2) and (3) were run and the specification tested using the Hausman test. Results of the Hausman test indicated that the x_{it} and α_i were correlated in both models, which is problematic since it suggests that the coefficients estimated with the random effects method will be inconsistent. Hausman and Taylor (1981) show that this issue can be corrected by instrumenting the correlated variables by their value in deviation from the individual (or in our case country) specific means. The newly derived instrumental variable estimators, referred to as the Hausman-Taylor estimators, will then by construction be uncorrelated with α_i.

3.0. Results

Results for the Hausman and Taylor instrumental variable estimators are summarized in **Table 2**.

Table 2: Hausman and Taylor Instrumental Variable Estimators for Panel Data Models Estimating the Effects of Openness on BOD and CO2 Emission Levels.

VARIABLE	***REGRESSAND = BOD (MODEL 2)***	***REGRESSAND = CO2 (MODEL 3)***
GDP	42.8956* (16.1562)	20.3391* (2.7251)
GDP2	-0.00155 (0.000979)	-0.000323* (0.0000797)
Trade	849.4993* (391.0458)	282.5713* (70.7702)
Polity	2544.4887 (2437.3317)	-736.8967** (422.6989)
Pop	0.00741* (0.00026)	0.00363* (0.000049)
Land	-0.05629* (0.0233)	0.0339* (0.0103)
Urban	4529.1797* (1385.09)	144.4103 (201.7152)
Disrupt	-1006.3682 (6521.4633)	2615.0143* (1256.1187)
Respond	-25.8889* (12.1007)	1.1796 (1.8762)
Respond2	0.00125 (0.000938)	0.0002* (0.00007)
ATrade	782.1948* (337.1787)	50.4677 (60.0931)
Haven	-0.10007** (0.05928)	-0.1002* (0.0084)
Constant	-403635.9* (85796.9)	-117481.6* (25159.6)
# Countries	N = 119	N = 143
Years	1980 - 1995	1970 – 2000

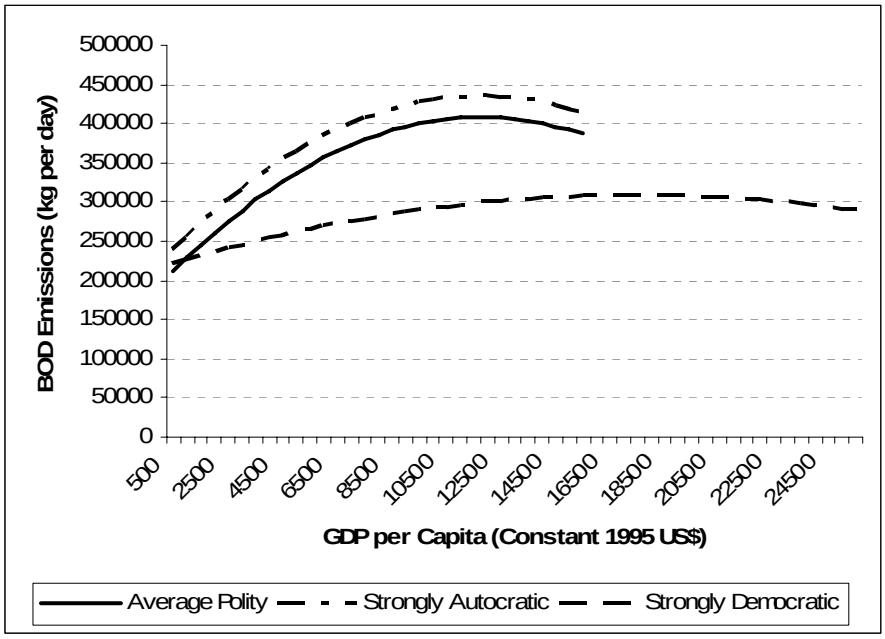
1 Standard errors provided in parentheses.
2 * indicates significance at the 5% level or better
3 ** indicates significance at the 10% level or better

3.1. Estimated Effects for Organic Water Pollutant (BOD) Emissions

Several inferences can be drawn from the estimated effects of the instrumental variables on the dependent variable *BOD* (Model 2). First of all, the variable *Trade* is positive and significant at the 5% level, which indicates that BOD emissions will be

worse in more open economies, *ceteris paribus*. A more interesting picture, though, emerges when the estimators on the interaction variables are considered in addition to the results for *Trade*.

Figure 1:Predicted BOD Emission Levels for Countries with Different Types of Governance as per Capita Incomes Increase.[2]



1 Average polity provided as a base case: *Polity* = 0.
2 For Strongly Autocratic *Polity* = - 5
3 For Strongly Democratic *Polity* = + 5.

The positive coefficient and small standard error on *ATrade* suggests that the environmental effects of openness to trade will be significantly different in strongly autocratic countries versus democratic or even weakly autocratic countries. Furthermore, the positive coefficient on *GDP* coupled with the negative coefficient for *GDP2* indicates that a representative country in our sample may follow an EKC path of BOD emissions as per capita income levels grow. Therefore, to the extent that an EKC for BOD

[2] Depictions for countries of average or strongly autocratic governance types are cut off at a per capita GDP of $15,000.00 because the BOD dataset does not support observations beyond this point.

emissions is observable, the coefficient on *ATrade* suggests strongly autocratic governance will cause an upward shift in emissions for any given level of per capita income, meaning a higher peak in the EKC and greater degradation before environmental improvements occur.[3] Furthermore, the negative, strongly significant coefficient on *Respond,* coupled with its large magnitude in comparison to that for *GDP*, suggests that the marginal effect of an increase in per capita income will be significantly reduced for democratic countries. These results for the regression of *BOD* on our instrumental variables are depicted in **Figure 1** above.

3.2. Estimated Effects for Carbon Dioxide (CO2) Emissions

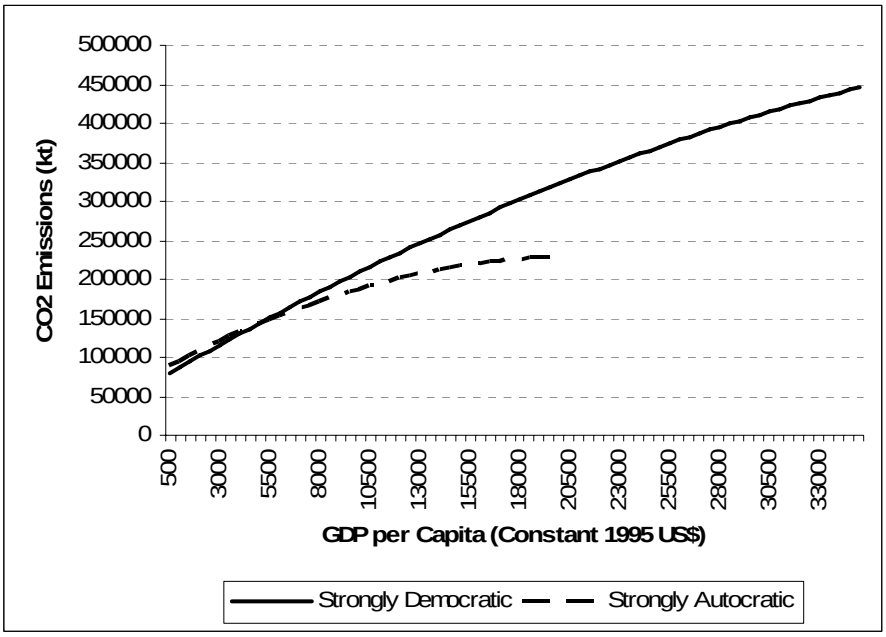
Interpreting the estimated effects of the instrumental variables on the dependent variable *CO2* (Model 3) yields some interesting comparisons. First, the variable *Trade* again has a positive and significant coefficient, indicating that CO2 emissions also increase with openness to trade, *ceteris paribus*. Furthermore, the variable *Polity* is weakly significant in this model, and its negative estimator indicates that an increase in the democracy level of a country (or lessening of autocracy) will marginally decrease emissions of CO2. However, the inclusion of *ATrade*, which interacts the effects of these two variables, is now found to be insignificant meaning that we fail to reject the null hypothesis that openness affects the environment similarly in autocratic and democratic countries.

Investigating the model further, we find a positive coefficient on the *GDP* variable and a negative coefficient on the *GDP2* variable, again indicating a possible

[3] Of note, while the estimated effect for *GDP* is highly significant, the insignificant coefficient for *GDP2* suggests that the downward sloping portion of the EKC might not be empirically observable.

EKC path for the relationship between emissions and income per capita. Moreover, unlike the estimators for BOD, both the linear and non-linear terms are now statistically significant, lending credibility to the hypothesis of reduced CO2 emissions at higher levels of income per capita. However, a curious result is obtained when the *Respond* and *Repsond2* variables are considered in conjunction with these results. While the estimator on *Respond* is insignificant, the positive and significant coefficient for *Respond2* will directly counteract the marginal effect of the *GDP2* estimator. Furthermore, the similar magnitude of these two estimators indicates that the non-linear component of the EKC will be almost entirely reversed for democratic countries. These results for the regression of *CO2* on our instrumental variables are depicted in **Figure 2** below.

Figure 2: Predicted CO2 Emission Levels for Countries with Different Types of Governance as per Capita Incomes Increase.[4]



1 For Strongly Democratic *Polity* = + 5.
2 For Strongly Autocratic *Polity* = - 5.

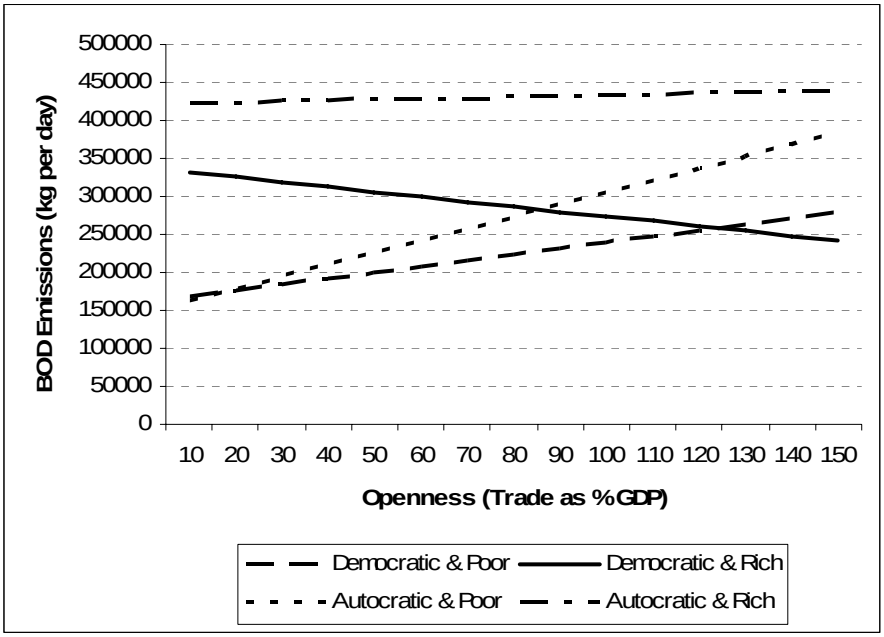
[4] The depiction for strongly autocratic countries is cut off at a GDP per capita of $20,000.00 because the CO2 dataset does not support observations beyond this point.

3.3. The Pollution Haven Effect

As discussed earlier, the pollution haven effect hypothesizes that relatively rich countries, which experience greater demand for environmental quality, may enact more stringent environmental regulation while taking advantage of trade and allowing poorer open countries to produce and sell products with high emissions. A negative coefficient on the *Haven* variable would thus indicate that rich countries may be utilizing trade to transfer pollution intensive activities outside their borders.[5]

The estimators on the *Haven* variables in each model are, indeed, negative. Moreover, this effect is strongly significant in the CO2 model and weakly so in the BOD model. We therefore fail to reject the hypothesis of a pollution haven effect between relatively rich and poor open economies. Depictions of these effects are provided in **Figures 3** and **4** below.

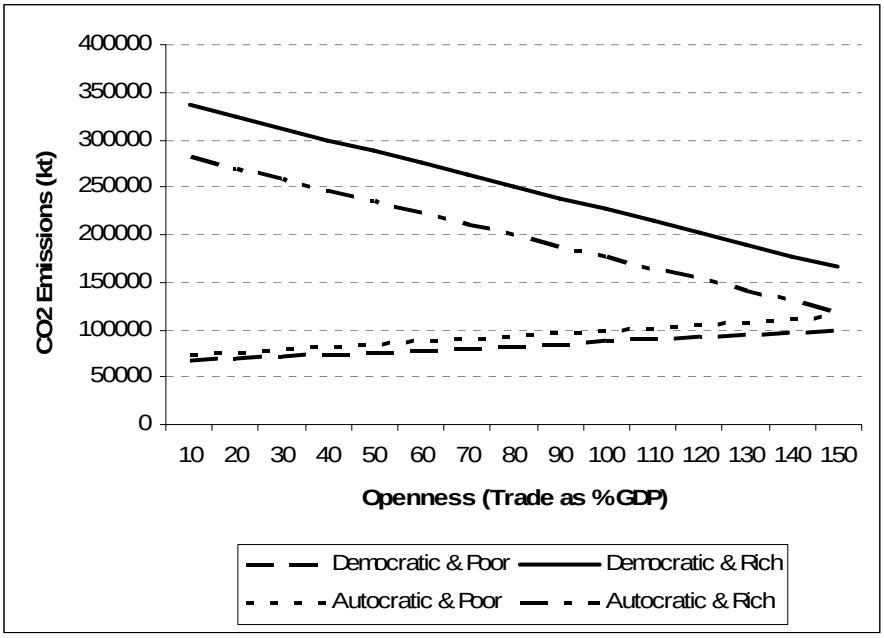
Figure 3:Potential pollution haven effects for BOD emissions.



1 Rich GDP per capita = $15,000.00; Poor GDP per capita = $500.00.
2 Democratic *Polity* value = + 5; Autocratic *Polity* value = - 5.

[5] The development of these ideas and test method closely follow the work of Frankel and Rose (2005).

Figure 4: Potential pollution haven effects for CO2 emissions.



1 Rich GDP per capita = $15,000.00; Poor GDP per capita = $500.00.
2 Democratic *Polity* value = + 5; Autocratic *Polity* value = - 5.

Interpreting the results in **Figures 3** and **4** provides some interesting insights. To begin, as reflected by the negative coefficients on the *Haven* variables, we see that in both models emissions increase as poor countries become more open to trade, but tend to decrease with greater openness in rich countries. In general, these observations support the potential for a pollution haven effect. The one exception to this trend is for relatively rich, autocratic countries in **Figure 3** (the BOD model), where emissions appear to stay relatively constant as openness increases. This anomaly can be accounted for by recalling that, due to the variable *ATrade*, BOD emissions increase for autocratic countries as free trade increases, likely negating any decline in emissions that may result from a pollution haven effect.

4.0. Discussion and Conclusion

The purpose of this paper was to report an empirical study into the effects of trade liberalization on the environment. Econometric models are estimated to predict the effects of openness on organic water pollutant (BOD) and carbon dioxide (CO2) emissions, and both models find that freer trade significantly increases emissions, thus reducing environmental quality. However, the panel data used in this study allowed inferences to be drawn beyond these *ceteris paribus* effects. By controlling for unobserved heterogeneity between countries, several additional observations are made regarding the impact of freer trade on the environment.

The model predicting BOD emissions suggests that the promotion of democracy may help to improve the relationship between trade liberalization and environmental quality. It is observed that democratic governments can induce significant reductions in BOD emissions as income levels rise while in open countries strongly autocratic governments increase water pollution at any given income level. The results from the model predicting CO2 emissions are more troubling, though. Here, we find that while democratic countries CO2 emissions appear to increase almost monotonically with income, these effects may be moderated for autocratic countries. It is unclear how to interpret these results, as it makes little sense to suggest promoting autocracy as a means for reducing CO2 emissions. Further research into the relationship between trade and purely global externalities, such as CO2, is clearly needed. One potential avenue, proposed by Copeland and Taylor (2005), suggests that international agreements reducing pollutants, like the Kyoto Accord, may be more efficient under conditions of free trade. Such a result might counteract the effects of openness on CO2 emissions

observed here. Alternatively, incorporating the endogeneity of trade and income into the model could prove interesting (see Frankel and Rose, 2005).

Finally, the results from testing for the pollution haven effect also provide some cause for concern. By failing to reject the pollution haven hypothesis, the transferability of the environmental improvements that rich, developed countries appear to experience through trade liberalization is called into question. Currently developing countries may not be able to grow their economies in the same way.

5.0. References

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