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Non-Economic Engagement and International Exchange: The Case of Environmental Treaties

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Abstract

We examine the role of non-economic partnerships in promoting international economic exchange. Since far-sighted countries are more willing to join costly international partnerships such as environmental treaties, environmental engagement tends to encourage international lending. Countries with such non-economic partnerships also find it easier to engage in economic exchanges since they face the possibility that debt default might also spill over to hinder their non-economic relationships. We present a theoretical model of these ideas, and then verify their empirical importance using a bilateral cross-section of data on international cross-holdings of assets and environmental treaties. Our results support the notion that international environmental cooperation facilitates economic exchange.

Keywords: assets, debt, trade, theory, reputation, discount, empirical, arrangement, partnership.

JEL Classification Numbers: F02, F10, F34

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1. Introduction

Countries, like people, interact with each other on a number of different dimensions. Some interactions are strictly economic; for instance, countries engage in international trade of goods, services, capital, and labor. But many are not economic, at least not in any narrow sense. For instance, the United States seeks to promote human rights and democracy, deter nuclear proliferation, stop the spread of narcotics, and so forth. Accordingly America, like other countries, participates in a number of international institutions to further its foreign policy objectives; it has joined security alliances like NATO, and international organizations such as the International Atomic Energy Agency. In this paper, we concentrate on the interesting and under-studied case of international environmental arrangements (IEAs). We ask whether participation in such non-economic partnerships tends to enhance international economic relations. The answer, in both theory and practice, is positive.

Memberships in IEAs yield costs and benefits. A country can gain directly from such interactions; its air might be cleaner, or there might be more fish in the sea. However, some gains can be indirect. For instance, countries with long horizons and low discount rates might be more willing both to protect the environment and to maintain a reputation as a good credit risk. If they can signal their discount rate through IEA activity, they indirectly gain from better credit. Alternatively, countries that are tightly tied into a web of international relationships may find that withdrawing from one domain (such as environmental cooperation), may adversely affect activities in an unrelated area (such as finance). The fear of these spillovers may then encourage good behavior in the first area.

Our theoretical analysis begins with an extension of the "reputation spillover" concept introduced by Cole and Kehoe (1997). In our model, countries – or rather, their policymakers –

have differing discount rates. More patient governments choose to join a greater number of environmental treaties; this sends a credible signal concerning a country's debt capacity. Creditors respond by granting the country more trade credit. The predictions of this model are *multilateral*, since membership in IEAs is easily-accessible common knowledge. A country that joins more IEAs enhances its reputation with all nations.

This multilateral model is an intuitive start. Still, it misses the fact that membership in an IEA confers special advantages on its members; if Argentina defaults on its Brazilian debt, Brazil can retaliate through environmental policy. We thus extend the model to accommodate *bilateral* spillovers. We allow a creditor to respond to default by reducing the debtor's gains from involvement in mutual IEAs.[1] This extended model demonstrates that cross-country economic interaction can be a function of *solo* and/or *joint* participation in environmental treaties. Succinctly: the more international environmental commitments that countries make individually and in common, the easier is economic exchange between the countries.

We then take these ideas to the data. Using a gravity model to control for other phenomena, we find that participation in IEAs is indeed positively associated with the international exchange of assets. This confirms the notion of positive spillovers between environmental cooperation and economic exchange. Moreover, we find that multilateral IEA participation is not a sufficient statistic to explain bilateral economic exchange; joint IEA participation is also related to asset cross-holdings. The data therefore support our extended model with both a multilateral reputation effect and some sort of bilateral punishment mechanism.

A brief survey of the literature section is provided in section 2, while our theoretical framework is developed in the following section. The empirical work is presented in section 4. The paper ends with a brief conclusion.

2. Literature Survey

The concept of reputation spillovers arose as a response to the Bulow and Rogoff (1989b) challenge to the sovereign debt literature. In their seminal paper, Bulow and Rogoff cast doubt on the possibility of sustainable sovereign lending based solely on the desire of borrowers to maintain their reputations. They demonstrated that such relationships would not be sustainable, because a borrower would eventually prefer to default on its debt and "self-finance" its consumption-smoothing.

This challenge was addressed in a series of papers by Cole and Kehoe (1995, 1997, 1998). They show that the problem with reputation-based borrowing stems from the fact that a borrower able to replicate interactions with other creditors receives only *transient* benefits from such relationships. At some point, the benefits of maintaining a reputation fall sufficiently that default and subsequent self-finance is the rational response. However, Cole and Kehoe (1995) show that the desire to maintain *other* interactions with creditor nations may support debt, provided that these other relationships are not transient but *enduring.* Cole and Kehoe (1998) demonstrate that the desire to maintain reputations in enduring relationships can support a debt relationship with transient benefits. Cole and Kehoe (1997) show that the desire to maintain an enduring relationship can support a transient debt relationship in a simple trigger-strategy model, where a creditor responds to default by breaking off debtor-relationship with enduring benefits.[2] We borrow this modeling this strategy below in our theoretical work.

A different literature of relevance concerns the formation and characteristics of IEAs; references here include Barrett (1994), Carraro and Siniscalco (1998), and Finus et al (2005). Most of the literature is skeptical about the ability of voluntary self-enforcing IEAs to improve on non-cooperative outcomes. The intuition is that the level of any attainable environmental objective – say, abatement of a certain pollutant – is limited in a heterogeneous group by the preferences of the nation least interested in the problem. While there has been some discussion about encouraging greater participation in IEAs through cooperation in other dimensions such as R&D activity (e.g., Carrero and Siniscalco, 1997), the literature is discouraged by the fact that such agreements are not explicitly found in practice (Barrett, 2003).

3. Economic Interaction and Participation in IEAs

This section introduces a simple model of economic interaction and participation in IEAs. We first introduce a model where IEA activity signals a country's type multilaterally, and then consider the implications of bilateral penalties for sovereign default.

3A. Pure Reputation Model

We begin with a reputation-based model, where a government's choices concerning membership in IEAs send a credible signal concerning its type to creditors; this, in turn, influences the country's borrowing constraint.

We assume that each of $k+1$ countries are endowed with x units of a perishable good in each period, $t = 0,1,...,\infty$. We model decisions in terms of a representative country i. Decisions are made by a national government that maximizes the discounted utility of a representative consumer. We assume utility is linear in consumption, so country i is interested in maximizing:

$$U_t^i = \sum_{j=t}^{\infty} \left(\beta^i\right)^j c_t^i \qquad (1)$$

where β^i represents the country's discount rate, $0 < \beta^i < 1$. We order the countries such that i is increasing in impatience, the key parameter of the model, i.e. $\beta^i \leq \beta^{i+1}$. We assume that the discount rate is private information. For notational simplicity, we drop the i superscript and analyze a representative country.

There are J categories of environmental issues, numbered $j = 1,...,J$. Each category is covered by an IEA (which we refer to interchangeably as a "treaty") that requires participants to contribute a fixed amount of their consumption good e in each period, including period 0, towards improving the environment. IEA j then yields a benefit, y_j, in each of the following periods $t > 0$. We number the treaties such that $y_j \geq y_{j+1}$ and assume that y_j is a continuous twice-differentiable function of j that satisfies $y_j' < 0$, $y_j'' > 0$, and $\lim_{j\to\infty} y_j = 0$.

Since effort levels are constant across treaties, while payoffs are decreasing in j, participation by country i in treaty j implies participation by *i* in IEAs 0 through *j-1*. We therefore concentrate on the government's choice of j^*, the number of treaties to join.

We assume that countries engage in economic interactions with the rest of the world. But while *environmental* interactions are multilateral in our model (at least initially), *economic* interactions occur between pairs of countries. We model the latter in terms of a representative bilateral partner country, k, and assume that there are K such countries with whom each country engages in trade. This trade is facilitated by a bilateral exchange of trade credit.[3] In particular, the gains from bilateral trade between countries i and k in period t satisfy $T_t^k = T\left(\eta_t^k, d_t^k\right)$, where $T' \geq 0$, $T'' \leq 0$ in both arguments and η_t^k is a vector of characteristics

of the two countries (we later associate this with arguments that enter the standard bilateral gravity equation). The payment due in period t on trade credit extended in period $t-1$ from country *i* to country *k* is represented by d_t^k, where $\partial T / \partial d_t^k \geq 0$ below an upper limit $T \leq \overline{T}$.[4]

The timing of the model is as follows: in period 0, the government chooses j^*, the number of IEAs to join. It then chooses whether or not to comply with the terms of these treaties. Next, the representative competitive creditor in country k chooses its repayment d_1^k. Finally, country *i* consumes the unused portion of its endowment. In subsequent periods, the government again decides whether to comply (or not) with the treaty. In addition, it decides whether or not to service its debt d_t^k, while country k chooses how much credit to extend and thus d_{t+1}^k. The country then consumes, subject to any penalties for default or shirking on its environmental commitments.

To insure sub-game perfection, we solve the model backwards, beginning in a representative period $t \geq 1$. Initially, we treat default and IEA penalties as separate; below, we also consider an extension which allows punishment through environmental treaties.

3B: Solving the Model

We solve the model in inverse sequential order for: a) the default decision; b) the IEA compliance decision; and c) the choice of participation in IEAs.

Consumption by country i in period $t > 0$ is equal to the country's endowment, plus the net gains from international trade (the gains from trade minus debt service) and environmental improvement, minus any penalties incurred for debt default or shirking on IEA commitments.[5] These are:

$$\left(c_t \,|t>0\right) = x + \sum_{k=1}^{K}\left[T\left(\eta_t^k, d_t^k\right) - \tilde{d}_t^k\right] + \sum_{j=1}^{j^*}\tilde{y}_j \qquad (2)$$

where: $\tilde{y}_j$ represents the net payoff from participation in treaty j (which equals $y_j - e$ under compliance, and $-\phi$ under non-compliance; the latter represents the penalty for reneging on an IEA), and $\tilde{d}_t^k$ represents the debt service payment (which equals d_t^k under debt service, and 0 under default).[6]

We assume that when the representative country services its debts it continues to obtain funds from all k countries in each period in the future. Discounted utility under debt service then satisfies

$$U_t = \left(\frac{1}{1-\beta}\right)\left\{x + \sum_{i=1}^{K}\left[T\left(\eta_t^i, d_t^i\right) - d_t^i\right] + \sum_{i=1}^{j^*}\left(y_i - e\right)\right\}. \qquad (3)$$

If the country chooses to default on its credit obligations to country k, we assume that it loses access to trade credit with that country in the future. Assuming that it fulfills its environmental treaty obligations and debt obligations to other creditors, discounted utility subsequent to default on credit obligations to country k satisfies

$$\tilde{U}_t = T\left(\eta_t^k, d_t^k\right) + \left(\frac{1}{1-\beta}\right)\left\{\left(x + \sum_{m=1}^{K}\left[T\left(\eta_t^m, d_t^m\right) - d_t^m\right] | m \neq k\right) + \sum_{j=1}^{j^*}\left(y_j - e\right)\right\}. \quad (4)$$

By (3) and (4), the representative country will choose to default unless

$$d_t^k \leq \beta T\left(\eta_t^k, d_t^k\right). \qquad (5)$$

By (5), the credit ceiling will be a function of the creditor's perception of the discount rate of the host country government. This raises the possibility that a country might join more than its optimal number of IEAs to misleadingly signal that it is more patient, and thus ease its credit ceiling. To address this issue, we first consider the decision problem faced in a separating

equilibrium, where governments reveal their true types through their IEA participation decisions. We then derive the conditions necessary to rule out pooling in the appendix.

We next turn to the IEA compliance decision. In any period $t \geq 1$, the country is a member of treaties 1 through j^*. If its government chooses to comply with the terms of treaty j^*, it is easy to demonstrate that it will also comply with all treaties $j \leq j^*$. Under compliance, and given debt service, the government's discounted utility again satisfies (3). Alternatively, given non-compliance, the country suffers a direct penalty of ϕ in every future period. Discounted utility under violation of treaty j^* then satisfies

$$U_t = y_{j^*} - \left(\frac{\beta}{1-\beta}\right)\phi + \left(\frac{1}{1-\beta}\right)\left\{x + \sum_{i=1}^{K}\left[T\left(\eta_t^i, d_t^i\right) - d_t^i\right] + \sum_{z=1}^{j^*-1}\left(y_z - e\right)\right\}. \qquad (6)$$

In the first period, the government chooses j^*, the number of IEAs to join. Consumption in period 0 is equal to the endowment minus the initial IEA effort.

$$c_0 = x - j^* e \qquad (7)$$

For any IEA j, the government has three choices: 1) it can choose not to join the treaty; 2) it can choose to join the treaty and comply with its terms, and 3) it can choose to join the treaty but to violate its terms. However, since the payoff from joining and shirking on a marginal treaty is negative due to the cost of non-compliance, no country will choose the last option; a country can always do better by simply not signing the IEA. The relevant choice is thus whether to join an IEA and comply with its terms, or never sign the treaty. By (3), (6), and (7), it follows that the representative country will choose to join (and comply with) treaty j if and only if

$$e \leq \beta\left(y_j + \phi\right). \qquad (8)$$

Equation (8) demonstrates that the treaty compliance decision is based upon the difference between the single-period gain from shirking on the treaty commitment, and the

discounted sum of future gains from remaining in the treaty and avoiding the shirking penalty. Compliance is more desirable the higher are ϕ, y_{j^*}, and β, and the lower is e.[7]

By (3) and (8), the discounted net benefit of joining any treaty j and complying satisfies

$$\Omega \equiv \left(\frac{1}{1-\beta}\right)\left(\beta y_j - e\right) \tag{9}$$

It can be seen by inspection in (9) that Ω is increasing in β. This leads to proposition 1:

PROPOSITION 1: Under a separating equilibrium, d^k is increasing in j^*.

The proof is in the appendix.

Proposition 1 demonstrates that in a separating equilibrium, the number of IEAs in which a country participates is a credible signal concerning its discount rate. Creditors respond to this signal by offering more credit to a country whose government joins more environmental treaties. Succinctly, the model implies that higher international environmental involvement is associated with more international exchange of credit.

3C. Adding Punishment via International Environmental Arrangements

The prediction of the analysis above is *multilateral*; when Ruritania signs its IEAs, *all* its potential trade partners see this signal. We now add *bilateral* linkages across countries, consistent with the framework of Cole and Kehoe (1997). We assume that if Ruritania defaults, its creditors punish it in the environmental sphere. We then demonstrate that this possibility increases economic integration over and above the level sustained through multilateral IEA

membership. In the next section, we take this prediction to the data to verify the empirical importance of reputation spillovers.[8]

Formally, we specify the bilateral punishment to debt default as reducing the net gains in each period from membership in IEAs in which both countries i and k are members by some fraction γ, $0 < \gamma \leq 1$, so that the gains from being in treaty j are equal to $(1-\gamma)(y_j - e)$. An intermediate value of γ may reflect a loss in cooperation between the two nations, while $\gamma = 1$ would involve a "grim strategy," where the creditor nation responds to a default by its debtor by rescinding the treaty altogether. For simplicity, we assume that the value of γ is constant across countries.[9]

Define m^k as the highest-numbered treaty which contains both countries i and k. With the addition of the bilateral treaty-based default penalty, the value of discounted utility under default satisfies

$$\tilde{U}_t = T\left(\eta_t^k, d_t^k\right) + \left(\frac{1}{1-\beta}\right)\left(x + \sum_{i=1}^{K}\left[T\left(\eta_t^i, d_t^i\right) - d_t^i\right] | i \neq k\right) + \sum_{z=1}^{j^*}\left[1 + \left(\frac{\beta}{1-\beta}\right)(1-\varphi\gamma)\right](y_z - e) \tag{10}$$

where φ is an indicator variable that takes value 1 if $z \leq m^k$, and value 0 otherwise.

By (3), (9), (10), and $\Omega \geq 0$, the credit constraint from country k satisfies

$$d_t^k \leq \frac{e}{y_{j^*}}\left[T\left(\eta_t^k, d_t^k\right) + \varphi\gamma\sum_{z=1}^{j^*}(y_z - e)\right] \tag{11}$$

Comparing (11) and (5), it can be seen that the capacity to levy bilateral treaty penalties under default eases the credit ceiling faced by country k. This leads to:

PROPOSITION 2: Under a separating equilibrium, and given the bilateral treaty-based default penalty γ, d_t^k is increasing in j^*. Moreover, d_t^k is also increasing in m^k.

The proof is in the appendix.

Both our models predict that the international exchange of trade credit (and thus d_t^k) will be increasing in the number of IEAs, j^*. Proposition 2 shows that the inclusion of bilateral penalties adds the prediction that international economic exchange d_t^k is also increasing in the number of joint treaties, m^k. Below, we test for the presence of both effects.

The addition of the bilateral default penalty potentially adds a distortion to the treaty-joining decision, as it increases the rate at which the credit ceiling eases when joining an additional treaty holding all else equal. This alters the condition for a separating equilibrium. We therefore also derive the augmented sufficient condition for a separating equilibrium in the presence of these bilateral penalties in the appendix.

4. Empirics

We think of the model above as illustrative rather than one to be taken literally. We have made a host of assumptions to keep the model stripped down to its bare essentials. For instance, the model assumes: no production, no uncertainty (and thus no renegotiation), much symmetry (and thus no net debtors or creditors), limited interactions between countries, and so forth. We think the analysis points to two key predictions (each summarized in a proposition). First, a country's non-economic commitments (which we model as the number of IEAs in which a country participates) should have a positive effect on its ability to conduct international economic exchange (which we model as trade credit). Second, bilateral non-economic

interactions may also matter; the level of multilateral IEA participation may not be a sufficient statistic for the level of environmental engagement. The number of IEAs common to both countries is also relevant to their bilateral economic interactions if there are "bilateral penalties." We now take these predictions to the data.

4A. Specification

Our pure reputation model characterized by Proposition 1, predicts that the level of international asset cross-holdings between two nations will be increasing in the number of IEAs in which each of them participates, while the extended bilateral penalty model, characterized by Proposition 2, predicts that the number of IEAs in which they are joint members is also relevant. Our goal in this section is to check these predictions.

Our empirical specification of international cross-holdings of assets is a generalization of the standard bilateral "gravity" model, which has been widely employed to model international economic exchange:

$$\begin{aligned}\ln\left(A_{ij}\right) &= \beta_1 \ln\left(D_{ij}\right) + \beta_{2i} \ln\left(Y_i\right) + \beta_{2j} \ln\left(Y_j\right) + \beta_{3i} \ln\left(Pop_i\right) + \beta_{3j} \ln\left(Pop_j\right) \\ &+ \beta_4 RTA_{ij} + \beta_5 CU_{ij} + \beta_6 Lang_{ij} + \beta_{7i} \ln\left(Area_i\right) + \beta_{7j} \ln\left(Area_j\right) + \beta_8 Cont_{ij} \\ &+ \beta_{8i} Landl_i + \beta_{8j} Landl_j + \beta_{9i} Island_i + \beta_{9j} Island_j + \beta_{10} ComCol_{ij} \\ &+ \gamma_1 IEA_{ij} + \gamma_2 IEA_i + \beta_{11} IEA_j + \varepsilon_{ij}\end{aligned} \tag{12}$$

where i denotes the host country, j denotes the source country, and the variables are defined as:

- A_{ij} denotes asset cross-holdings held in host country i and sourced from j, measured in (millions of) dollars,
- D_{ij} is the distance between i and j,
- Y_i is real GDP of i,

- Pop_i is population of i,
- RTA_{ij} is a binary variable which is unity if i and j belong to the same regional trade agreement and zero otherwise,
- CU_{ij} is a binary variable which is unity if i and j use the same currency at time t,
- $Lang_{ij}$ is a binary variable which is unity if i and j have a common language,
- $Area_i$ is the total area of i,
- $Cont_{ij}$ is a binary variable which is unity if i and j share a land border,
- $Landl_i$ is a binary variable which is unity if country i is land-locked,
- $Island_i$ is a binary variable which is unity if country i is an island nation,
- $Comcol_{ij}$ is a binary variable which is unity if i and j were ever colonies after 1945 with the same colonizer,
- IEA_i is the number of environmental treaties that i has ratified at t,
- IEA_{ij} is the number of environmental treaties that i and j have both ratified at t,
- β is a vector of nuisance coefficients, and
- ε_{ij} represents the other influences on bilateral credit, assumed to be well behaved.

The coefficients of interest to us are $\{\gamma\}$. γ_1 represents the effect on international economic exchange of host country i's participation in international environmental treaties; γ_2 is the analogous effect of joint IEA participation by i and j.

4B. Data

Our regressand is asset cross-holdings. We use the *Coordinated Portfolio Investment Survey* (CPIS) data set, available annually for 2001, 2002, and 2003 from the IMF.[10] This records cross-holdings of asset stocks between up to 68 source and 221 host "countries"

measured in millions of US$. The countries in the data set are listed in appendix table A1. Asset cross-holdings are a good measure of economic exchange, but not a perfect measure of trade credit. Accordingly, and to check the sensitivity of our results, we also use trade flows as a regressand. We do this by merging into the CPIS data set bilateral data on exports and imports, measured in American dollars taken from the IMF's *Direction of Trade* data set. To smooth the data out, we average our series across the years available, so that our data becomes a single bilateral cross-section.

As control variables, we merge in data on population and real GDP data (in constant dollars) taken from the World Bank's *World Development Indicators*. We exploit the CIA's *World Factbook* extensively for data on other regressors.[11] From it we find series on: latitude and longitude, land area, landlocked and island status, physically contiguous neighbors, language, colonizers, and dates of independence. We use these to create great-circle distance and other controls. We obtain data from the World Trade Organization to create an indicator of regional trade agreements, including some 178 regional trade agreements. Finally, we add the Glick and Rose (2002) currency union dummy variable.

The coefficients of interest measure the effect of solo (multilateral) and joint (bilateral) participation in environmental treaties. Our data set on environmental treaties is the Environmental Treaties and Resource Indicators (ENTRI) data set produced by Columbia University.[12] The ENTRI data set contains country-by-country indicators of participation in up to 464 treaties. The treaties range from the "Act regarding Navigation and Economic Co-operation between the States of the Niger Basin" through the "Vienna Convention on the Law of Treaties." The data set includes the usual suspects, including, e.g.: CITES (the "Convention on International Trade in Endangered Species of Wild Fauna and Flora"); Biodiversity

("Convention on Biological Diversity"); and the Kyoto Protocol (to the United Nations Framework Convention on Climate Change).

ENTRI provides data for individual countries on: 1) which agreements the country has signed (so that a country is a "signatory" to a treaty); 2) which agreements are in force (where the country is a "party" to an agreement); as well as 3) agreements denounced (so that the country is a "former party" to a treaty). There are only a small number of the latter; almost one hundred countries have not denounced any agreements (the United States has denounced three agreements; and the United Kingdom has denounced the largest number of treaties, ten).

For our multilateral regressor IEA_i (as well as IEA_j, which we use simply as a control symmetrically), we simply sum up the number of agreements either signed or in force, and subtract from this the number of denounced agreements. For our bilateral regressor (IEA_{ij}) we sum up the number of agreements that are either signed or in force by both countries and subtract from this the number of jointly denounced agreements. Simply adding up the number of international environmental treaties is obviously a crude starting point, since treaties are not all of equal importance. We consider a more careful weighting of participation in different treaties to be an interesting topic for future work.[13]

We do not think there is much cause for concern with simultaneity. The key variables – individual and joint participation in environmental treaties by the source and host countries – are plausibly exogenous. There is certainly little evidence from the literature that countries take into account their potential attractiveness as a potential recipient for capital flows when contemplating environmental negotiations.[14] Nevertheless, we estimate our equations with both Ordinary Least Squares (OLS) and Instrumental Variables (IV), using standard errors that are robust to heteroskedasticity. We use IV mostly to take into account measurement error, since a

simple summation of the number of active environmental treaties in which a country is participating is a noisy indicator of its international environmental commitments.[15] However, it is possible that a latent country-specific characteristic both makes a country a good destination for capital flows and a committed environmentalist.

We use two instrumental variables for the number of environmental agreements as our default (we also experiment with our choices to check the robustness of our results). The first is the country's "polity" score, taken from the Polity IV data set.[16] This is a score that measures the political nature of the country. It is available for 161 countries annually through 2003; the score for an individual country during a given year ranges from -10 (a high autocracy such as Qatar or Saudi Arabia) through 10 (a high democracy such as Australia or Austria). We think of this instrumental variable as desirable since more democratic political regimes are likely to have longer time horizons.

Our second instrumental variable is more directly tied to environmental considerations. We use the "Environmental Sustainability Index" (ESI), described by its creators as "a measure of overall progress towards environmental sustainability".[17] The ESI was developed by the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network at Columbia University, for the World Economic Forum, and is available for up to 145 countries for 2001 and 2002. In 2001, the three countries with the highest and lowest ESI scores were Finland, Norway and Canada, and Haiti, Saudi Arabia, and Burundi respectively. The ESI can be decomposed into five "core components"; above and beyond the ESI itself, we use the three most plausible of its components as IVs for sensitivity analysis ("Environmental Systems," "Environmental Stress," and "Human Vulnerability" to the environment).[18]

Descriptive statistics for the key variables are presented in Table A2. Table A3 contains simple bivariate correlations between the key variables of interest. The regressors of interest are all positively correlated with the regressands. Further, both instrumental variables have positive simple correlations with the number of environmental treaties.

4C. Results

Our benchmark OLS results are presented in Table 1. The first column presents a specification in which only there are no environmental treaties entered at all. The next two columns add: first, the number of treaties to which each of the host and source countries separately belong (multilateral measures); and second, the number of environmental treaties to which both countries belong (a bilateral measure). The most important column is that on the right, which includes both the bilateral and multilateral measures of environmental treaties.

While the control variables are not of direct interest, it is reassuring to see that the default gravity model seems to work well. Countries that are further apart have fewer asset cross-holdings, while countries with greater economic mass (as measured by GDP) have more. Holding GDP constant, countries with larger population (i.e., lower GDP per capita) exchange fewer assets. A number of sensible features seem to raise cross-holdings, including a common language, currency, land border, colonizer or regional trade agreement. Some of the purely geographic features (the physical size of a country, whether it is landlocked, and whether it is an island nation) also matter. The equation fits well, with an impressive R^2 of .61 on a purely cross-sectional basis.

Is there space for environmental commitment to matter above and beyond these factors? Yes. Both the multilateral and bilateral number of environmental commitments have a positive

effect on asset cross-holdings. If one examines the column on the extreme right (which gives the weakest results since it examines multilateral and bilateral effects simultaneously), for each additional jointly signed environmental treaty, asset cross-holdings by .03%. This effect is small but plausible, and statistically significant at any reasonable confidence level. If a pair of countries were to move from the 25th percentile (with 7 jointly signed environmental treaties) to the 75th percentile (with 54 joint treaties) holding other factors constant, asset cross-holdings would be expected to rise by around 1.5%. Similarly, the effect of a host country's environmental commitment also has a small positive and statistically significant effect on asset holdings; a one standard deviation increase in the number of environmental treaties signed raises asset cross-holdings by around .65%.

We consider our OLS results to be basically supportive of the idea that non-economic partnerships play a small but positive role in supporting economic exchanges such as international cross-holdings of assets. Moreover, as we find that both multilateral and joint IEA membership are significantly positive, the results appear to support some level of bilateral punishment as well.

Nevertheless, since our measure of a country's international environmental commitment is both measured with error and potentially simultaneously determined with asset flows, we want to take instrumental variable results seriously. These are presented in Table 2, which is formatted similarly to Table 1. Reassuringly, both coefficients of interest remain positive and statistically significant when estimated with IV. Indeed, consistent with the notion of either attenuation or simultaneity bias, the coefficients are even larger. The effect of joint environmental treaties has almost doubled while the effect of a host country's environmental treaties has more than quintupled![19] We tend to act conservatively in our interpretation and thus

try not to take these magnitudes too seriously, especially given that the precision of the estimates has deteriorated.[20] Still, it seems reasonable to conclude that our OLS results do not stem simply from a flawed estimation strategy.

We check the sensitivity of our results further in Table 3. We pursue four types of robustness checks: 1) moving from time-averaged to annual data; 2) changing the instrumental variables; 3) using merchandise trade instead of asset cross-holdings as the dependent variable; and 4) taking into account regional effects.

We are comfortable with our strategy of averaging our three years of data into a single cross-section. The span of the data is short so that the observations are highly dependent, and some country-pairs are not available for every year. Still, panel estimation is certainly feasible. Accordingly, we estimated our equation by pooling our annual cross-sections, including year effects. The OLS and IV results are tabulated in the first two rows of Table 3. They indicate that our key finding of positive and significant effects of the number of both multilateral and joint (bilateral) environmental treaties on asset cross-holdings is robust to using pooled annual instead of a single cross-section of data.

The next few rows experiment with the exact choice of instrumental variables. First, we substitute the three most plausible components of the ESI ("Environmental Systems," "Environmental Stress," and "Human Vulnerability" to the environment) for the portmanteau ESI measure itself. This allows us to eliminate the two other potentially problematic ESI components ("Social and Institutional Capacity" and "Global Stewardship"). Our two key coefficients of interest are still positive and significant when we follow this estimation strategy. The same is true when we replace the ESI as an IV with the number of environmental treaties listed in the CIA's *World Factbook*. Appendix C of the *Factbook* tabulates 27 "Selected

International Environmental Agreements"; we use these in place of the (over 450) agreements listed by ENTRI, excluding only four that deal with the Antarctic.[21] Again, our two key coefficients of interest remain positive and significant. However, our results are eliminated when we use either polity or ESI alone for instrumental variables; our only significant finding is for the number of joint environmental treaties when we use polity as the sole IV.

A different check is to use the bilateral trade in merchandise goods instead of asset cross-holdings. Bilateral trade may involve trust relationships analogous to the role of debt in our model above, and therefore be increasing in the level of reputation spillovers from IEA memberships. Still, our model is primarily concerned with default and punishment, so there is no clear reason to expect positive results. Our results demonstrate that while the bilateral term is insignificantly different from zero (so that the number of jointly-signed environmental treaties does not seem to matter), the more agreements a country signs, the higher its trade. Loosely, the trade results support pure reputation spillovers, but fail to identify evidence for punishment effects at standard significance levels.

Out final checks have to do with regional effects. We do this in two ways. First, we add three regional dummies: one for observations where either country is African; another for observations where either country is either Latin American or Caribbean; and a third where either country is Asian. We then exclude observations for each of these three regions, one by one. The results are tabulated in the bottom four rows of Table 3. They indicate that our bilateral result – the effect of jointly signed environmental treaties – on asset cross-holdings is sensitive to the inclusion of regional dummies, or the exclusion of regional observations. While the effects remain consistently positive, they are not significantly different from zero at

traditional confidence levels. On the other hand, the key multilateral effect remains positive and significant throughout.

We have also conducted a number of other sensitivity checks. We looked for a non-linear effect of environmental treaties in a number of different ways (adding quadratic terms, using non-parametric techniques …) but found no compelling evidence of any significant non-linearity. We also looked without much luck for separate effects of both "small" and "large" environmental treaties, defining small treaties as those with less than ten participating countries, and large ones as those with fifty or more countries.

We conclude from all this that there is indeed a link between environmental engagement – as proxied through environmental treaty obligations – and international exchanges of assets. Moreover, this link appears to reflect both overall and joint IEA participation, suggesting that both the pure reputation and bilateral punishment channels for reputation spillovers play a role in the determination of cross-holdings of assets. Sensitivity analysis also confirmed a role for overall IEA participation in the determination of trade levels, although joint IEA participation did not enter measurably in this specification, casting some doubt on the presence of bilateral environmental punishments as a facilitator of overall trade levels.

5. Caveats, Summary and Conclusion

In this paper, we first developed a theoretical model that suggests that countries more deeply enmeshed in international environmental arrangements should also find it easier to engage in the international exchange of goods and assets with the rest of the world. We then showed that two countries with a joint interest in the environment should also find it easier to sustain large cross-holdings of assets, since each can punish the other in one domain for

transgressions in a different domain. We then tested these ideas, using a recent cross-section of international asset holdings, and environmental commitments. Our empirics verify the significance of both effects, especially the first; multilateral environmental engagement facilitates international economic exchange.

Is there a cost to "going it alone"? Is it costly for countries to ignore international environmental agreements? Yes. Countries have varying degrees of foreign engagement. Some are deeply enmeshed in defense alliances, environmental treaties, and international organizations; others are not. Above and beyond the direct consequences of such entanglements, we have found in this paper that countries with greater IEA participation also have higher trade in goods and assets. Thus membership in international institutions brings indirect benefits; not joining such partnerships has costs. If our assertions are correct, they have consequences for policy. For example, the debate on American participation in the Kyoto Protocol was framed in terms of the costs and benefits to the United States of participation in that treaty. We chose to examine international environmental arrangements as one example of non-economic interactions. However, there are a variety of other domains in which countries interact; security arrangements and international organizations come to mind immediately. If participation in such organizations also conveys broader economic benefits, these externalities should not be ignored.

A number of questions remain: First, does bad behavior in the economic sphere (e.g., debt default) actually lead to retaliation outside the economic domain? More directly, what are the costs of violating IEAs? Do countries that violate international partnerships pay a cost, either indirect or direct? We leave such fascinating questions for future research.

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Table 1: OLS Results

# Environmental Treaties, Host		.024** (.001)		.013** (.002)
# Environmental Treaties, Joint			.048** (.003)	.032** (.004)
Log Distance	-1.07** (.08)	-.85** (.09)	-.49** (.09)	-.59** (.09)
Log Host Real GDP	3.51** (.05)	2.83** (.07)	2.95** (.06)	2.76** (.07)
Log Source Real GDP	2.73** (.09)	2.33** (.12)	2.14** (.10)	2.26** (.12)
Log Host Population	-2.27** (.07)	-1.72** (.08)	-1.84** (.08)	-1.67** (.08)
Log Source Population	-2.12** (.10)	-1.79** (.12)	-1.53** (.11)	-1.67** (.12)
Regional Trade Agreement	1.13** (.16)	1.20** (.16)	.69** (.16)	.89** (.16)
Currency Union	3.17** (.21)	1.77** (.24)	.83** (.25)	.90** (.26)
Common Language	1.83** (.16)	2.06** (.16)	1.97** (.16)	2.00** (.16)
Log Host Area	.13** (.04)	.01 (.04)	-.00 (.04)	-.03 (.04)
Log Source Area	-.26** (.03)	-.28** (.03)	-.44** (.03)	-.36** (.04)
Common Land Border	.97** (.36)	.87* (.38)	.56 (.39)	.61 (.39)
Host Landlocked	-.56** (.14)	-.48** (.14)	-.29* (.14)	-.36* (.14)
Source Landlocked	.35* (.18)	.43* (.18)	.28 (.18)	.38* (.18)
Host Island Nation	.61** (.18)	.57** (.18)	.31** (.17)	.38* (.18)
Source Island Nation	1.37** (.17)	1.43** (.17)	1.27** (.17)	1.33** (.17)
Common Colonizer	1.00** (.41)	1.81** (.40)	1.37** (.39)	1.66** (.40)
# Environmental Treaties, Source		.009** (.001)		.003 (.001)
Observations	6432	6354	6432	6354
R^2	.61	.63	.63	.63
Root MSE	4.227	4.131	4.116	4.111

Dependent variable: log asset cross-holdings. Columns estimated separately.
OLS with robust standard errors in parentheses.
Data averaged over 2001-2003.
Intercept included but not tabulated.
Coefficients that are significantly different from zero at .05 (01) are marked with one (two) asterisk(s).

Table 2: IV Results

# Environmental Treaties, Host	.113** (.007)		.077** (.013)
# Environmental Treaties, Joint		.176** (.011)	.057** (.022)
Log Distance	-.02 (.18)	.98** (.18)	.28 (.24)
Log Host Real GDP	.12 (.22)	1.10** (.16)	.40 (.21)
Log Source Real GDP	-.25 (.78)	.61** (.18)	.25 (.73)
Log Host Population	.07 (.17)	-.60** (.13)	-.12 (.16)
Log Source Population	.34 (.60)	.10 (.18)	.10 (.57)
Regional Trade Agreement	1.85** (.22)	-.04 (.22)	1.24** (.30)
Currency Union	-3.15** (.64)	-4.91** (.70)	-3.73** (.73)
Common Language	3.09** (.29)	2.13** (.21)	2.74** (.27)
Log Host Area	.34** (.07)	.06 (.05)	.26** (.07)
Log Source Area	.07 (.10)	-.33** (.06)	-.08 (.09)
Common Land Border	.28 (.65)	-1.13 (.62)	-.19 (.65)
Host Landlocked	.06 (.20)	.42* (.18)	.18 (.19)
Source Landlocked	1.09** (.38)	.79** (.26)	.91* (.36)
Host Island Nation	1.10** (.35)	-.35 (.31)	.65 (.38)
Source Island Nation	1.79** (.49)	.18 (.27)	1.16** (.44)
Common Colonizer	6.22 (.88)	4.53** (.80)	5.66** (.82)
# Environmental Treaties, Source	.060** (.012)		.037** (.011)
Observations	4430	4430	4430
R^2	.40	.55	.50
Root MSE	5.288	4.552	4.822

Dependent variable: log asset cross-holdings. Columns estimated separately.
IV with robust standard errors in parentheses. Polity and ESI (host&source/product/both) as IVs.
Data averaged over 2001-2003.
Intercept included but not tabulated.
Coefficients that are significantly different from zero at .05 (01) are marked with one (two) asterisk(s).

Table 3: Sensitivity Analysis

	# Environmental Treaties, Host	# Environmental Treaties, Joint
OLS, Annual Panel with year effects	.006** (.002)	.042** (.003)
IV, Annual Panel with year effects	.062** (.011)	.065** (.018)
IV, Polity and 3 ESI components as IVs	.028** (.006)	.094** (.013)
IV, CIA Treaties as IVs	.018** (.002)	.028** (.006)
IV, Polity as IV	-.008 (.022)	.167** (.039)
IV, ESI as IV	.021 (.067)	.143 (.122)
Bilateral Goods Trade, OLS	.005** (.001)	-.001 (.001)
IV, with regional dummies	.080** (.013)	.024 (.023)
IV, without Africa	.083** (.016)	.038 (.028)
IV, without Latins and Caribbean	.075** (.013)	.043 (.023)
IV, without Asians	.093** (.013)	.031 (.021)

Other controls included but not reported: Log Distance, Log Host Real GDP, Log Source Real GDP, Log Host Population, Log Source Population, Regional Trade Agreement, Currency Union, Common Language, Log Host Area, Log Source Area, Common Land Border, Host Landlocked, Source Landlocked, Host Island Nation, Source Island Nation, Common Colonizer, and intercept.
Dependent variable: log asset cross-holdings. Rows estimated separately. Data averaged over 2001-2003 unless noted.
Robust standard errors in parentheses. Polity and ESI (host&source/product/both) are IVs.
Coefficients that are significantly different from zero at .05 (01) are marked with one (two) asterisk(s).

Appendix.

Proof of Proposition 1

By definition, j^* is the largest value of j for which $\Omega \geq 0$ in (9). By (9), since $\Omega \geq 0$ is required for an IEA to be joined voluntarily, and since y_{j^*} is decreasing in j^*, an increase in an increase in j^* requires an increase in the minimum value of β. As more credit is desirable, competition among creditors will then imply that they set the debt ceiling such that (5) is binding for the minimum value of β that satisfies $\Omega \geq 0$. Let d_t^k represent the credit constraint given that the representative country it joins j treaties. d_t^k satisfies

$$d_t^k \leq \frac{e}{y_{j^*}} T\left(\eta_t^k, d_t^k\right) \tag{13}$$

An interior solution for d_t^k requires that $T' \leq y_{j^*} / \bar{e}$, where $T' \equiv \partial T / \partial d^k$, which we adopt. Totally differentiating d_t^k with respect to j^* yields

$$\frac{dd_t^k}{dj^*} = -\frac{eTy_{j^*}'}{\left(y_{j^*} - \bar{e}T'\right) y_{j^*}} \geq 0 \tag{14}$$

where $y_j' \equiv \partial y / \partial j$, and the denominator is positive when we have an interior solution. This completes the proof.

Proof of Proposition 2

If $j^* = m^k$, by (11)

$$\frac{dd_t^k}{dj^*} = \frac{-e\left[T + \gamma \sum_{i=1}^{j^*} \left(y_i - e\right)\right] y_{j^*}' + e\gamma\left(y_{j^*}\right)^2}{\left(y_{j^*} - eT'\right) y_{j^*}} \geq 0 \tag{15}$$

where the denominator can again be signed as positive given an interior solution.

Alternatively, if $m^k < j^*$, by (11) dd_t^k / dj^* is the same as in (14) and positive, since the bilateral penalty is unaffected by the increase in j^* in this case. Finally, by (11) dd_t^k / dm^k satisfies

$$\frac{dd_t^k}{dm^k} = \frac{e\gamma y_{j^*} y_{m^k}}{\left(y_{j^*} - eT'\right) y_{j^*}} \geq 0 \qquad (16)$$

where the denominator is again be signed as positive given an interior solution. This completes the proof.

Conditions for separating equilibrium

We can rule out a pooling equilibrium if no individual country would choose to deviate from its separating equilibrium solution to mimic a more patient government. We first examine the case where there are no bilateral penalties. Suppose that instead of joining j^* treaties, an individual government chose to join j^*+1 treaties. Under a separating equilibrium, the country would receive a credit extension that exceeded its borrowing constraint and then default on all K countries. By (3) and (8), its discounted utility would satisfy

$$U_{j^*} = x - \left(j^*+1\right)e + \beta \sum_{i=1}^{K} T\left(\eta_t^i, d_t^i\left(j^*+1\right)\right) + \left(\frac{\beta}{1-\beta}\right)\left\{x + \sum_{i=1}^{j^*+1}\left(y_i - e\right)\right\} \qquad (17)$$

so that the gain in utility from joining an additional treaty relative to playing the separating equilibrium strategy is equal to

$$U_{j^*+1} - U_{j^*} = \left\{\left(\frac{1}{1-\beta}\right)\left[\beta y_{j^*+1} - e\right]\right\} + \beta \sum_{i=1}^{K}\left\{T\left(\eta_t^i, d_t^i\left(j^*+1\right)\right) - T\left(\eta_t^i, d_t^i\left(j^*\right)\right)\right\} \qquad (18)$$

The first term is negative, reflecting the loss from entering into an excessive number of IEA treaties, while the second term is positive, reflecting the gains from easing country i's credit constraint.

To evaluate the condition needed to rule out pooling, we also need to consider infra-marginal choices of j. We first demonstrate that the utility from mimicking a more patient government by choosing to join more than the number of treaties that would be optimal under the separating equilibrium, $\hat{j} > j^*$, is decreasing in $\hat{j}$. By (18)

$$U_{\hat{j}+1} - U_{\hat{j}} = \left(\frac{1}{1-\beta}\right)\left[\beta y_{\hat{j}+1} - e\right] + \beta\sum_{i=1}^{K}\left[T\left(\eta_t^i, d_t^i\left(\hat{j}+1\right)\right) - T\left(\eta_t^i, d_t^i\left(\hat{j}\right)\right)\right] \quad (19)$$

Differentiating with respect to $\hat{j}$ yields

$$\frac{\partial}{\partial \hat{j}}\left(U_{\hat{j}+1} - U_{\hat{j}}\right) = \beta\left\{\frac{\partial y_{\hat{j}+1}}{\partial \hat{j}} + \sum_{i=1}^{K}\left[\left(\frac{\partial T}{\partial j}\middle| j = \hat{j}+1\right) - \left(\frac{\partial T}{\partial j}\middle| j = \hat{j}\right)\right]\right\}. \quad (20)$$

The entire term will be negative if T is concave in j, i.e. if

$$\frac{\partial^2 T}{\partial j^2} = T''\left(\frac{\partial d^k}{\partial j}\right)^2 + T'\left(\frac{\partial^2 d^k}{\partial j^2}\right) < 0 \quad (21)$$

By (14)

$$\frac{\partial^2 d^k}{\partial j^2} = \frac{eT}{\left(y_{j^*} - eT'\right)y_{j^*}}\left[\frac{\left(2y_{j^*} - eT'\right)\left(y_{j^*}'\right)^2}{\left(y_{j^*} - eT'\right)y_{j^*}} - y_{j^*}''\right] \quad (22)$$

which is ambiguous in sign. Substituting (14) and (22) into (21), T is concave in j if

$$\frac{\partial^2 T}{\partial j^2} = \left\{\frac{T''eT + T'\left(2y_{j^*} - eT'\right)}{\left(y_{j^*} - eT'\right)y_{j^*}}\left(y_{j^*}'\right)^2 - T'y_{j^*}''\right\}\left[\frac{eT}{\left(y_{j^*} - eT'\right)y_{j^*}}\right] < 0 \quad (23)$$

This condition will be satisfied if T is sufficiently concave in d^k. A sufficient, but not necessary, condition is

$$\left|T''\right| \geq \frac{T'\left(2y_{j^*} - eT'\right)}{eT} \quad (24)$$

which we take as a parameter restriction.

Given the parameter restriction in (24), the gain from joining an additional treaty relative to any $\hat{j} > j^*$ is decreasing in $\hat{j}$. A separating equilibrium will then obtain if no country would choose to join j^*+1 treaties, i.e. if the term in equation (18) is negative.

The necessary and sufficient condition is

$$\sum_{i=1}^{K}\left\{T\left(\eta_t^i, d_t^i\left(j^*+1\right)\right) - T\left(\eta_t^i, d_t^i\left(j^*\right)\right)\right\} \leq \left(\frac{1}{1-\beta}\right)\left[y_{j^*} - y_{j^*+1}\right] \quad (25)$$

which we adopt. Satisfaction of conditions (23) and (25) then guarantee a separating equilibrium.

Finally, we examine the conditions for a separating equilibrium in the presence of bilateral default penalties. The gain from joining an additional treaty relative to any $\hat{j} > j^*$ will be the same as in (19), with the exception that d_t^k will now also be a function of m^k if $m^k < j*$. As before, this gain will be decreasing in $\hat{j}$ if $\partial^2 T / \partial j^2 \leq 0$. However, the components of $\partial^2 T / \partial j^2$ now incorporate the impact of bilateral penalties.

To derive a sufficient, but not necessary, condition for a separating equilibrium, we evaluate the case where adding an additional treaty yields the largest impact possible. This would is the case where joining an additional treaty increase m^{ik} for all k creditor nations, i.e. where $j* = m^k \forall k \in K$. $\partial d^k / \partial j$ would then satisfy (15).

The second derivative now satisfies

$$\frac{\partial^2 d^k}{\partial j^2} = \frac{-e\left[T + \gamma \sum_{i=1}^{j^*} (y_i - e)\right]\left\{y_{j^*}''\left(y_{j^*} - eT'\right) y_{j^*} - \left(y_{j^*}'\right)^2 \left(2y_{j^*} - eT'\right)\right\} - e\gamma \left(y_{j^*}\right)^3 y_{j^*}'}{\left[\left(y_{j^*} - eT'\right) y_{j^*}\right]^2} \tag{26}$$

T will then be concave in j if T is sufficiently concave in d_t^k. The necessary and sufficient condition is

$$\left|T''\right| \geq \frac{T'\left\{-e\left[T + \gamma \sum_{i=1}^{j^*} (y_i - e)\right]\left\{y_{j^*}''\left(y_{j^*} - eT'\right) y_{j^*} - \left(y_{j^*}'\right)^2 \left(2y_{j^*} - eT'\right)\right\} - e\gamma \left(y_{j^*}\right)^3 y_{j^*}'\right\}}{\left\{-e\left[T + \gamma \sum_{i=1}^{j^*} (y_i - e)\right] y_{j^*}' + e\gamma \left(y_{j^*}\right)^2\right\}^2} \tag{27}$$

As before, then, we can rule out a pooling equilibrium if a government would not choose to join an additional treaty relative to its undistorted choice. The formal condition is again that in (25), with d_t^k now corresponding to (11). This condition is more restrictive because of increasing the number of joint treaties between countries i and k, raises the penalty for default on obligations to country k. It therefore follows that satisfaction of conditions (25) and (27) with d_t^k corresponding to (11) are sufficient, but not necessary, to rule out pooling in the nested model, i.e. with or without bilateral penalties.

Table A1: Countries in CPIS Data Set

Afghanistan	Albania	Algeria	American Samoa	Andorra
Angola	Anguilla	Antigua and Barbuda	Argentina*	Armenia
Aruba*	Australia*	Austria*	Azerbaijan	Bahamas*
Bahrain*	Bangladesh	Barbados	Belarus	Belgium*
Belize	Benin	Bermuda	Bhutan	Bolivia
Bosnia and Herzegovina	Botswana	Brazil	British Virgin Islands	Brunei Darussalam
Bulgaria*	Burkina Faso	Burundi	Cambodia	Cameroon
Canada*	Cape Verde	Cayman Islands*	Central African Rep.	Chad
Chile*	China	Colombia*	Comoros	Congo (Zaire/Kinshasa)
Congo (Brazzaville)	Cook Islands	Costa Rica*	Côte d'Ivoire	Croatia
Cuba	Cyprus*	Czech Republic*	Denmark*	Djibouti
Dominica	Dominican Republic	Ecuador	Egypt*	El Salvador
Equatorial Guinea	Eritrea	Estonia*	Ethiopia	Falkland Islands
Faeroe Islands	Fiji	Finland*	France*	French Guiana
French Polynesia	Gabon	Gambia	Georgia	Germany*
Ghana	Gibraltar	Greece*	Greenland	Grenada
Guadeloupe	Guam	Guatemala	Guernsey*	Guinea
Guinea-Bissau	Guyana	Haiti	Honduras	Hong Kong*
Hungary*	Iceland*	India	Indonesia*	Iran
Iraq	Ireland*	Isle of Man*	Israel*	Italy*
Jamaica	Japan*	Jersey*	Jordan	Kazakhstan*
Kenya	Kiribati	Korea*	Kuwait	Kyrgyz Republic
Laos	Latvia	Lebanon*	Lesotho	Liberia
Libya	Liechtenstein	Lithuania	Luxembourg*	Macau*
Macedonia	Madagascar	Malawi	Malaysia*	Maldives
Mali	Malta*	Marshall Islands	Martinique	Mauritania
Mauritius*	Mexico	Micronesia	Moldova	Monaco
Mongolia	Montserrat	Morocco	Mozambique	Myanmar
Namibia	Nauru	Nepal	Netherlands*	Netherlands Antilles*
New Caledonia	New Zealand*	Nicaragua	Niger	Nigeria
North Korea	Norway*	Oman	Pakistan*	Palau
Panama*	Papua New Guinea	Paraguay	Peru	Philippines*
Poland*	Portugal*	Puerto Rico	Qatar	Réunion
Romania*	Russian Federation*	Rwanda	St. Helena	St. Kitts and Nevis
St. Lucia	St. Pierre & Miquelon	St. Vincent & Gren.	Samoa	San Marino
São Tomé and Príncipe	Saudi Arabia	Senegal	Serbia and Montenegro	Seychelles
Sierra Leone	Singapore*	Slovak Republic*	Slovenia	Solomon Islands
Somalia	South Africa*	Spain*	Sri Lanka	Sudan
Suriname	Swaziland	Sweden*	Switzerland*	Syrian Arab Republic
Taiwan	Tajikistan	Tanzania	Thailand*	Togo
Tonga	Trinidad and Tobago	Tunisia	Turkey*	Turks & Caicos Islands
Turkmenistan	Tuvalu	Uganda	Ukraine*	United Arab Emirates
United Kingdom*	United States*	Uruguay*	Uzbekistan	Vanuatu*
Venezuela*	Vietnam	Virgin Islands	Yemen	Zambia
Zimbabwe				

Note: Source countries also marked with an asterisk.

Table A2: Descriptive Statistics

	Obs.	Mean	Std. Dev.	Min	Max
Log Assets	9,396	-3.33	6.62	-9.21	13.20
Log Trade	11,031	2.41	3.53	-6.40	12.85
# Environmental Treaties, Joint	14,960	38.47	32.53	0	232
# Environmental Treaties, Host	13,403	78.08	50.09	1	278
# Environmental Treaties, Source	13,420	125.4	60.75	1	278
Log Distance	14,960	7.91	.75	3.18	9.27
Log Host Real GDP	10,242	17.37	2.09	12.85	23.03
Log Source Real GDP	11,710	18.90	1.72	13.27	23.03
Log Host Population	11,862	8.56	2.08	3.00	14.06
Log Source Population	12,200	9.19	1.97	4.15	12.57
Regional Trade Agreement	14,960	.106	.31	0	1
Currency Union	14,960	.014	.12	0	1
Common Language	14,960	.19	.39	0	1
Log Host Area	14,960	10.63	3.20	.69	16.65
Log Source Area	14,960	11.11	3.20	3.04	16.65
Common Land Border	14,960	.01	.12	0	1
Host Landlocked	14,960	.17	.37	0	1
Source Landlocked	14,960	.08	.28	0	1
Host Island Nation	14,960	.21	.41	0	1
Source Island Nation	14,960	.20	.40	0	1
Common Colonizer	14,960	.07	.26	0	1
Host Polity	10,487	3.21	6.64	-10	10
Source Polity	11,660	7.68	4.42	-7	10
Product, Host and Source Polity	8,162	24.47	60.52	-100	100
Host ESI	9,605	49.45	9.02	23.9	73.9
Source ESI	11,220	54.36	9.08	35	73.9
Product, Host and Source ESI	7,191	2687.2	666.7	836.5	5394.7

Data averaged over 2001-03.

Table A3: Bivariate Correlations

	Log Assets	Log Trade	# Joint Env. Trts	# Host Env. Tr.
Log Trade	.71			
# Environmental Treaties, Joint	.70	.65		
# Environmental Treaties, Host	.63	.57	.78	
Host Polity	.48	.31	.49	.56
Product, Host and Source Polity	.47	.30	.52	.49
Host ESI	.33	.17	.36	.40
Product, Host and Source ESI	.23	.01	.30	.29

4,636 observations

Table A4: First Stage

	# Environmental Treaties, Joint	# Environmental Treaties, Host
Host Polity	.141 (.086)	1.75** (.161)
Source Polity	-.146 (.087)	.091 (.163)
Product, Host and Source Polity	.082** (.009)	-.016 (.017)
Host ESI	-.023 (.152)	.619* (.284)
Source ESI	-.104 (.141)	-.054 (.264)
Product, Host and Source ESI	.007* (.003)	.001 (.005)
R^2	.70	.65

Other controls included but not reported: Log Distance, Log Host Real GDP, Log Source Real GDP, Log Host Population, Log Source Population, Regional Trade Agreement, Currency Union, Common Language, Log Host Area, Log Source Area, Common Land Border, Host Landlocked, Source Landlocked, Host Island Nation, Source Island Nation, Common Colonizer, and intercept.
Columns estimated separately. Standard errors in parentheses. Data averaged over 2001-2003.
Coefficients that are significantly different from zero at .05 (01) are marked with one (two) asterisk(s).

Table A5: Determination Equation

	Log	Log	Level
Income per capita, $	.117** (.019)	.140** (.037)	.003** (.001)
Population	.131** (.028)	.116** (.037)	2.3 e-8 (1.8 e-8)
Total Area	-.029 (.023)	-.014 (.030)	1.9 e-7 (2.2 e-6)
Island Nation	-.246** (.087)	-.260** (.096)	-39.** (11.)
Landlocked Nation	-.206** (.057)	-.168** (.060)	-21** (4.4)
Polity	.021** (.005)	.028** (.005)	2.21** (.49)
ESI	.011** (.004)		.64 (.41)
Environmental Systems		.002 (.003)	
Environmental Stress		-.002 (.003)	
Environmental Vulnerability		-.000 (.002)	
R^2	.72	.70	.66
RMSE	.271	.281	30.9

Cross-section of 134 countries. Regressand is number of environmental treaties a country has signed or ratified, minus those it has denounced. "Log" columns take natural logarithms of regressand, income, population, and area.
Robust standard errors in parentheses. Columns estimated separately.
Coefficients that are significantly different from zero at .05 (01) are marked with one (two) asterisk(s).

Endnotes

[1] A cautionary note: there is little evidence of punishment of any form for transgressions in international economic exchange. However, as our model is deterministic, punishment is not observed along equilibrium paths.
[2] There have been other approaches to the challenge raised by Bulow and Rogoff (1989b). Some have concentrated on the ability of another creditor to step in and allow for self-finance subsequent to default. Eaton (1996) and Kletzer and Wright (2000) examine the implications of limiting the commitment capabilities of creditors in sovereign debt models to the level of their debtors. Wright (2002) concentrates on the possibility that the alternative Swiss bankers may not be available for the pursuit of self-finance if creditors find it optimal to collude against a borrower with a history of default. Krueger and Uhlig (2003) examine relationships where creditors have the ability to commit to making contingent payments, but there is a positive cost of initiating a credit relationship that limits a borrower's ability to switch creditors subsequent to a default. All of these generalizations concerning alternative financing opportunities defang the Bulow-Rogoff problem sufficiently to allow sovereign borrowing to reemerge.
[3] Trade credit is a simple device to ensure that capital flows both ways between countries without introducing the complications of risk-sharing.
[4] As the benefits from trade are enduring and the endowment is constant by assumption, the Bulow-Rogoff critique concerning the unsustainability of reputation-based borrowing does not apply here.
[5] There are also flows from lending activity by private creditors in country i with the rest of the world. However, as creditors are risk neutral by assumption, the expected (and realized in this deterministic model) sum of these flows reflecting activity by private agents in country i are zero. In particular, we maintain the assumption that the validity of private claims by agents in country i are independent of that country's default decision on its sovereign debt.
[6] For simplicity, we assume that the penalty for shirking on environmental obligations is homogeneous across treaties. This drives none of our results, but allows treaties to differ only in their payoffs.
[7] A more realistic approach to environmental policy would make the benefits – y_j in our model – rise over time, so that pollution abatement is viewed as an investment project where the costs are borne immediately for later benefits. Adding such time-variation in the net benefits of IEAs would only strengthen our results.
[8] It should be emphasized that denying participation in other relationships as a result of default does not require remaining within the framework of "reputation-based" models of sovereign lending. One could interpret spillover enforcements as sanctions, and remain within a large sovereign debt literature associated with sanctions. We focus below on the effects of reputation spillovers in determining international trade flows. Interruptions of trade can quite reasonably be characterized as default penalties; Bulow and Rogoff (1989a), Rose and Spiegel (2004).
[9] The capacity to punish partners may differ across countries. For example, a large country may be able to influence treaty policies more than a small one. However, as influence may differ in a number of unknown dimensions, we do not attempt to introduce any explicit heterogeneity in punishment technology across countries, although we do condition for other attribute differences, such as country size, in our empirical specification.
[10] http://www.imf.org/external/np/sta/pi/cpis.htm. The CPIS data set has its foibles; for instance, a number of entries are missing. Since a large number of asset cross-holdings are reported to be zero, we add .0001 to these observations.
[11] http://www.cia.gov/cia/publications/factbook/
[12] http://sedac.ciesin.columbia.edu/entri/
[13] In the model above, our ability to monotonically order the IEAs in terms of desirability implied that if $j^* \geq j_i^*$ an increase in j^* would have no impact on m^i. In the data, however, countries are likely to have heterogeneous preferences across treaties for a variety of reasons, allowing j^* and m^i to vary independently. We therefore treat these variables as independent in our empirical analysis.
[14] This is in contrast to participation in security alliances and/or international organizations, which are sometimes linked to international trade of goods, services, and assets. Indeed, this is one of the reasons for our focus on IEAs as opposed to some other form of non-economic international partnership.
[15] Measurement error likely exists in a number of dimensions: Other international organizations, such as the European community, also contain environmental accords. Alternatively, the United States is not a member of the Niger River Basin Accord primarily due to its location, and not due to the policy preferences of its government.
[16] http://www.cidcm.umd.edu/inscr/polity/
[17] http://sedac.ciesin.columbia.edu/es/esi/
[18] This is potentially important since one of the (67) inputs into the ("Global Stewardship" component of the) ESI is the number of international environmental organizations in which a country participates. Environmental Systems measures things like air and water quality through SO2 and NO2 air and phosphorus water concentrations.

Environmental Stress measures things like pollution through fertilizer and pesticide use as well as coal and vehicular usage. Human Vulnerability use things like death rates from respiratory and intestinal infectious disease.

[19] The effect of a source country's environmental commitment is now positive and significant; we have no explanation for this result.

[20] The relevant part of the first stage of our IV estimates is presented in Table A4 of the appendix. It shows that the two instrumental variables (polity and ESI) are positively linked to the number of environmental treaties.

[21] http://www.cia.gov/cia/publications/factbook/appendix/appendix-c.html