Environmental Regulation and Trade Flows

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Abstract

Should international trade agreements be extended to include negotiations over environmental policy? The answer depends on whether countries distort levels of environmental regulations as a secondary means of providing protection to domestic industries; our results suggest that they do. Previous studies of this relationship have treated the level of environmental regulation as exogenous, and found a negligible correlation between environmental regulation and trade flows. In contrast, we find that, when the level of environmental regulation is modeled as an endogenous variable, its estimated effect on trade flows is significantly higher than previously reported.
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1 Introduction

Environmental advocates and labor unions have long pushed for governments to expand trade agreements (such as GATT/WTO or NAFTA) to include cooperation over domestic policies such as environmental or labor standards. Two primary arguments have been advanced for requiring countries' domestic policies to conform to international standards. The first is the "level playing field" argument: the idea that it is unfair for countries to gain a comparative advantage in trade through lax environmental (or

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labor) standards. Economists generally dismiss this argument as a misunderstanding of the principle of comparative advantage, arguing that there are legitimate reasons for diversity in environmental regulations across countries (e.g., differences in preferences, natural endowments, or population density), and that differences in comparative advantage arising from regulatory differences are part of the argument for mutually beneficial trade.[1]

The second argument for expanding international trade agreements to cover domestic policies is that, as countries ratify agreements constraining their ability to pursue trade goals through trade policy, there will be unilateral incentives for governments to distort domestic policies as a secondary means of protection.[2] Assuming that countries have an incentive to erect barriers to trade, one means of decreasing imports within an industry is to relax environmental standards (or other domestic regulation) in that industry. However, while lax regulatory standards may be unilaterally optimal, they are inefficient for the world economy (since they lead to a global loss of trade). Therefore, international cooperation over environmental policies that deters countries from relaxing their environmental standards as a trade barrier can lead to increased global welfare. Clearly, these arguments about the potential use of domestic policy as a means of trade protection can be categorized as "second-best" arguments, since the most direct means of affecting trade flows is through trade policy. However, when countries are constrained in their ability to set trade policy freely (e.g., by an international trade agreement), these second-best arguments provide theoretical justification for international cooperation over domestic policy as well.

While many economists concede that it is possible for second-best models to offer a theoretical justification for incorporating domestic policies into international trade agreements, they remain unconvinced of the empirical importance of these second-best arguments. For example, Krugman (1997) concludes that, "...while it is possible to devise second-best models that offer some justification for demands for harmonization of standards, these models–on the evidence of this collection, at any rate–do not seem particularly convincing." (p. 177)[3]

What is the empirical evidence on this issue? Second-best models typ-

[1] See, for instance, Bhagwati and Srinivasan (1996).

[2] For example, Copeland (1990) examines negotiation over one trade barrier, leaving a secondary trade barrier (e.g., non-tariff barriers, domestic legislation) to be set non-cooperatively. He shows that trade liberalization will induce substitution toward the less efficient, non-negotiable instrument of protection due to countries' incentives to maintain levels of protection.

[3] Also see Bhagwati and Srinivasan (1996).

ically rest on the joint assumption that countries: (i) use domestic regulations as a means of manipulating trade flows; and (ii) trade flows are in fact responsive to regulatory choices. Previous empirical studies of environmental regulations and trade (e.g., Leonard (1988), Kalt (1988), Tobey (1990), Grossman and Krueger (1994), and Low and Yeats (1992)) have examined the second hypothesis (that environmental regulation has a significant impact on trade flows). These papers argue that if stringent environmental regulations are a major source of comparative disadvantage, then the most regulated industries should also have the highest levels of import penetration, controlling for the type of industry. They typically find little support for this proposition. Thus, "second-best" arguments for cooperation over environmental regulation are often dismissed as being of little practical importance.

In this paper, we argue that the reason previous research estimated only a small impact of environmental regulations on trade flows is because these studies treat the level of environmental regulation as exogenously determined (implicitly assuming away the possibility that trade considerations may play a role in the setting of environmental policy). Not only do second-best models argue that environmental regulations are set endogenously, this hypothesis is supported by anecdotal evidence, which suggests that concern with international competition has played a role in setting environmental regulation. Some of the earliest national environmental legislation (such as the U.S. Federal Water Pollution Control Act of 1970) mandated studies of the effects on U.S. competitiveness of environmental regulations on U.S. firms. More recently, Presidents Reagan and Bush established committees (the Task Force on Regulatory Relief and the Council on Competitiveness, respectively) with the stated goal of relaxing domestic regulations that adversely affected U.S. trade competitiveness. In addition, there are several cases of countries challenging foreign environmental regulations as disguised forms of protection.[4]

We argue that the endogeneity of environmental regulation may have biased downward previous estimates of the effect of environmental regulation on trade flows.[5] For example, if countries tend to (endogenously) relax

[4]The U.S. has challenged Canada's low stumpage fees and 10-cent levy on metal beer cans as disguised forms of protection, while the European community has challenged the U.S. Corporate Average Fuel Economy mileage standards and "gas guzzler" taxes as trade protection masquerading as environmentalism. See Esty (1994) for more complete discussions of these cases.

[5]This argument parallels that of Trefler (1993), who notes that previous estimates of the small impact of trade barriers on trade flow are biased because they ignore the theory

environmental regulation on those industries facing strong import competition, then import penetration and the level of environmental regulation may appear to be only weakly correlated across industries, even if stringent environmental regulations are a major source of comparative disadvantage.

This paper attempts to address this concern directly by estimating the impact of environmental regulations on import levels while controlling for simultaneity between imports and environmental policy. This will be accomplished by estimating a system of simultaneous equations: an equation modeling the determination of environmental protection, and an equation modeling the determination of imports. Section 2 explores the theories behind the specification of the environmental regulation equation and Section 3 discusses the data. Section 4 presents the results for the simultaneous equation estimation of imports, modeling environmental regulation as an endogenous variable. Section 5 explores the robustness of these results to alternative specifications and Section 6 concludes.

2 Theories of Protection

Standard theories of why countries impose barriers to trade revolve around two basic (and non-mutually exclusive) explanations. The political economy theory argues that industries demand protection in exchange for political support. The other strand of the literature, which focuses on strategic theories of protection, argues that countries strategically alter trade flows in order to gain some type of market advantage (e.g., a terms-of-trade advantage). In the following subsections, we apply these theories to the endogenous setting of environmental regulation and discuss the specification of the environmental regulation equation.

2.1 Political Economy Theories of Protection

The political economy literature is rooted in the work of Stigler (1971) and Peltzman (1976), who view the level of an industry's regulation as determined endogenously by self-interested regulators serving special interest groups. This literature models trade protection as a function of a lobbying

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of endogenous protection (that increased imports intensify lobbying for protection, leading to higher levels of protection). After controlling for simultaneity between trade barriers and imports, trade barriers have a large effect on trade flows. In contrast to Trefler (1993), who examined the relationship between *trade barriers* and trade flows, this paper is concerned with the impact of *environmental regulation* on trade flows.

process, whereby industries provide political support in exchange for protection from foreign competition.[6] A parallel body of literature has attempted to identify the industry characteristics that determine the effectiveness of an industry's lobby (with respect to protection).[7] The level of environmental regulation can be interpreted as the result of a similar lobbying process; thus, our equation estimating the level of environmental regulation contains variables commonly found in theories of endogenous trade protection.

The analysis focuses on five industry characteristics that measure the political influence of the industry seeking regulatory relief.[8] These variables include the four-firm concentration ratio of the industry and the number of firms in the industry. A greater concentration of firms and a smaller number of firms alleviates the free-rider problem in coordinating a lobby, thus leading to more effective lobbying against regulation. The third variable measures the size of the industry (measured by value of shipments of the industry), where the standard hypothesis is that larger industry size increases the power of the industry's lobby. The final variables measure the rate of union membership and the rate of unemployment within an industry. Unions provide an organization through which to lobby against regulation, and so higher union membership may lead to lower regulation. Finally, several theories of political economy predict that politicians may be influenced by progressive concerns, and so factors like unemployment in an industry may contribute to more effective lobbying.[9]

In addition, political economy theories predict that industries respond to increased import competition by intensifying their lobbying efforts for less regulation (perhaps arguing that they are victims of "unfair trade"). To the extent that a government compensates these industries with relaxed environmental regulations, import volume and environmental policy will be negatively correlated (as import volume increases, environmental regulations will be relaxed). By parallel reasoning, exports and environmental regulations are expected to be positively correlated.

Finally, the political economy literature argues that trade and environmental regulations are substitutes in the sense that either policy can be used to implement transfers of wealth.[10] In the political economy models,

[6] e.g., Caves (1976), Brock and Magee (1978), and Hillman (1982).

[7] e.g., Ray (1981a), Ray (1981b), Marvel and Ray (1983), and Baldwin (1985).

[8] The data used in this study are described more completely in the Appendix.

[9] A similar prediction is made by Magee et al. (1989), who argue that protection will be aimed at the disadvantaged, since these groups have a lower opportunity cost of lobbying.

[10] Note that, to the extent that tariffs and environmental policy are functions of similar lobbying processes, they will be complementary (since industries with stronger lobbies are

the equilibrium levels of regulation and protection achieve a distribution of income that is optimal for given levels of political influence. Thus, changes in the underlying conditions will require a restructuring of regulatory levels to maintain political equilibrium. One can view the formulaic tariff cuts of the Kennedy and Tokyo rounds of GATT negotiations as an exogenous shock to that political equilibrium. Countries will respond by using non-tariff policies (e.g., environmental regulations) to offset the losses to preferred industries that otherwise would have resulted from the reductions in tariff rates.

2.2 Terms-of-trade Theories of Protection

A second strand of literature argues that countries strategically alter the level of trade volume to capture a market advantage (e.g., see Markusen (1975)). In the following analysis, we extend one such model to the setting of two policy instruments: tariffs and environmental taxes. A terms-of-trade argument is used since these models provide a theoretically consistent justification of the incentives underlying international cooperation.[11] It follows naturally from both general and partial equilibrium models that, when countries are large, both trade and domestic policies will have terms of trade effects, implying that they can be treated as substitutes by the government (since either policy can be used to pursue terms-of-trade gains).

The analysis is conducted within a simple partial equilibrium model of trade with two countries, a home and foreign (rest-of-world) country (denoted by *). We assume that the home country chooses both trade and environmental policies, where environmental policy consists of domestic taxes and/or subsidies on production, while trade policy consists of taxes on trade flows.

Linear demand and supply functions are given exogenously for each good, with the usual assumptions that demand is monotonically decreasing in consumer prices and supply is monotonically increasing in producer prices. Demand functions for each country are given by: $D(p^d)$ and $D^*(p^{d*})$, where p^d and p^{d*} are consumption prices of the good for the home and foreign countries, respectively. Supply functions are given by $Q(p^s)$ and $Q^*(p^{s*})$,

able to achieve both higher tariff barriers and lower levels of environmental regulation). However, controlling for the strength of the lobby, tariffs and environmental policy will act as substitutes (since an otherwise-identical industry with less tariff protection will be compensated with relaxed environmental regulations). For a discussion of this with respect to tariff and non-tariff barriers, see Marvel and Ray (1983).

[11] See Bagwell and Staiger (1999) for a discussion of the incentives underlying trade liberalization, and Ederington (1998) for a discussion of cooperation over both trade and domestic policies.

where p^s and p^{s*} are production prices for the home and foreign country. The home country production tax is denoted by t, and τ is the specific trade policy (an import tariff or an export subsidy). Therefore, in the home country, producer and consumer prices (provided that the trade tax is not prohibitive) are given, respectively, by: $p^s = p^w - t + \tau$ and $p^d = p^w + \tau$, where p^w denotes the world (untaxed) price of the good. For simplicity, we assume that for the rest of the world, $p^{s*} = p^w$ and $p^{d*} = p^w$.

Given a positive trade volume, world markets clear:

$$D(p^d) + D^*(p^w) = Q(p^s) + Q^*(p^w) \tag{1}$$

Solving (1) yields the market-clearing world (untaxed) price for the good: $p^w(\tau, t)$. Given the monotonicity of the demand and supply functions, the world price is decreasing in the home country's import tariff (export subsidy) and increasing in its production taxes. Local producer and consumer prices can be expressed as functions of these world prices, and, using these local prices, the market-clearing trade volume can be calculated $[T(\tau,t) = Q(p^s(p^w(\tau,t),\tau,t)) - D(p^d(p^w(\tau,t),\tau))]$. Note that T is positive when the home country exports the good, and negative when the home country imports the good.

Pollution is modeled as a negative externality arising from the production of the good (the cost of which is given by the function $S(Q_x)$). For simplicity, this externality is modeled as a distinct linear function of production of the import good $[S(Q_x) = s \cdot Q_x(p_x^s)]$ that enters separably into a country's welfare function (the externality can be thought of as an "eyesore" type pollutant). Finally, goverments are assumed to maximize the sum of consumer surplus and producer surplus, net of external costs of production, and trade policy and domestic policy revenue. Welfare for the home country is given by:

$$W_x = \int_{p^d}^{\infty} D(p^d)dP + \int_0^{p^s} Q(p^s)dP + t \cdot Q - \tau \cdot T - s \cdot Q \tag{2}$$

Taking the derivative of this welfare function (2) with respect to environmental policy for the home country yields a first order condition for the unilaterally optimal production tax:[12]

[12] This first-order condition implicitly assumes that countries are constrained in setting trade policy (e.g., by an international trade agreement), since if countries could set trade policy freely, they would fully pursue terms-of-trade gains with trade policy, leaving environmental policy to counter the domestic externality ($t = s$).

$$t = s - \frac{\partial p^w/\partial t}{\partial Q/\partial t} \cdot T + \frac{\partial T/\partial t}{\partial Q/\partial t} \cdot \tau \qquad (3)$$

There are three basic components of the environmental tax in this model: the marginal cost of pollution, s, the trade flow component, $[\frac{\partial p^w/\partial t}{\partial Q/\partial t}] \cdot T$, and the trade policy component, $[\frac{\partial T/\partial t}{\partial Q/\partial t}] \cdot \tau$. The trade components of this equation represent the second-best trade considerations for environmental policy.

Note that, from the second term on the right-hand side of (3), the domestic environmental tax will be correlated with trade volume in the industry. Assume that the home country is importing the good (i.e., $T < 0$). In that case, as import volume increases (T becomes more negative), the domestic environmental tax (t) will decrease (since $\frac{\partial p^w/\partial t}{\partial Q/\partial t}$ is negative). Intuitively, since production taxes increase the world price of the good, the terms of trade for importing countries are diminished and the importing country faces more than the full costs of its environmental regulation. Thus, there will be a tendency to under-tax production of the import-competing good.

Alternatively, assume that the home country is exporting the good (i.e., $T > 0$). Then as export volume increases, the domestic environmental tax will increase. Intuitively, part of the cost of the home country's environmental regulation is transferred to consumers in the foreign country in the form of a higher world price. Since the home country does not pay the full cost of its regulation, it will have a tendency to over-tax industries with higher export volume.

From the third term on the right hand side of (3), when import tariffs (τ) are lowered, the domestic environmental tax (t) will also be lowered (because $\frac{\partial T/\partial t}{\partial Q/\partial t}$ is positive). Intuitively, less stringent domestic environmental regulation acts as a secondary barrier to imports, and thus, a decrease in a country's tariff barriers induces substitution toward environmental policy as a secondary means of protection.

Thus, a simple terms-of-trade model predicts: (i) that trade and environmental policies act as substitutes (as tariffs fall, environmental regulations will be relaxed); (ii) that import volume and environmental costs will be negatively correlated (as import volume increases, environmental regulations will be relaxed); and (iii) that environmental costs and export volume will be positively correlated.

The theories described above show that the environmental tax placed on an industry can be represented as a function of the marginal cost of pollution in that industry, import barriers within the industry, the volume of trade (denoted by T), and a vector of political economy variables. That is, $t = t(s, T, \tau, P^n)$, where P^n is the vector of political economy variables. Note that both the political economy and terms-of-trade theories predict that increased import competition will result in a relaxation of environmental regulation (a negative coefficient on import volume in a regression of environmental regulation on its determinants). Attempts to estimate the extent to which stringent environmental regulations increase import volume that ignore this "feedback" effect (that higher levels of imports may lead to a relaxation of environmental regulations) will underestimate the impact of these regulations on trade flows.

3 Data

We focus on U.S. manufacturing industries, since the U.S. is the only country to provide time series data on pollution abatement costs; all data and sources are described more completely in the Appendix. To measure the stringency of environmental regulation, we employ time-series data on pollution abatement costs of U.S. industries from 1978-92. Both the stringency of environmental laws and the degree to which they are enforced should be reflected in the costs incurred by firms subject to environmental regulations, and so environmental compliance costs are used as a proxy for the stringency of U.S. environmental regulations and enforcement. Shanley (1992) and Eads and Fix (1984) describe the Reagan administration's environmental strategy as characterized as much by changes in the severity of the enforcement of laws as by changes in the laws themselves.[13]

Data on environmental abatement costs are provided by the Census Bureau's Pollution Abatement Costs and Expenditures (PACE) survey, which provides information on the pollution abatement costs incurred by firms since 1972 at the 4-digit SIC level. To measure environmental stringency facing each industry, we use the proportion of total direct costs in that industry spent on satisfying environmental regulations.[14]

[13] More specifically, the administration's policies consisted of: (i) a reduction in the dollar amount of civil penalties assessed; (ii) the adoption of more exclusive screening criteria for identifying potential violators; (iii) reduced discretion for field personnel, and greater reliance on state, local and trade associations as substitute enforcers; and (iv) the adoption of a less threatening and more flexible posture toward regulated industries.

[14] The PACE survey provides data on both pollution abatement operating costs and capital expenditures on pollution abatement. As in Levinson (1999), we use pollution abatement operating expenses rather than capital expenses because (i) capital expenses on abatement are difficult for respondents to separate from other capital expenses; and

The NBER Trade Database provides data on trade flows and import barriers. It contains information on import volume and duties paid at the 4-digit SIC level from 1972-94. Dividing duties paid by import value gives a measure of average *ad valorem* tariffs for each industry.

Factor shares and political economy data were provided by the Census of Manufacturers and the Current Population Survey. The political economy variables include the size of the industry (measured by the value of shipments of the industry), the four-firm concentration ratio of the industry, and the percentages of unionization and unemployment in the industry.

4 Estimation

Previous empirical studies of environmental regulation and trade have been concerned with the extent to which environmental regulation affects trade flows.[15] Their primary hypothesis is that, if stringent environmental regulations are a major source of comparative disadvantage, the most regulated industries within a country should have the highest levels of import penetration. Thus, we follow Grossman and Krueger (1994) and regress import penetration (M_{it}) on the level of environmental regulation (t_{it}) and trade barriers (τ_{it}) within the industry, and a vector of factor endowment variables, $\boldsymbol{F}_{it}^{n}$:

$$M_{it} = \mu_i + \mu_t + \beta^1 \cdot t_{it} + \beta^2 \cdot \tau_{it} + \boldsymbol{\beta}^3 \cdot \boldsymbol{F}_{it}^{n} + \eta_{it} \tag{4}$$

We run a fixed effects model in which μ_i and μ_t control for industry- and time- specific effects. The stringency of environmental regulations t_{it} is measured by the ratio of pollution abatement costs to total costs of materials in industry i at time t, and industry-level imports M_{it} are scaled by domestic production (that is, imports are measured by import penetration).

The factor endowment variables ($\boldsymbol{F}_{it}^{n}$) measure the human and physical capital intensity of the industry. To calculate the (direct) factor shares of both types of capital, we employ a method proposed by Grossman and Krueger (1994) in which we assume that the payroll expenses of an industry represent the combined payments to unskilled labor and human capital. Payments to unskilled labor in an industry are calculated by taking the product of the number of workers in the industry and the average yearly

(ii) abatement capital expenditures are highest when new capital investment occurs, and so industries experiencing high levels of new investment are likely to have high abatement capital expenditures, regardless of the stringency of environmental legislation.

[15] See Levinson (1996) for a survey of this research.

Table 1: Import Penetration Regressions

	Regression 1 OLS	Regression 2 3SLS
environmental regulation	1.20 (0.188)**	15.73 (1.82)**
tariff	-2.30 (0.166)**	-2.33 (0.277)**
human capital	-0.849 (0.140)**	-1.45 (0.247)**
physical capital	-0.605 (0.098)**	-0.830 (0.263)**
R^2	0.933	0.795

Notes to Table: Constant terms vary by time periods and 4-digit SIC codes; standard errors appear in parentheses. ** indicates statistical significance at the 99% level. The number of observations is 3,310 in each regression.

income of workers with less than a high school education in that industry.[16] The factor share of human capital is then determined by dividing the remaining portion of the payroll by value added for the industry. The share of physical capital in value added is then calculated by subtracting the payroll share (to unskilled labor and human capital) of value added from one.

The results of OLS estimation of equation (4) are reported in Column 1 of Table 1. As expected, both human and physical capital are sources of comparative advantage for the U.S. (indicated by negative coefficient estimates), and tariffs lead to lower levels of import penetration. In this regression, the coefficient of interest is that on the environmental regulation variable (β^1). This coefficient estimate is positive and statistically significant (in line with the theory of comparative advantage): industries facing higher relative pollution abatement costs tend to have higher levels of import penetration. However, as previous research has reported, this estimate is quantitatively small. An industry in which environmental costs rose by one percentage point is estimated to have an increase in import penetration of only 1.2 percentage points.[17] Such an estimate suggests that environmental regulations have little effect on trade flows, and are only a minor source of comparative disadvantage.

As previous research has done, this approach treats the level of environmental regulation as exogenous. However, both the political economy and terms-of-trade models of Section 2 predict that the level of environmen-

[16] The average income for a worker in manufacturing with less than a high school education was calculated for each year from the Current Population Survey.

[17] An increase of 1 percentage point in environmental costs is a very large increase, given that the mean of the pollution abatement cost (as a proportion of total costs) in our sample is only 1.15%, with a standard deviation of 1.88%. In comparison, the mean import penetration is 17.18% (the standard deviation is 44.72%).

tal regulation is an endogenous variable that is a function of trade volume within the industry. If it is the case that the government endogenously relaxes environmental regulations facing industries with high levels of import competition, then estimates of β^1 that treat the level of environmental regulation as exogenous will be biased downward.

Following the theories summarized in Section 2, we model the level of environmental protection in an industry as a function of the marginal cost of pollution of the industry, the level of import tariffs and import volume in the industry, export volume, and various political economy concerns. Since the marginal cost of pollution differs substantially across industries (for example, the chemical and paper-milling industries face higher environmental regulation than other industries, simply because they create more pollution), we use a fixed-effects model to account for these differences in costs (i.e., we include industry-specific indicator variables (α_i) in equation (5)).

There is also the possibility that tariffs and environmental regulations are simultaneously determined (e.g., industries facing higher environmental regulation may lobby harder for protection and receive higher tariffs). We follow Trefler (1993), Ray (1981a), and Ray (1981b) in treating tariffs as regressors in the equations. The argument for treating tariffs as exogenous regressors is that tariff levels over the time period studied were a result of a linear tariff-cutting formula adapted in the Tokyo Round (1973-79) and were themselves functions of previous binding tariff rates.[18]

Finally, we follow previous empirical political economy studies in assuming that the function determining environmental regulation can be approximated by a linear regression:

$$t_{it} = \alpha_i + \alpha_t + \delta^1 \cdot \tau_{it} + \delta^2 \cdot M_{it} + \delta^3 \cdot X_{it} + \boldsymbol{\delta}^n \cdot \boldsymbol{P}^n_{it} + \epsilon_i t \qquad (5)$$

where, as before, t_{it} measures the stringency of environmental regulations in industry i at time t; τ_{it} are industry-level tariffs; M_{it} are industry-level imports and X_{it} are industry-level exports (scaled by domestic industry production); and $\boldsymbol{P}^n_{it}$ is a vector of political economy variables. To control for trends in environmental regulation over time, the regression also includes time dummy variables (α_t). Both theories of protection discussed in Section 2 predict that lower tariffs, higher levels of imports, and lower levels of exports in an industry will be correlated with less stringent environmental

[18] Over the time period studied, U.S. trade policy was often carried out through the use of non-tariff barriers such as quotas. Due to data limitations, we are not able to incorporate measures of non-tariff barriers in this paper. However, as mentioned previously, we do include industry-level dummy variables to control for industry-specific factors.

Table 2: ENVIRONMENTAL REGULATION REGRESSIONS

	OLS Regression 1	3SLS Regression 2
tariff	0.016 (0.017)	-0.129 (0.051)*
imports	0.007 (0.002)*	-0.051 (0.020)*
exports	0.028 (0.004)**	0.065 (0.012)**
industry size	-0.123 (0.079)	-0.057 (0.072)
percent union	-0.003 (0.006)	-0.008 (0.006)
unemployment	0.032 (0.010)**	0.028 (0.010)**
number of companies	0.0002 (0.001)	-0.00002 (0.001)
concentration ratio	0.004 (0.004)	-0.014 (0.005)**
R^2	0.642	0.521

Notes to Table: Constant terms vary by time periods and 4-digit SIC codes; standard errors appear in parentheses. ** indicates statistical significance at the 99% level; * at 95%. The number of observations is 3,310 in each regression. The environmental regulation variable is defined as pollution abatement costs divided by total material costs. The variable 'import' ('export') is defined as the value of imports (exports) divided by the value of shipments for the industry.

regulations (i.e., $\delta^1 > 0; \delta^2 < 0$; and $\delta^3 > 0$).

Simultaneous estimation of equations (4) and (5) allows us to treat both the level of environmental regulation and the level of import penetration as endogenous variables. Equation (4) captures the positive effect of changes in environmental regulation (t_{it}) on import levels (M_{it}), while equation (5) captures the negative effect of changes in import levels on the stringency of environmental regulation. The level of exports (X_{it}), the political economy variables ($\boldsymbol{P}^n_{it}$), and factor endowments ($\boldsymbol{F}^n_{it}$) are used as instrumental variables to isolate the effect of environmental regulation on import penetration. We use three-stage least squares to estimate the model, which allows us to control for both simultaneity and cross-equation correlations of disturbances in the model.

The results of the simultaneous equation estimation are presented in Tables 1 and 2. Table 2 reports the result of equation (5) (the determinants of environmental regulation) with import penetration treated both as exogenous (in the OLS regression) and as endogenous (in the 3SLS regression). Note that, in the OLS regression, the coefficient estimate on import penetration is positive (implying that industries facing greater import competition tend to face more stringent environmental regulation). This result contradicts the predictions of both the political economy and strategic theories of regulation. However, the OLS regression treats the level of imports in an industry as an exogenous variable. The level of imports in an industry are a function of the U.S.'s comparative advantage (or disadvantage) in that industry, and one aspect of comparative advantage is the relative stringency of regulations imposed on firms in that industry.

In the simultaneous equation estimate (Column 2 of Table 2), the coefficient estimate on import penetration is now negative and statistically significant (in accord with the predictions of both the political economy and terms-of-trade theories). In addition, as we hypothesized, the estimated coefficient on exports is positive. Thus, our estimation provides support for the predictions of the standard theories of protection that governments will tend to under-tax (and under-regulate) import industries, and over-tax (and over-regulate) export industries.

The only other variables that are statistically significant in the environmental regulation regression (equation (5)) are tariffs, unemployment rates, and the concentration ratio of the industry. As the political economy theory predicts, the coefficient on the concentration ratio is negative (i.e., the more concentrated the industry, the stronger the lobby and therefore the lower the cost of regulation imposed on the industry). However, the coefficient on tariffs is also negative (i.e., the higher the tariff within an industry, the lower the amount of environmental regulation), contradicting the theories of Section 2, and suggesting that tariffs and environmental regulations are complements.[19] Finally, the coefficient on unemployment is positive, which also contradicts the theories of Section 2. The positive coefficient estimate indicates that industries with higher levels of unemployment tend to also have more stringent levels of environmental regulation.

As Table 2 shows, countries tend to endogenously under-tax import-competing industries and over-tax export industries. Previous research that treated the level of environmental regulation as exogenous did not capture this effect and thus produced potentially biased estimates of the effect of environmental regulations on imports. In Column 2 of Table 1 we present the results of 3SLS estimation of equation (4). The magnitude of the coefficient estimate on environmental regulation (β^1) is now more than thirteen times greater than the OLS estimate. Indeed, when the level of environmental regulation is modeled as an endogenous variable, it is estimated that an industry with pollution abatement costs one percentage point higher than otherwise identical industries will have an import ratio over fifteen percent-

[19] A similar result was found by Marvel and Ray (1983), who discovered that tariff and non-tariff barriers are complements (in the Kennedy Round, a decrease in tariffs was correlated with a decrease in non-tariff barriers as well).

age points higher. This estimate is both quantitatively and statistically significant, and calls into question earlier claims that there is little correlation between trade flows and levels of environmental regulation. Using the Hausman (1978) specification test, we can easily reject the null hypothesis that the level of environmental regulation is exogenous (i.e., $H_0 : E[\eta_{it}|t_{it}] = 0$; the test statistic is 64.4). Thus, it appears that when treated as an endogenous variable, stringent environmental regulations can be a major source of comparative disadvantage.

5 Sensitivity Analysis

Although the previous result provides a strong case against treating the level of environmental regulation exogenously, there are some qualifications that must be attached to this result. As is true of any instrumental variable estimation, misspecification of the environmental regulation equation may bias the results of the import penetration regression. Thus, before our result can be interpreted as strong evidence in favor of the competitiveness effects of environmental regulation, its robustness must be established. As the following sections show, inferences about the impact of environmental regulation on import levels are sensitive to the treatment of exports as an instrumental variable in the model, although the conclusions otherwise appear fairly robust.

Table 3: SENSITIVITY ANALYSIS

	(1) Omission-β^1	(2) Endogenous-β^1
exports	1.59	1.12
industry size	15.98**	16.24**
union	15.73**	16.05**
unemp	16.68**	16.89**
# companies	15.74**	16.04**
concentration	16.40**	16.88**
human capital		16.05**
physical capital		14.87**

Notes to Table: Each entry reports the estimate of β^1, the coefficient on environmental regulation in the import equation. Each row in Column 1 represents a specification in which the regressor listed is omitted from the environmental regulation equation. Each row in Column 2 represents a specification in which the regressor listed is treated as an endogenous variable. ** indicates statistical significance (from zero) at the 99% level.

5.1 Choice of Instruments

Precise specification of the process by which the level of environmental regulation is determined is difficult. To address possible misspecification of the environmental regulation equation that may bias the estimate of β^1 (the coefficient measuring the correlation between environmental regulation and import levels), we employ a method used by Trefler (1993) to test whether the estimate of β^1 is sensitive to the choice of instruments. Column 1 of Table 3 presents the results of seven different specifications of the environmental regulation equation, with each specification omitting one of the environmental regulation instruments. The estimates of β^1 are fairly insensitive (i.e., they do not differ significantly from the previous estimate of 15.73) to the omission of any instrument except exports. However, when exports are omitted from the system of equations, then environmental regulation is estimated to have a much smaller impact on trade flows. We address this further in Section 5.3.

5.2 Regressor Exogeneity

A second concern is that the estimate of β^1 is biased due to the presence of endogenous regressors in the import and environmental regulation equations. To address this possibility, we again follow a procedure employed by Trefler (1993) in testing for exogeneity (more precisely, testing whether the estimate of β^1 is inconsistent due to endogeneity). We assume that the vector of regressors suspected of being endogenous, $\boldsymbol{Z}_i$, is generated by the following linear process:

$$\boldsymbol{\Theta_Z} \cdot \boldsymbol{Z}_i = \Theta_M \cdot M_i + \Theta_t \cdot t_i + \boldsymbol{\Theta_X} \cdot \boldsymbol{X}_i + E_i \tag{6}$$

where M_i represents imports, t_i represents pollution abatement costs, and i indexes observations. $\boldsymbol{Z}_i$ is "instrumented" by the remaining exogenous regressors in the import and environmental regulation equations, $\boldsymbol{X}_i$. The reduced form of equation (6) and the import and environmental regulation equations are then simultaneously estimated using three stage least squares. Column 2 of Table 3 reports estimates for β^1 when each of the regressors is treated as endogenously determined by the other (exogenous) regressors. Formally, the Hausman test rejects the hypothesis of inconsistency between estimates of β^1 for all regressors except exports. That it does not reject for exports is hardly surprising, since the sensitivity analysis of the previous section is the basis for the Hausman test.

5.3 Export Penetration as an Instrumental Variable

As the previous sections show, our results are sensitive to the use of export penetration as an instrumental variable. This is a concern if it is the case that the level of export penetration within an industry is directly correlated with the level of import penetration (in which case export penetration is not an appropriate instrumental variable). In this section, we employ two means of controlling for such a correlation.

The most immediate concern is that export penetration is an endogenous variable, and thus may be contemporaneously correlated with import penetration. To respond to this concern, we use lagged export penetration as an instrument for current exort penetration, under the standard argument that predetermined variables can be treated as exogenous within the regression. Thus, one-year lagged export penetration now serves as the instrumental variable in place of exports in equation (5).[20] The coefficient estimates of equation (4) are presented in Regression 1 of Table 4. Note that the estimate of the correlation between environmental regulation and import penetration is over four times higher than the OLS estimate (5.2, with a standard error of 2.9), and this point estimate is statistically different from zero at the 90% level. Thus, controlling for contemporaneous correlation between export

[20] Because export data precede 1978, we lose only nine observations due to missing data, rather than the entire first year.

Table 4: Revised Import Penetration Regressions

	Regression 1	Regression 2 $IIT < 0.8$
environmental regulation	5.18 (2.94)*	5.98 (3.60)*
tariff	-2.32 (0.169)**	-2.65 (0.210)**
human capital	-1.03 (0.205)**	-1.20 (0.257)**
physical capital	-0.646 (0.102)**	-0.744 (0.129)**
R^2	0.922	0.921
Observations	3,301	2,537

Notes to Table: Constant terms vary by time periods and 4-digit SIC codes. Estimation is by 3SLS; the results of the second regression are similar to those presented in Table 2, with lagged exports used to instrument for contemporaneous exports in both regressions presented in this Table. Regression 2 restricts the sample to observations with values of the intra-industry trade index below 0.6. ** indicates statistical significance at the 99% level; * at the 90% level.

and import penetration, we still find evidence that stringent environmental regulations are a significant source of competitive disadvantage.

A second concern is that high levels of intra-industry trade may be biasing our results. Specifically, it is possible that export and import penetration are directly positively correlated in industries with high levels of intra-industry trade where high levels of exports (due, perhaps, to low transportation costs or economies of scale) accompany high levels of imports. If this is the case, then our 3SLS estimate of the coefficient β^1 may be spuriously high, since the level of environmental regulation is proxying for (lagged) export penetration in the IV estimation. To test this concern, we exclude those industries with "high" levels of intra-industry trade. Our hypothesis is that, if intra-industry trade is causing a spuriously high estimate of β^1, then we should observe our estimate of β^1 falling as we exclude the high intra-industry trade industries.

We construct a measure of the extent of intra-industry trade for each industry, also known as the Grubel-Lloyd index (see Grubel and Lloyd (1971)): $IIT_{it} = [1 - \frac{|X_{it} - M_{it}|}{X_{it} + M_{it}}]$. The value of this index is constructed so that IIT is equal to zero in industries with only *inter*-industry trade, and equal to one in industries with completely *intra*-industry trade.

We repeat the simultaneous equations estimation, retaining lagged export penetration as an instrument, and excluding observations with values of the intra-industry trade measure greater than 0.8.[21] Regression 2 in Table 4

[21]The results presented here exclude observations with measures of IIT greater than

presents these results; the estimate of β^1 is now 5.98, with a standard error of 3.6, and this is statistically significant at the 90% level. Given that this estimate is greater than the estimate of β^1 when the "high" intra-industry trade observations are included, we find no evidence that "high" levels of intra-industry trade are biasing our estimate of β^1 upward. Repeating the estimation with alternate cutoff points (ranging from 0.9 to 0.4, at intervals of 0.05) also fails to uncover evidence that high levels of intra-industry trade are causing spuriously high estimates of β^1.[22]

Thus, while introducing lagged exports as an instrument into the full sample reduced the estimate of β^1, the coefficient estimate remains statistically significant and higher than OLS estimates. In addition, we fail to find evidence that intra-industry trade is biasing our estimate of β^1. Although the sensitivity of our results to the choice of instruments is a concern, we do interpret our results as providing evidence that (when treated as an endogenous variable) environmental regulations have a significant impact on trade flows.

6 Conclusions

An important empirical issue behind questions of whether international trade agreements should include negotations over environmental policy is whether countries actually distort levels of environmental regulation as a secondary means of providing protection to domestic industries. In this paper, we investigated the hypothesis that environmental policy has been used as a secondary trade barrier, and estimated the impact of environmental regulation on trade flows when environmental policy is modeled endogenously. We found empirical support for modeling environmental policy endogenously, and also found that environmental policy has a much stronger impact on import levels than had previously been reported. While this result must be interpreted with some caution, as it is sensitive to our choice of instruments, it does provide support for the claim that countries' environmental regulations are a valid area of international negotiation.

the cutoff point. We also repeated the procedures using the mean value of IIT for the industry over the sample period, excluding all observations for industries with mean values over the cutoff; results were comparable.

[22] Our estimates of β^1 were consistently above the estimate of 5.18 of Regression 1 in Table 4 (with one exception when the cutoff was at 0.7). This may be due to the fact that trade flows are more sensitive to differences in regulatory costs in those industries with primarily *inter*-industry (or comparative advantage-driven) trade.

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A Variable Definitions

The following table defines variables used in the tables. Definitions of sources and further details appear on the following page.

Table 5: Variable Definitions

Variable	Definition	Source
environmental regulation	gross annual pollution abatement operating costs as percentage of total cost of materials	CIR, CM
tariff	ratio of duties paid to customs value	NBER
human capital	$\frac{(\text{total payroll} - \text{payments to unskilled labor})}{\text{value added}}$	CM, CPS
physical capital	$1 - \frac{\text{total payroll}}{\text{value added}}$	CM
imports	ratio of (customs value of) imports to total shipments	NBER
exports	ratio of exports to total shipments	NBER
industry size	value of shipments (millions)	CM
percent union	% of workers in industry who are union members	CPS
unemployment	industry unemployment	CPS
number of companies	number of firms in industry (thousands)	CM
concentration ratio	% of industry shipments produced by four largest firms	CM 1987, 1992
intra-industry trade (IIT)	$[1 - \frac{\lvert X_{it} - M_{it} \rvert}{X_{it} + M_{it}}]$ (Grubel-Lloyd index)	

CIR: *Current Industrial Reports: Pollution Abatement Costs and Expenditures* reports by the Census Bureau/U.S. Department of Commerce, 1972-92. The data from 1989-92 are provided at the 4-digit 1987 SIC level; we used the concordance described for the *Census of Manufacturers* data to allocate those data to 1972 SIC industries. Pollution abatement operating costs include all costs of operating and maintaining plant and equipment to abate air or water pollutants, and expenses to private contractors or the government for solid waste management. Pollution abatement operating costs were not collected in 1987, and totals by industry were not reported in 1979, so these years are dropped from our sample. Due to the incompatibility (in the treatment of small plants) between the data collected in the first several years and later years, we include only data since 1978 (see Levinson (1999)).

CM: *Census of Manufacturers* (1978-92). The 1987 *Census* provides data on value added, value of shipments and total costs of materials at the 4-digit 1972 SIC level. The 1992 *Census* provides these data only for 1987 SIC industries. We used a concordance based on 1987 domestic production (value of shipments) ratios to allocate the data into 1972 SIC industries (the 1987 *Census* provides industry data for both the 1987 and 1972 SIC industries).

CPS: *Current Population Survey* (1978-92).

NBER: NBER Trade Database. This database provides U.S. import and export data for 1972-94. For 1972-88, these data are provided at the 8-digit MSIC (import-based SIC) level. We aggregated these data to the 4-digit level, and then used a concordance (generously provided by Chris Magee) that allocates MSIC imports to SIC industries in proportion to domestic production to convert these data to 1972 SIC industries. For 1989-94, the data are provided at the 4-digit 1987 MSIC level. We converted these data to 1972 MSIC industries using the concordance provided in the NBER database (which allocates 1987 MSIC imports to 1972 MSIC industries in proportion to their 1988 customs value ratios–import data for 1988 are presented for both 1972 and 1987 MSIC industries).