Environmental Standards and Dirty Exports:

A Case Study Analysis of 24 Countries

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I. Introduction

The relationship between environmental standards and trade is at the forefront of policy debate. Disputes over linkages between trade and the environment have intensified over the past decade. The Seattle Ministerial of the World Trade Organization in 1999 ended in failure, at least in part, due to profound differences over the tying of environmental performance to market access.

Most of those who fear that lenient environmental regulations would lead to specialization in dirty industries in developing countries rest their arguments on the "factor abundance" concept promoted by trade theory. According to this argument, environment is treated as a factor of production that is directly used for agricultural and industrial production as input or that the environment is degraded through air and water pollution as an end product of production processes. The Heckscher-Ohlin theorem, if it is extended to this context, suggests that countries which are environmentally abundant will, under a free trade regime, specialize in pollution intensive goods.

Environmental abundance can take two forms; it could simply mean that a country has a large natural assimilative capacity. This could be the case in countries that are still in the very early stages of industrialization. In this case, countries could tolerate higher emission levels relative to other countries, and could be characterized as "environmentally abundant". Environmental abundance could also be a direct result of lax environmental regulations and policies which emphasize economic growth at the cost of the environment. A country's relative environmental abundance could be increased further, if it was paralleled by the imposition of stringent environmental regulations by other countries that produce similar goods.

Investigating the impact of environmental polices on trade patterns is important for two reasons; first, if environmental abundance is created merely by regulation, then there is room for limiting such a trend, possibly through international agreements, or by increasing public awareness of the issue. Second, an argument that has been frequently used by industries is to exert pressure on governments in developed countries to hinder imposition of stringent regulations, or to gain concessions from developing countries on environmental regulations.

If such a correlation does exist, then there is a need for coordination among developed and developing countries to prevent the so called “race to the bottom.” However, if lax environmental regulations do not serve as an incentive for industries, then developing countries should refrain from providing environmental concessions in hopes of enhancing their own industries or by promoting foreign investment in such industries.

This paper examines how the stringency of environmental regulations affects international trade patterns. It explores the hypothesis that lax environmental regulations foster specialization in pollution intensive goods, which is particularly relevant to developing countries. We develop a model that complies with industries that differ in their pollution intensity. The industries examined are mining, metals, pulp and paper, steel, and chemicals. Our hypothesis can be associated with a Rybczynski theorem, which holds that less restrictive regulations on air and water pollution translate to an abundant endowment of these factors.

II. Trade and Environmental Regulation

Concerns over the link between environmental standards and trade patterns mostly rest on the concept of "factor abundance", and that its impact on international trade was promoted by trade theory. Environmental abundance can take two forms; it could simply mean that a country has a large natural assimilative capacity, which could be the case in countries that are still at very early stages of industrialization. Such countries may still have very low concentrations of pollutants in their air and water that would allow them to adopt lax environmental policies without posing any health hazards to the population. The other form of environmental abundance, which has received increased attention, is the one which results from lenient environmental regulations and policies. Environmental abundance could be created by policies that are adopted with the intention of attracting certain industries, without accounting for costs to human health and natural resources.

The growing concern over implementation of lenient environmental polices, especially by developing countries, has triggered an increasing number of empirical studies. While the majority of economic literature investigates the link between trade and the stringency of environmental regulations, others have focused on the concepts of factor abundance and comparative advantage. One can highlight at least two approaches that appear on economic research on the issue.

Some research has explored this issue through investigating the factors that determine industry location and whether environmental regulations have influenced offshore investment decisions. The primary question underlining these studies is: Can environmental regulations serve as an incentive or disincentive for foreign pollution intensive industries to immigrate? These types of studies are mostly concerned with the possibility of flight by pollution-intensive industries from developed to developing countries. However, the industry flight hypothesis is not supported by empirical evidence.

Pearson (1987) and Leonard (1988) have found no significant evidence for the industry flight hypothesis. Pearson found that there is no reason to believe that benefits arising from lax environmental regulations would be captured by foreign investors as opposed to local industry. Similarly, Leonard presents case studies of Foreign Direct Investment in Ireland, Mexico, and Romania and examines trade data and investment statistics. He finds no evidence that environmental regulations have altered plant location decisions. Factors such as the level of training of labour, infrastructure, and stability were much more important location decisions (Dean, 1992).

Lucas, et al investigates whether environmental regulations in OECD have led to the displacement of dirty industries to developing countries. While noting that isolating and testing the direct impact of environmental regulations on production relocation is difficult, the authors tried to track any differences in trends of growth of emissions relative to GDP, among countries across differing time periods. They tested the pollution intensity trend for a large sample of countries for three time periods. They found that growth in toxic intensity has been far more rapid in developing countries than in developed countries, suggesting that the implementation of progressively strict environmental regulations in OECD countries have led to significant location displacement of pollution intensive industries variation for three periods (Lucas, 1990).

Levinson (1996) uses the industrial location approach to measure the effect of state environmental regulations on new manufacturing plant locations in the U.S. He uses establishment-level data on location choice and pollution abatement costs. He uses two separate indices that were developed to measure environmental performance of state governments, along with other factors that affect industrial location decisions, including industry abatement costs, business taxes, wages, energy costs, and roads. He uses a logit model which measures the effect of these factors on the probability that a new industry plant would open in a certain state. He finds little evidence that stringent state environmental regulations deter new plants from opening. These findings are surprising given that the industries covered had an average abatement cost of 4 percent, which is not too small to affect location decisions. Levinson points out that firms operating in a number of states may operate according to the most stringent environmental regulations in all locations eliminating the necessity of designing different production processes for each specific location.

The other line of research treats environmental regulations as a production factor that can alter production and consequently trade patterns. This type of research is more concerned with the specialization in pollution intensive goods that arise in developing countries as a result of lax environmental regulations, potentially by domestic industries and multinationals. In theory, environmental abundance could trigger specialization in pollution intensive goods. Environment is treated as a factor of production (just like labor and capital), and countries that are environmentally abundant will, under a free trade regime, specialize in pollution intensive goods.

This industrial specialization hypothesis was examined by numerous recent studies (Tobey 1990, Low and Yeats 1992, Grossman and Krueger 1993, Xu 1999). They analyze the link between trade and environmental regulations by treating environment as a production factor whose abundance would create a comparative advantage in producing “environment intensive goods”.

Tobey (1990) employs a cross section Hecksher-Ohlin-Vanek (HOV) model to investigate whether domestic environmental regulations have an impact on international trade patterns. The model uses data on international trade in five pollution intensive industries for 23 countries. Tobey defines pollution intensive commodities as, “the products of industries whose direct and indirect abatement costs in the U.S. are equal to or greater than 1.85 percent of totals costs.” According to the author the point 1.85 percent is used because it results—when the commodities are aggregated—in a set of five industries that are generally considered the most polluting; mining, primary nonferrous metals, paper and pulp, primary iron and steel, and chemicals. He finds no evidence that environmental regulations have caused trade patterns to deviate from predictions of the Heckscher-Ohlin-Vanek (HOV) model. In other words, other factor endowments such as physical and human capital still play the major role in determining countries trade patterns (Low and Yeats, 1992).

Low and Yeats use the comparative advantage approach to investigate trade trends in trade in “environmental sensitive goods” in developed and developing countries. A country’s comparative advantage in a certain industry is measured by the share of that industry in total exports, relative to the industry’s share in total world export manufactures. They study trade trends in pollution intensive goods for a large sample of developed and developing countries between 1965 and 1988. They find that “dirty industries” account for a large growing share of exports of some developing countries, and a decreasing share of exports of developed countries. The authors have emphasized that their model and the aggregated data does not allow isolation and capturing the effect of environmental regulations on the observed trade trends.

Grossman and Krueger (1993) investigate the environmental impact of North American Free Trade Agreement (NAFTA). They regress 1987 data on US imports from Mexico in 135 industries using factor shares, which indicate different factor intensities for each industry. They measure environmental intensity by using the ratio of pollution abatement costs to the total value added to a specific US industry. They found no evidence that a competitive advantage is being created by lenient environmental regulations in Mexico. The traditional determinants of trade and investment came out significant.

Xu (1999) uses an extended gravity equation framework to test whether differences in environmental regulations have affected patterns of bilateral trade between a sample of developed and developing countries in pollution intensive Goods. He defines POLLUTION INTENSIVE GOODs as products of industries that incurred pollution control costs in the U.S. of approximately 1 percent or more of the value of their total sales in 1988. This definition results in four industries; iron and steel, metal manufactures, cement, and agriculture chemicals. The framework uses a stringency index of environmental regulations developed by the Dasgupta et al. (1995) that measures the relative "environment stock" in each country. He found no evidence that countries with stricter environmental standards lower their total exports of pollution intensive goods.

This study belongs to the second type of literature. We are more concerned with production specialization patterns, which are assumed to be reflected in trade patterns whether they are caused by FDI, or is just simply increased domestic investment in the industries which we are concerned with. Therefore, we utilize the cross-section multifactor HOV model that incorporates a measure of environmental endowment to test whether or not exports of pollution intensive goods are negatively correlated with the stringency of environmental regulations. The implicit assumption here is that more stringent environmental regulations reflect environmental scarcity. Clearly, the major data constraint that dictated our choice of the countries to study was the environmental stringency variable. We have made use of the World Bank indices developed by Dasgupta et al. (which were also used by Xu) as a measure of the environment stock. These indices measure the status of environmental policy and performance using a UNCED survey of 31 countries. Tobey studied five pollution intensive industries; mining, primary nonferrous metals, paper and pulp, primary iron and steel, and chemicals.

III. The Measure of Stringency of Environmental Regulation and Model Specification

An index of stringency in environmental regulation was developed by Dasgupta et al. (1995). A higher score in the index reflects more stringent environmental standards.

The authors have randomly selected 31 UNCED reports from a total of 145 (see Table 2A, p. 6). These 31 countries range from highly industrialized to extremely poor. They are drawn from every world region, and they range in size and diversity from China to Jamaica.

Based on these reports, they conducted a survey that considers the state of policy and performance in four environmental dimensions: Air, Water, Land and Living Resources. We analyzed the apparent state of policy as it affects the interactions between these four environmental dimensions and five activity categories: Agriculture, Industry, Energy, Transport and the Urban Sector. Although many overlaps undoubtedly exist, we attempt to draw a separate assessment for the interaction of each activity category with each environmental dimension.

The survey assessment uses twenty five questions to categorize the state of (i) environmental awareness; (ii) scope of policies adopted; (iii) scope of legislation enacted; (iv) control mechanisms in place; and (v) the degree of success in implementation. The status in each category is graded High, Medium, or Low, with assigned values of 2, 1 and 0, respectively. For each UNCED country report, all twenty-five questions are answered, and then the scores are developed for each country.

They compute four composite indices by adding scores within each environmental dimension. They also calculate a total score to provide a composite index of the state of environmental policy and performance.

Table 1 shows the composite scores assigned to the countries subject to our study. Germany has the highest score at 951 that is approximately higher than Malawi that has the lowest score at 352. The highest five countries are all in West Europe whereas the lowest five countries are in Africa or South Asia. This suggest a correlation between stage of development and stringency of environmental regulation.

Table 1. Index of the environmental regulations stringency in 24 countries

Country	Env	Country	Env
Germany	951	India	507
Switzerland	947	Brazil	493
Netherlands	900	Jordan	474
Finland	894	Kenya	463
Ireland	871	Thailand	449
Bulgaria	750	Philippines	447
Korea	686	Paraguay	443
Jamaica	633	Egypt, Arab Rep.	441
South Africa	619	Zambia	439
Tunisia	589	Mozambique	378
Trinidad and Tobago	564	Bangladesh	366
China	529	Malawi	352

Source: Dasgupta et al. (1995).

A high correlation is also found between stage of development and capital labor ratio. Table 2 shows ranking of countries with respect to capital labor ratio. The highest five countries are the same as those in Table 1. Four countries of the lowest five are in the lowest five in Table 1. As Nordstrom (2001) indicates, correlation between capital labor ratio and stringency of environmental regulation is high. Since many manufacture industries are capital intensive, this correlation can prevent us from observing potential relationship between stringency of environmental regulation and exports. This problem perhaps tends to be more apparent in Chemicals Industries, which require more advanced technology and capital investment, and less apparent in Mining Industry, which requires simpler technology and more labor inputs.

In order to mitigate the effect of this correlation on the regression analysis, we divide the sample into four groups which are ranked by capital intensity.

Table 2. Capital and Labor Ratio in 24 Countries ($ 1,000/worker)

Croup	Country		Group	Country	
1	Switzerland	85.99	3	Jamaica	4.84
	Germany	65.86		Paraguay	4.70
	Netherlands	50.50		Bulgaria	3.15
	Finland	48.55		Egypt, Arab Rep.	2.57
	Ireland	33.78		Philippines	2.49
	Korea	28.36		China	1.06
2	Brazil	9.13	4	India	0.78
	South Africa	7.76		Bangladesh	0.53
	Trinidad and Tobago	7.37		Zambia	0.52
	Thailand	6.48		Kenya	0.47
	Tunisia	6.15		Malawi	0.41
	Jordan	5.88		Mozambique	0.24

Source: Authors' calculation from the World Development Indicator (World Bank)

We estimate the relationship between the stringency of environmental regulation and the country's exports in polluting industries using a regression method. We use an index of the stringency of environmental regulation developed by the World Bank in this analysis. Our study extends the scope of Tobey's study by expanding the chemical industries into three sub-industries; Inorganic Chemicals, Organic Chemicals, and Plastics. These industries are:

Mining : SITC (Revision 1) 281, 283

Primary metals : 681, 682, 683, 684, 685, 686, 687, 689

Pulp and waste paper : 251, 641, 642

Primary iron and steel : 671, 672, 673, 674, 675, 676, 677, 678

Inorganic chemicals : 513, 514

Organic chemicals : 512

Plastics: 581

The analysis employs trade data on these industries from 24 developed and developing countries for which the World Bank has environmental regulation data available. We use a regression model based on the HOV model but with gross exports for dependent variable instead of net exports.

The regression model for an individual industry is specified as follows:

$$Y_{j,t} = b_0 + b_1 cap_{j,t} + b_2 lab_{j,t} + b_3 coal_{j,t} + b_4 oil_{j,t} + b_5 arland_{j,t} \tag{1}$$
$$+ b_6 schl_{j,t} + b_7 env_{j,t} + b_8 env_{j,t}^{\ 2} + b_{01} D1 + b_{02} D2 + b_{03} D3 + e_{j,t}$$

where the subscripts *j* and *t* denote country and year, Y is the value of exports (US$ million) in country *j* in the year *t*. Capital stock (*cap*), labor (*lab*), coal (*coal*), oil (*oil*) and arable land (*arland*) are included as they measure resource endowments of a country. Secondary school enrollment rate (*schl*) is included in our model, as it measures the quality of labor. The variable *env* is the stringency measure of environmental regulation. The quadratic term of *env* is included to capture the decreasing marginal effect of environmental regulation. Dummy variables for subregions 1 to 3, *D1* to *D3*, are included to control the capital intensity effect on exports. These variables were obtained for the five-year period between 1994 and 1998.

The parameter b_0 is the estimated coefficient for the intercept term. b_1 to b_8 are the estimated coefficients for the explanatory variables. b_{01} to b_{03} are estimated coefficients for the dummy variables. The term $e_{j,t}$ is the error term.

Capital stock (in US$ billion) is computed as an accumulated and discounted gross domestic investment flow in constant 1995 US dollars since 1980, assuming an average life of 15 years, and a constant depreciation rate of 13.3 percent per year.[1] Labor (in millions of people) is computed as the number of workers in labor force who meet the International Labor Organization definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. While national practices vary in the treatment of such groups as the armed forces and seasonal or part-time workers, in general, the labor force includes the armed forces, the unemployed, and first-time job-seekers. Arable land measures the area of arable land in hectares. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land left temporarily fallow. The value of the production of primary solid fuel in U.S dollars is used to measure the endowment of coal. The value of oil and gas production in US dollars is used to measure oil endowment.

The variable *schl* follows the definition of International Standard Classification of Education on net secondary school enrollment ratio. It is the ratio (in percent) of the number of children of official school age (as defined by the national education system) who are enrolled in school, to the population of the corresponding official school age. Secondary education completes the provision of basic education that began at the primary level, and aims to lay the foundation for lifelong learning and human development, by offering more subject- or skill-oriented instruction, with more specialized teachers.

Data on capital, labor and secondary school enrollment were obtained from the World Development Indicators of the World Bank. Data on oil gas production (in

[1] See Maskus (1991) for the discussion on this approach.

millions of barrels), and coal (in millions of short tons) were obtained from the US Department of Energy USDOE database.

IV. Results

The linear model in (1) is first estimated for the seven pollution intensive good exports using an ordinary-least square (OLS) method. Since the variance of the error term is likely to differ across countries, we tested for heteroscedasticity using the Cook and Weisberg (1983) test. The squared residuals from the OLS models were regressed on the fitted value. The test rejected homoscedasticity of the model for all studied exports at one percent level. Instead of identifying the sources of heteroscedasticity, we corrected for heteroscedasticity by weighting the observations by the square root of the OLS estimated variances from the individual country.[2] The results of this weighted least squares (WLS) method are reported in Table 3.

The results indicate negative and significant relationships between the stringency of environmental regulation and exports in four of the seven industries; Non-Ferrous Metals, Pulp and Paper, and the Inorganic and Organic Chemicals industries. The quadratic term of this variable in the regressions for these industries are also significant. The Iron and Steel industry exhibit the opposite signs to these variables. The positive sign implies a decreasing marginal effect of environmental regulation. No significance is found for these variables in the regressions for the Mining and Plastics industries.

Overall, these results are not sufficiently strong to support the hypothesis that lax environmental regulation promotes all kinds of pollution intensive good exports. But, they suggest that there are some industries that exhibit this relationship. One of the

[2] See Greene (1992) for the detail of this method.

crucial difficulties that previous studies have faced, was the strong correlation between capital intensity, and the stringency of environmental regulation. Grouping of samples with respect to capital intensity, and allowing different intercept terms for the groupings seems to help reveal this relationship.

Table 3. FGLS Coefficient Estimates for 7 Pollution Intensive Good Exports

	Mining	NFMetals	Pulp/Paper	Iron&Steel	Inorg.chem	Plastics	Org.C
Capital	-0.06**	1.30***	2.95***	5.54***	3.57***	5.55***	2.77*
	(0.03)	(0.08)	(0.23)	(0.26)	(0.26)	(0.31)	(0.20)
Labor	-11.70***	1.94***	-5.73***	-13.56***	5.84***	6.74***	5.15*
	(0.88)	(0.61)	(1.32)	(2.36)	(1.60)	(2.26)	(1.50)
Coal	0.96***	0.63***	1.37***	4.54***	0.01	-2.07***	-0.92*
	(0.23)	(0.18)	(0.46)	(0.85)	(0.48)	(0.58)	(0.43)
Oil	3.53***	-0.68***	0.04	0.39*	-0.97***	-2.72***	-0.89*
	(0.46)	(0.11)	(0.21)	(0.22)	(0.35)	(0.72)	(0.32)
Land	25.64***	-7.09***	7.17***	17.59***	-13.33***	-18.63***	-8.81*
	(1.87)	(1.18)	(2.66)	(4.75)	(3.09)	(4.35)	(2.74)
School	7.01***	6.69***	3.36**	0.56	19.43***	14.03**	16.83
	(2.36)	(1.40)	(1.60)	(3.29)	(4.28)	(5.55)	(4.03)
Env	-1.18	-9.37***	-14.45***	13.09***	-26.65***	-3.11	-22.6
	(2.34)	(1.72)	(3.23)	(4.68)	(4.12)	(3.93)	(3.44)
Env^2	0.0002	0.01***	0.01***	-0.01***	0.03***	0.003	0.02*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
D1	142.45	-665.09	724.82*	1514.92***	-522.16	-15.51	705.6
	(110.04)	(159.45)	(393.08)	(550.82)	(490.96)	(397.36)	(374.1
D2	173.88*	-6.56	-20.68	-311.54**	-38.34	-71.02	-30.3
	(100.30)	(40.22)	(65.81)	(144.32)	(102.58)	(166.70)	(82.0
D3	94.92	3.36	-82.92*	-283.94**	-160.82	-53.22	-118.
	(120.55)	(35.02)	(48.38)	(131.36)	(112.62)	(160.46)	(88.5
Intercept	83.86	2125.49***	3567.66***	-3320.47***	5449.14***	74.43	4822.
	(659.92)	(421.16)	(830.48)	(1171.93)	(966.67)	(915.94)	(793.
Log-likelihood	-433.32	-544.66	-713.64	-668.12	-686.89	-663.16	-668.
Chi-square (d.f.=11)	347.06	913.69	818.56	969.34	1584.95	619.92	1566.
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of observations	83	99	116	103	103	103	102

Note: Inside parentheses are standard errors. Notations "*", "**" and "***" signify significance at the 10, 5 and 1 percent levels based on a two-tailed test, respectively.

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