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Cooperation in Environmental Policy: A Spatial Approach*

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Abstract

Inefficient competition in emissions taxes creates benefits from international cooperation. In the presence of cross-border pollution, proximate (neighboring) countries may have greater incentives to cooperate than distant ones as illustrated by a model of tax competition for mobile capital. Spatial econometrics is used to estimate participation in 37 international environmental treaties. Data on 41 countries from 1980-1999 reveal evidence of increased cooperation among proximate countries. Furthermore, the results indicate that FDI usually increases treaty participation. We also find that both OECD and non-OECD countries respond positively to OECD countries' participation but the response to non-OECD countries is primarily from similar countries. This suggests that the rich countries may lead others in setting environmental quality.

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I. Introduction

Among the many controversies surrounding globalization, one of the fiercest is the effect of increased international commerce on environmental quality. Among the issues engaging the public and academic debate is the implications of competition in environmental policy for foreign direct investment (FDI). As discussed by Copeland and Taylor (2003, 2004), if firms seek to avoid emissions taxes (the "pollution haven hypothesis"), then this can lead to governments lowering such taxes in order to attract firms (the race to the bottom). Thus, as firms become mobile, competition between hosts can then lead to sub-optimal emissions taxes. This inefficiency then provides a role for international environmental treaties that can coordinate standards across countries and lower world-wide pollution levels. While several papers have considered the impact of environmental policy on FDI or of FDI on the environment, these do not actually estimate whether there is indeed strategic interaction in environmental policies, i.e. whether there is evidence of international competition for FDI in environmental standards.

This paper fills this gap in two key ways, one theoretical and one empirical. First, we develop a model of emissions tax competition with cross-border pollution spillovers. This simple model yields two key predictions. First, when emissions cross borders more easily, Nash equilibrium taxes are lower. This is because if a country is going to suffer pollution damages even if the firm locates elsewhere, it is better to host the firm and collect the benefits that hosting provides as this offsets at least some of the pollution damages. Second, when cross-border spillovers increase, the gain from cooperation (i.e. raising emissions taxes and lowering pollution) increases. This yields a testable prediction: that a country's own treaty participation depends on that of others and that it is more responsive to the participation of nearby countries.

The second contribution of the paper is our modeling of the spatial autoregressive relationships in treaty participation.[2] Using information on 37 treaties and 41 countries over a twenty year period, we find that the more treaties other countries ratify, the greater the propensity of a given country to ratify treaties. Furthermore, this effect is declining in distance between countries just as the theory predicts when cross-border spillovers are declining in distance. We interpret this as direct evidence of international strategic interactions in environmental policy. In particular, given the sign of our coefficient, we find that policies are strategic complements, a key requirement for finding an inefficient "race to the bottom" in environmental standards. As such, this provides evidence for the contention that international economic agreements should be coupled with clauses related to environmental policy. In addition, we find, at least in the OECD countries, that inbound foreign direct investment (FDI) is a significant determinant of treaty participation. Finally, we find that the strategic responses are primarily driven by the treaty participation of the OECD countries. That is, both OECD and non-OECD countries tend to increase their treaty participation when their OECD neighbors increase participation. For the non-OECD responses this suggests a "leader-follower" relationship, indicating that the wealthy countries

[2] This adds to the single treaty studies of Beron, et. al. (2003) and Murdoch, et. al. (2003). It also adds to the cross-US state spatial studies of Fredriksson and Millimet (2002), Levinson (2003), and Frediksson, et. al. (2004). Below, we discuss all of these in detail.

may need to take a lead role in international environmental agreements if there is to be a hope of the developing countries following suit.

The theoretical tax competition literature has demonstrated that the nature of the Nash equilibrium from tax competition for FDI is highly sensitive to the functional forms and parameters of the model. Depending on these choices, as discussed by Wilson's (1986) seminal model, equilibrium taxes between jurisdictions can be strategic substitutes or strategic complements. As a result, Nash equilibrium taxes can be too high or too low relative to their optimal level.[3] In part, this ambiguity arises due to changes in the elasticity of capital with respect to taxes since a rise in one country's tax can increase or decrease the sensitivity of investment to the other country's tax. As demonstrated by Rauscher (1995), Markusen, Morey, and Olewiler (1995), and Hoel (1997), adding pollution externalities adds additional ambiguities. In addition to tax sensitivity, ambiguities arise in the desirability of investment (since benefits to hosting must be compared to the environmental costs of hosting). Furthermore, Barrett (1994) finds that whether a race to the top or to the bottom in environmental taxes occurs can be determined by the market structure. Since these issues make it impossible to derive general results on the nature of tax competition equilibria even without cross-border spillovers, any results derived from a general model would be contingent on numerous additional assumptions. This is indeed what is shown by Fredriksson

[3] Note that even the definition of the optimal level is subject to debate since the optimal tax depends on where the mobile firms' profits accrue. If a social planner is maximizing a function of the host countries' welfares, then she will not necessarily include the profits from FDI as a benefit from investment. This would then tend to lead to a tax rate greater than that which would be set if FDI profits accrue to the citizens of one of the host countries. This is why we use the term "optimal" rather than Pareto efficient since our model does not include FDI profits in the social planner's objective function.

and Millimet (2002) who also consider strategic interaction in pollution abatement costs with cross-border pollution.[4]

Because of this, we begin by making several simplifying assumptions in order to obtain results that match the concerns expressed in the popular debate: international competition for multinational enterprises (MNEs) leading to a race to the bottom in environmental standards. As is standard in the literature, we consider a MNE that allocates output to two jurisdictions taking into account the relative costs in each (including the cost of emissions taxes). Governments then use these taxes to balance out the benefits of hosting (which includes tax revenues collected from local emissions) versus the costs of hosting (pollution damages). A key facet of our model is that emissions not only cause pollution damages at their point of origin, but also overseas in the other country. The extent of these overseas damages depends on a parameter called the transfer coefficient. When the transfer coefficient is high (as it might be when countries are close to one another) these cross-border damages are higher.

In the Nash equilibrium of the tax setting game, governments set taxes too low for three reasons. First, as is well-known in the tax competition literature, since a government does not internalize the lost benefits to the other country, it will set sub-optimal taxes in order to attract FDI. Second, with cross-border pollution, a host government does not internalize the international pollution damages caused by FDI within its borders. Therefore it will overly encourage firms to invest by implementing low taxes. Third, if a country does not host a

[4] Their model differs in two key ways. First, they assume that the pollution is ‘perfectly’ cross-border implying the same pollution level is faced by the two countries. Second, their model does not involve any competition for capital. Instead, in their model equilibrium pollution abatement is too low because neither country can trust the neighbor to choose the higher, globally more efficient, level of pollution abatement.

given unit of capital, it will still suffer pollution damages due to cross-border pollution. Combining these implies that Nash equilibrium tax rates will be too low compared to those that maximize the sum of the two countries' welfares. Furthermore, this third effect means that as the transfer coefficient rises (i.e. countries become closer to one another), Nash equilibrium taxes fall even more. At the same time, a rise in the transfer coefficient increases global damages from pollution. As such, when the distance between countries falls, the gain from joining an international environmental treaty that raises emissions taxes increases.

Spatial econometrics provide an excellent method of testing such interactions because they allow the econometrician to use the dependent variable from one observation (treaty participation by country i) as an explanatory variable in another observation (treaty participation by country j) in a way that deals with endogeneity this interdependence causes.[5] This method contrasts sharply with the bulk of the literature on globalization and the environment which either considers the effect of FDI on pollution or the effect of emissions taxes on FDI.[6] Since neither of these approaches use the policy variable as the dependent variable, they do not test for strategic interactions, i.e. whether the environmental policy of

[5] Note that if one country ratifies a treaty before another, it is possible to treat that decision as exogenous to those that occur later in time (as is used in calculating a Stackelberg equilibrium instead of a Nash equilibrium). However, since ratification typically follows an extended period of consideration by a signatory country, there is still the possibility of interaction during this phase. Furthermore, since our explanatory variables are limited to annual observations, we cannot exploit the finer time series information that the exact date of ratification provides us. Therefore, since there is still the possibility of endogeneity in our annual data on ratifications, we turn to spatial econometrics. For a detailed discussion of spatial econometrics, see Anselin (1988).

[6] Antweiler, Copeland, and Taylor (2001) find little evidence of a relationship of FDI on SO_2 concentrations. Brunnermeier and Levinson (2004) provide a literature review of the studies considering the effect of host country environmental regulations on FDI. More recent studies include Jeppesen et al. (2002), Fredriksson et al. (2003), List et al. (2003), Javorcik and Wei (2004), and Henderson and Millimet (2006). The evidence of the effect of environmental stringency on investment decisions has been mixed. To contrast the FDI literature, Antweiler, Copeland, and Taylor (2001), Dean (2002), Harbaugh et al. (2002), Frankel and Rose (2005), and Naughton (2006) find that openness to trade improves the environment.

one country is affected by the environmental policy of another. Of those papers that do consider strategic interactions in environmental policy, they are limited either in their time series or country information.[7]

Using spatial probit techniques Beron, Murdoch, and Vijverberg (2003) and Murdoch, Sandler, and Vijverberg (2003) estimate strategic interactions in ratification of the Montreal and the Helsinki Protocols, respectively. Using either a trade-based or emissions-based weighting scheme, Beron, Murdoch, and Vijverberg find no significant strategic interactions in ratification of the Montreal Protocol in their sample of 89 countries. Murdoch, Sandler, and Vijverberg use a cross-section of 25 European countries to estimate the strategic interactions in Helsinki Protocol ratification using emissions-based weights. They model treaty participation in a two-stage setting, where in the first stage countries decide whether or not to ratify the Protocol and in the second stage they choose their level of sulfur emissions reduction. The authors find positive and statistically significant interaction effects in Montreal Protocol ratification. Our study improves upon these studies in two ways. First, rather than using cross-sectional data, we employ panel data on 41 countries for 1980-1999. In particular, allowing us to control for contemporaneous effects of neighboring countries. Second, we employ a comprehensive measure of international cooperation that involves 37 treaties instead of using a single treaty as others have. This adds to these results by yielding information on the general propensity of a country to participate in treaties rather than whether it joins a particular treaty.

[7] For a review of empirical tax competition studies see Brueckner (2003).

Of the studies that do use panel data, they all use information for a single country and employ US state level data to estimate strategic interactions in environmental stringency. Fredriksson and Millimet (2002), Levinson (2003) and Fredriksson, List, and Millimet (2004) all find that states compete in environmental stringency, as measured by the Levinson Index. Levinson (2003) also finds competition across states in the hazardous waste disposal tax rates. Additionally, Fredriksson, List, and Millimet (2004) allow for strategic interactions across different policy variables. They find that considering strategic interactions in a single policy setting provides lower bound estimates. Although we use a comparable empirical approach, we work with international data. One of the primary difficulties in extending these state-level studies to international competition is that emissions taxes and other policies are very difficult to compare across countries due to the wide range of regulatory policies surrounding them. This is one of the primary advantages to using international environmental treaties as our variable of interest since by definition, these are comparable across countries.

The remainder of the paper proceeds as follows. The next section presents the theoretical model. In section 3 we overview the empirical approach and discuss the data. Section 4 discusses the empirical results and section 5 concludes.

II. Theoretical Model

As discussed above, any general theory of tax competition for FDI will be plagued by ambiguities that can only be resolved by making restrictive assumptions.[8] Since our goal in this section is to construct a model that motivates our empirical work, rather than impose

[8] Wilson (1999) and Gresik (2001) provide recent overviews of tax competition for FDI. Their literature reviews highlight the various ambiguities found in the literature both with and without pollution.

such restrictions ex-post we impose them at the beginning by choosing specific functional forms. This is the easiest method of illustrating our underlying story: that proximity can worsen the inefficiencies resulting from tax competition and increase the gain from cooperation.

Consider a multinational firm that invests in two countries, home and foreign. Foreign variables are denoted with *s. The timing of choices is that governments simultaneously choose emissions tax rates and then the MNE maximizes profits through its capital allocation. Using subgame perfection, we begin by describing the firm and work our way backwards. Production in each country uses capital (K) in a constant returns to scale technology. We normalize the production function so that output in home is K and output in foreign is K^*. This output is then sold on world markets according to the inverse demand curve:

$$P = A - \frac{B}{2}(K + K^*) . \tag{1}$$

The firm faces three types of costs. First, it faces a cost of raising capital $\frac{\gamma}{2}\left(K + K^*\right)^2$.

Second, it faces transportation costs between each country and the world market. Transportation costs from home are $\frac{\alpha}{2}K^2$ while those from foreign are $\frac{\delta}{2}K^{*2}$.[9] Third it faces a tax on the emissions it creates in a given country. Emissions are a linear function of

[9] Alternatively, these transportation costs could be increasing costs of hiring local factors such as labor. If the wage is an increasing convex function of labor hired, as would occur if other sectors use labor, then it is possible to derive labor cost functions as they depend on K and K^* that are comparable to these transport cost functions. This approach could also provide a link between these and the benefits of hosting. However, in the interest of simplicity, we use this alternative, trade cost approach.

output, where units are again normalized so that home (foreign) emissions are K (K^*). The per-unit home emission tax is t and the per-unit foreign emission tax is t^*. Combining these yields the firm's profit function:

$$\pi = \left(A - \frac{B}{2}(K + K^*) \right)\left(K + K^*\right) - \frac{\alpha}{2}K^2 - \frac{\delta}{2}K^{*2} - tK - t^*K^* - \frac{\gamma}{2}\left(K + K^*\right)^2 . \qquad (2)$$

Taking tax rates as given, the first order conditions from this with respect to K and K^* yield respectively:

$$A - B\left(K + K^*\right) - \alpha K - tK - \gamma\left(K + K^*\right) = 0 \text{ and} \qquad (3)$$

$$A - B\left(K + K^*\right) - \delta K^* - t^*K^* - \gamma\left(K + K^*\right) = 0 . \qquad (4)$$

From these, we obtain the following effects of taxation:

$$\frac{dK}{dt} = -\frac{B + \gamma + \delta}{\Delta} < 0 , \qquad (5)$$

$$\frac{dK^*}{dt} = \frac{B + \gamma}{\Delta} > 0 , \qquad (6)$$

$$\frac{dK}{dt^*} = \frac{B + \gamma}{\Delta} > 0 \text{ and} \qquad (7)$$

$$\frac{dK^*}{dt^*} = -\frac{B + \gamma + \alpha}{\Delta} < 0 \qquad (8)$$

where $\Delta \equiv (\alpha + \delta)(B + \gamma) > 0$. Thus, an increase in one country's tax drives FDI from that country to the other. It is also worth noting that total investment ($K + K^*$) is decreasing in either tax rate. These results on the impact of taxes on capital (either in a given country or worldwide) are standard in the literature and are robust to generalizations of our functional forms.

These tax rates are chosen simultaneously by the two governments in order to maximize their own national welfares. Home welfare consists of three items. The first is a benefit of hosting FDI given by K^{λ} where $\lambda \in (0,1)$. This represents gains to local employment, technological spillovers, and the like. The second item is the cost of local emissions. This is linear in the level of local emissions and is (partially) offset by the taxes collected on those emissions. Therefore the net environmental damage from hosting is $(1-t)K$. Finally, it suffers damages from overseas emissions through cross-border pollution. The level of these damages is aK^{*} where $a > 0$ is the transfer coefficient and represents the impact of emissions across borders. How equilibrium tax rates change in a is the primary focus of this section.[10]

With these ideas in place, home welfare then is given by:

$$Y = K^{\lambda} + (t-1)K - aK^{*}. \tag{9}$$

Foreign welfare is analogously:

$$Y^{*} = K^{*\lambda} + (t^{*}-1)K^{*} - aK. \tag{10}$$

Taking the first-order condition of (9) results in an implicit best response function $t(t^{*})$ for home. Specifically, this is determined by:

[10] For simplicity, we assume that both λ and a are the same across countries. While the first is not necessary for our results, the second is important because it ensures that the global environmental damages are a function of the total amount of investment, not the distribution of investment. Having linear damages with equal marginal impact across countries is important to ensure that the social planner does not have an incentive to shift investment from one country to another as a changes. If we relax this, it complicates the problem and again introduces ambiguities that, although interesting, detract from the purpose of our theory.

$$\frac{dY}{dt} = -\frac{B+\gamma+\delta}{\Delta}\left(\lambda K^{\lambda-1} + t(t^*) - 1\right) - a\frac{B+\gamma}{\Delta} + K = 0 \qquad (11)$$

where K is determined by the two tax rates. From this, we can determine the following results. First,

$$\frac{dt(t^*)}{dK} = \left(B+\gamma+\delta\right)\lambda\left(1-\lambda\right)K^{\lambda-2} + \frac{\Delta}{B+\gamma+\delta} > 0 \qquad (12)$$

i.e. a rise in FDI increases home's tax best-response tax rate since pollution damages rise and the benefits of hosting decline. Second, holding K constant,

$$\frac{dt(t^*)}{d\alpha} = \frac{K(B+\gamma)}{(B+\gamma+\delta)} > 0\,. \qquad (13)$$

Thus, for a given level of FDI, a country with higher trade costs will impose higher taxes. Third,

$$\frac{dt(t^*)}{dt^*} = -\frac{(B+\gamma)\left(1-\lambda(\lambda-1)K^{\lambda-2}\left(B+\gamma+\delta\right)\Delta^{-1}\right)}{(B+\gamma+\delta)\left(\lambda(\lambda-1)K^{\lambda-2}\left(B+\gamma+\delta\right)\Delta^{-1}-2\right)} > 0\,. \qquad (14)$$

This shows that home's best-response tax is increasing in the foreign tax, i.e. taxes are strategic complements for home. As indicated in the above cited work, such a finding is dependent on the functional forms used. However, since the common belief is that taxes are bid down as governments compete for investment, this result matches that covered by the public debate. Finally, we find that

$$\frac{dt(t^*)}{da} = \frac{B+\gamma}{(B+\gamma+\delta)\left(\lambda(\lambda-1)K^{\lambda-2}\left(B+\gamma+\delta\right)\Delta^{-1}-2\right)} < 0\,, \qquad (15)$$

indicating that as the transfer coefficient rises, home's best-response tax falls. Graphically, this would be a shift in home's best response from the solid line to the dashed line in Figure 1 when a rises from a_1 to a_2. The intuition for this change is straightforward. As the transfer coefficient rises, the damages home suffers from foreign's investment rises. As such, home has a greater incentive to "steal" that investment since this allows it to enjoy the benefits of hosting and collect additional emissions taxes, offsetting a portion of the environmental damages.

Foreign's best response tax rate $t^*(t)$ is found in a similar fashion and is implicitly given by:

$$\frac{dY^*}{dt^*} = -\frac{B+\gamma+\alpha}{\Delta}\left(\lambda K^{*\lambda-1} + t^*(t) - 1\right) - a\frac{B+\gamma}{\Delta} + K^* = 0 \qquad (16)$$

From this, it is straightforward to show that foreign's optimal tax is increasing in home's tax and falling in the transfer coefficient for reasons analogous to those for home.

The Nash equilibrium in the tax-setting game is found by simultaneously solving (11) and (16) accounting for how FDI levels vary in the tax rates. What is important for our purposes, however, is how this equilibrium changes in the transfer coefficient. Since a rise in a reduces both $t(t^*)$ for a given t^* and $t^*(t)$ for a given t, Nash equilibrium tax rates fall when a rises. Graphically, this moves the Nash equilibrium from A to B in Figure 1. Note that as tax rates fall, total investment (and total environmental damages) rise.

At the same time, however, a rise in the transfer coefficient raises the optimal taxes for a social planner maximizing the sum of the nation's welfares. Consider such a planner who maximizes $W \equiv Y + Y^*$. The first order conditions from the social planner's problem yield optimal taxes implicitly determined by:

$$\frac{dW}{dt} = -\frac{B+\gamma+\delta}{\Delta}\left(\lambda K^{\lambda-1} + t - 1 - a\right) + \frac{B+\gamma}{\Delta}\left(\lambda K^{*\lambda-1} + t^* - 1 - a\right) + K = 0 \qquad (17)$$

and

$$\frac{dW}{dt^*} = -\frac{B+\gamma+\alpha}{\Delta}\left(\lambda K^{*\lambda-1} + t^* - 1 - a\right) + \frac{B+\gamma}{\Delta}\left(\lambda K^{\lambda-1} + t - 1 - a\right) + K^* = 0\,. \qquad (18)$$

Evaluating (17) at the Nash equilibrium yields:

$$\frac{dW}{dt} = a\frac{B+\gamma+\delta}{\Delta} + \frac{B+\gamma}{\Delta}\left(\lambda K^{*\lambda-1} + t^* - 1\right) > 0 \qquad (19)$$

as long as foreign welfare is increasing in K^* (i.e. hosting is desirable). A similar condition can be found for the foreign tax. As a result, Nash equilibrium taxes are lower than those the social planner would choose, yielding the oft-discussed "race to the bottom" in environmental taxes. This is because when choosing that tax in one location, the social planner internalizes the lost benefits of hosting to the other country, the additional tax revenue from emissions in the other country, and the effect of cross-border pollution. Note that this result does not hold in general as discussed by Markusen, Morey, and Olewiler (1995) since under different assumptions (particularly very large damages from pollution) a race to the top is also possible.[11]

It is now necessary to ask how these optimal taxes change as the transfer coefficient changes. For notational convenience, we define the following three variables:

$$\Phi = \frac{d^2W}{dt} = \left(\lambda(\lambda-1)\left(K^{\lambda-2}\left(\frac{B+\gamma+\delta}{\Delta}\right)^2 + K^{*\lambda-2}\left(\frac{B+\gamma}{\Delta}\right)^2\right) - 2\frac{B+\gamma+\delta}{\Delta}\right) < 0\,,$$

[11] Furthermore, McAusland (2002) and Eerola (2004) find that, due to the exclusion of multinational firm profits from the countries' objective functions that taxes are inefficiently high compared to the global welfare maximum. Similarly, since our combined welfare measure does not include multinational profits optimal taxes are higher than those that would arise from maximizing the sum of Y, Y^*, and the firm's profits.

$$\Gamma = \frac{d^2W}{dt^{*2}} = \lambda(\lambda-1)\left(K^{\lambda-2}\left(\frac{B+\gamma}{\Delta}\right)^2 + K^{*\lambda-2}\left(\frac{B+\gamma+\alpha}{\Delta}\right)^2\right) - 2\frac{B+\gamma+\delta}{\Delta} < 0, \text{ and}$$

$$\Omega = \frac{d^2W}{dtdt^*} = -\left(\frac{B+\gamma}{\Delta}\lambda(\lambda-1)\left(K^{\lambda-2}\left(\frac{B+\gamma+\delta}{\Delta}\right) + K^{*\lambda-2}\left(\frac{B+\gamma+\alpha}{\Delta}\right)\right) - 2\frac{B+\gamma}{\Delta}\right) > 0.$$

Note that by the social planner's second order condition, $\Psi \equiv \Phi\Gamma - \Omega^2 > 0$. We can now compute the comparative statics of the social planner's optimal tax rates with respect to the transfer coefficient:

$$\frac{dt}{da} = -\frac{\delta\Gamma - \alpha\Omega}{\Delta\Psi} > 0 \tag{20}$$

and

$$\frac{dt^*}{da} = -\frac{\alpha\Phi - \delta\Omega}{\Delta\Psi} > 0. \tag{21}$$

As in the individual country's cases, the intuition is straightforward. As the transfer coefficient rises, environmental damages rise from a given amount of capital.[12] This reduces the social planner's desired level of total capital, leading her to increase both tax rates and reduce overall investment. This would then move optimal taxes from C to D in Figure 1. This result is comparable to that of Cremer and Gahvari (2004), who study competition in commodity taxes and emissions taxes with cross-border pollution. They too find that

[12] An alternative modeling choice would be to have the transfer coefficient represent the percent of emissions that "land" in the overseas country, leaving only *(1-a)K* emissions in home. This yields similar results regarding Nash equilibrium taxes compared to the social planner's taxes since as a rises, a country's incentive to attract FDI rises since its pollution costs fall. Under this assumption, however, worldwide pollution damages are invariant to the transfer coefficient, implying that the social planner's desired taxes do not change when a changes. Nevertheless, here too the gains from cooperation rise as the distance between countries falls.

harmonization of emissions taxes above the Nash equilibrium level across countries reduces aggregate emissions and increases overall welfare.

An important implication of this result is that as the transfer coefficient rises, the gap between the Nash equilibrium taxes and the optimal taxes rises. As a result, the combined gains from cooperating and increasing tax rates increases as the transfer coefficient increases This then gives us a testable prediction – that countries for which the transfer coefficient is large will tend to find cooperation more beneficial than countries for whom it is small. If the damages from cross-border pollution are falling in distance, i.e. a is inversely related to the distance between countries, then proximate countries will have a greater incentive to cooperate than distant ones. If participation in international environmental agreements is a sign of such cooperation, the theory predicts that nearby countries may be more likely to jointly sign on to environmental agreements than distant countries. In the next section, we turn discuss the empirical methods used to find evidence of exactly such patterns in environmental treaty participation.

III. Empirical Approach and Data

If competition for FDI leads to inefficiently low taxes and conversely higher gains from cooperation this should be evidenced in the data on environmental treaty participation. Furthermore, if due to cross-border spillovers these gains are greater for nearby countries, then a country's own treaty participation should depend more on the participation of proximate countries rather than distant ones. In this section we use participation in international multilateral environmental treaties to measure cooperation in environmental policy. The set of multilateral environmental treaties is large and growing.[13] The Center for International Earth Science Information Network (CIESIN) provides country-level participation data for 384 multilateral agreements. Of these agreements, we use the 37 treaties that are neither explicitly restricted to certain countries nor are amendments to previous agreements.[14] Appendix A classifies the included treaties into categories, provides the year of signature and the number of parties. The treaty categories include the sea, fish and air treaties. First, there are twelve sea treaties which have to do with prevention of and response to marine pollution. Second, the ten fishing treaties are those that deal with conservation and harvest of fish and whales.[15] Third, three air treaties deal with air pollution. Note that although it may not necessarily be the case that a given treaty directly affects a multinational firm, to the extent that treaty participation is correlated with policies that do have a direct impact, our estimates are still informative regarding the nature of competition for FDI. Using these, the dependent variable in our empirical model is treaty participation measured as the count of treaties a country has ratified as of a given year.[16,17]

Our empirical specification follows closely Fredriksson and Millimet (2002):

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[13] For an overview of international environmental treaties see Mitchell (2003).
[14] Two treaties in our sample have a restriction on participation to only include countries that are members of the Food and Agriculture Organization of the United Nations (this includes 190 countries). Eight more treaties require the potential parties to be member countries of the United Nations. These restrictions did not bind for any of our sample countries.
[15] We also considered a more general sub-group of treaties that dealt with conservation of animals and plants. The issues dealt with by this broader category are less focused than those of fishing treaties which often specify very specific goals for members. This is why we present results for this more focused category of treaties. Nevertheless, the results for this classification were similar to the fish treaties' results.
[16] Note that countries that initially sign treaties must also ratify the treaty to become a party.
[17] In similar vein, Roberts, Parks, and Vasquez (2004) estimate a model determining treaty participation in 22 multilateral environmental treaties using a comparable count variable. They use cross-sectional data and do not allow for strategic interactions.

$$E_{it} = \gamma_t + \delta \sum_{j \neq i} \omega_{ij} E_{jt} + \phi FDI_{it} + x_{it}\beta + \varepsilon_{it}, \qquad (22)$$

where E_{it} is treaty participation by country *i* in year *t*; γ_t are year fixed effects; ω_{ij} is the time invariant weight assigned to country *j* by country *i*; E_{jt} is treaty participation by country *j* in year *t*; δ is the spatial lag coefficient that measures strategic interaction in treaty participation; FDI_{it} is FDI flow into country *i* in year *t*; x_{it} is a vector of country *i* characteristics in year *t*; and ε_{it} represents i.i.d. idiosyncratic shocks uncorrelated across countries or years.[18]

The spatial lag, $\sum_{j \neq i} \omega_{ij} E_{jt}$, is the weighted average of other countries' treaty participation in year *t*. The coefficient on spatial lag provides information about the strategic interactions in treaty participation and our theoretical model predicts it to be positive (i.e. environmental policies are strategic complements). That is if a country's neighbors increase treaty participation in a given year, then the country tends to increase its participation as well.[19] It is important to note that the spatial lag introduces an endogeneity problem inherent to spatial autoregression: E_{it} depends on E_{jt} and E_{jt} on E_{it}.[20] This gives us the first endogenous variable that we will need to control for.

[18] Including quadratic trend terms in place of year fixed effects does not qualitatively change the results.
[19] A negative spatial lag suggests that an increase in proximate countries' treaty participation would reduce treaty participation. This type of dynamic could arise if the emissions tax response functions are strategic substitutes (i.e. best responses have a negative slope). As discussed above, generalized versions of emissions tax competition show that this is indeed a theoretical possibility although one contradicted by most of our estimates.
[20] Again, because we are not able to exploit the information on the exact timing of ratifications, we must allow for possible endogeneity.

While the theory suggests that the weights used in the construction of the spatial lag should be declining in distance (increasing in cross-border pollution), it does not suggest a specific form. Similar to Levinson (2003), the results presented in this paper use the following specification of spatial weights:

$$\omega_{ij} = \frac{1}{d_{ij}^2} \bigg/ \sum_{j \neq i} \frac{1}{d_{ij}^2}, \qquad (23)$$

where d_{ij} is the distance between country *i* and country *j*. The sum in the denominator ensures that our spatial lag is a weighted average not a weighted sum of other countries' treaty participation.[21] This so-called "row standardization," where the sum of weights for each country equals one, is standard in spatial autoregression analysis. Using this row standardization allows us to interpret the spatial lag's coefficient as the marginal effect of other countries' participation, not the "remoteness" of country *i*. Alternative spatial weight specifications provide qualitatively similar results.[22]

In addition to the spatial lag, FDI is a second endogenous variable. Previous studies that estimate environmental policy variables have not included FDI in the set of independent variables. Nevertheless, Ederington and Minier (2003), Fredriksson, List, and Millimet (2003), and List et al. (2003) argue that not only does FDI respond to environmental regulation but also that environmental regulation can be impacted by FDI. Also, our theoretical model includes FDI in the government's problem of choosing emissions taxes,

[21] Specifying the spatial lag as a non-row standardized weighted sum, such that $\omega_{ij} = \frac{1}{d_{ij}^2}$, does not qualitatively change the full sample results.

[22] Alternative weights included $\omega_{ij} = \exp\left(-\frac{d_{ij}}{1000}\right) \bigg/ \sum_{j \neq i} \exp\left(-\frac{d_{ij}}{1000}\right)$.

and emissions taxes influence the capital owner's allocation of FDI across countries. Therefore, we include FDI as a determinant of treaty participation and instrument for it as described below to allow for the endogeneity. Consistent with the theoretic results in equation (12), we anticipate a positive coefficient for our instrument for FDI.

Estimating equation (22) using OLS would provide biased estimates because of the endogeneity problems. We use instrumental variable (IV) estimation instead of spatial maximum likelihood (ML) estimation for two reasons. First, IV estimation provides consistent estimates even in the presence of spatially correlated errors. Second, this approach is easier to implement when dealing with the endogeneity of FDI. Brueckner (2003) describes both IV and ML methodologies used in estimation of strategic interactions.

To instrument for the spatial lag and FDI, two first-stage equations must be estimated:

$$\sum_{j\neq i}\omega_{ij}E_{jt} = a_t + b\sum_{j\neq i}\omega_{ij}x_{jt} + c\sum_{j\neq i}\omega_{ij}z_{jt} + z_{it}d + x_{it}f + e_{it} \tag{24}$$

and

$$FDI_{it} = \rho_t + z_{it}\kappa + \chi\sum_{j\neq i}\omega_{ij}x_{jt} + \psi\sum_{j\neq i}\omega_{ij}z_{jt} + x_{it}\theta + u_{it}\,. \tag{25}$$

The instruments for the spatial lag are the weighted averages of all exogenous variables using the same weights as those used to calculate the spatial lag itself. Details on the sources and descriptions of all variables are found in Appendix B. Summary statistics and a list of countries in the sample are reported in Table 1. FDI is instrumented for by a set of variables z_{it}: trade costs, education, and investment costs.[23] In the second stage, the fitted values of

[23] Note that since we are estimating a country's total inbound FDI flows, we do not control for parent country

equations (24) and (25) are used in estimation of equation (22) in place of $\sum_{j \neq i} \omega_{ij} E_{jt}$ and FDI_{it}.

In addition to the endogenous spatial lag and FDI variables, the model includes eleven exogenous variables.[24] GDP, population and area control for the economic, demographic and geographic sizes of the countries. Following other studies, we expect to find that large economies are likely to participate in more international agreements. On the other hand, holding GDP constant, increasing population decreases GDP per capita. If environmental quality (provided by increased standards and treaty participation) is a normal good then the income effect captured by population would lead to a negative coefficient. The geographic area is included for two reasons. First, it allows us to control for the population density and second it is a proxy for the abundance of natural resources in the country. Holding population constant, as area increases population density decreases lowering environmental pressures and increases regulation. On the other hand, countries with more natural resources may want to have an unrestricted ability to exploit these resources and therefore have more lax environmental policies. Given these conflicting predictions, we have no a priori expectation regarding this sign and merely acknowledge that our results will estimate the net effect of geographic size.

variables as bilateral FDI flow regressions do (e.g. Eaton and Tamura, 1994 or Blonigen and Davies, 2004).

[24] A great advantage of our approach is that we are able to include these additional variables whereas a simple cross-section such as the spatial probit analysis of Beron et al. (2003) and Murdoch et al. (2003) are unable to since the inclusion of so many explanatory variables dramatically reduces their degrees of freedom. If we instead use a cross-sectional probit approach as they do, we are similarly forced to cut some of our explanatory variables in order to obtain results making it impossible to directly compare these results with those reported.

Urbanization and unemployment are included to characterize the countries' economic climate. Urbanized countries are likely to be more industrialized and opt for lower regulation to encourage higher output. This suggests a negative coefficient. Similarly, one might expect that countries with higher unemployment are more interested in attracting investment, leading them to set lower standards and reduce their treaty participation.

A country's political climate is captured through political freedom, corruption and the European Union (EU) dummy variables. Political freedom comes with improved information about environmental issues and ability of citizens to impact government policy. Hence, presuming that citizens prefer strong environmental standards, political freedom should increase treaty participation. Corrupt countries are likely viewed as not credible in the international arena and may not be courted for treaty participation by other countries. Furthermore, corrupt countries may be more isolated and less likely to engage themselves in any international agreements. EU countries are undergoing a major wave of harmonization in all types of policies. It is likely that this is also true with respect to environmental policies. In addition, these relatively wealthy countries are well-known for their pro-environmental stances. Therefore, we expect them, all else equal, to participate in more treaties.

To distinguish between coastal and landlocked countries, we include a landlocked country dummy variable. Inclusion of this variable is particularly important when analyzing different types of treaties because landlocked countries receive more cross-border pollution while coastal countries are likely relatively more concerned with sea pollution and fish.

Finally, two trade related variables are included: export diversification and market potential. A country with a diverse export base may choose to engage in more environmental regulation because it may be able to switch between industries easier.[25] Higher market potential, defined as the distance-weighted sum of other countries' GDPs, acts as a proxy for the importance of other countries as trading partners and is inversely related to the trade cost between a country and the world market described in theory. Thus, given the prediction of equation (13), we anticipate a negative coefficient on the market potential.

IV. Results

We first present the results for treaty participation in all 37 treaties by the full sample of countries to determine the potential biases caused by omitting the spatial lag and by not instrumenting for FDI. Then to allow for different underlying processes in participation decisions by treaty type we group treaties into those related to the sea and ocean pollution, fish treaties, and air pollution treaties. Following this, because environmental policy decisions by rich and poor countries may not be driven by the same motives we separately estimate models for the OECD and non-OECD sub samples. In addition, we examine whether a given country's treaty participation responds differently to countries in the same income category as those outside of it. Finally, we utilize several alternative specifications to check the robustness of our results.

IV.1 Baseline Results

Table 2 begins with an initial specification without a spatial lag or an accounting for the endogeneity of FDI. In column (2) we instrument for FDI. Column (3) again treats FDI as exogenous but adds a spatial lag. Finally, in column (4) both instrument for FDI and use a

[25] Roberts, Parks, and Vasquez (2004) also include this variable in their model of treaty participation.

spatial lag. This sequence of specification allows us to examine the sensitivity of our estimates to both the assumption of exogenous FDI and the need for a spatial lag.

When we instrument for FDI, the sign on the FDI variable switches from positive and statistically insignificant to negative and statistically significant. Therefore, we find a positive endogeneity bias on the FDI coefficient. Inclusion of the spatial lag changes the coefficient on the market potential from positive to negative and statistically significant. Therefore, omission of the spatial lag affects the market potential variable.[26] Because both the spatial lag and the market potential have geographic features, it is not surprising that the two are related. In both cases, several coefficients also changed statistical significance relative to column (1), however since these are not our preferred specifications, we do not discuss these for brevity's sake.

When both corrections are implemented by the regression model in column (4) there are two key changes in the results from column (1) — both FDI and market potential change coefficients to negative and statistically significant. As predicted, the spatial lag is positive and statistically significant implying a complementary strategic interaction among proximate countries' decision to join treaties. Given the results, we find that if all other countries (weighted by a negative function of distance) in the sample join one more treaty, that the country in question will join 0.76 more treaties, i.e. they increase their treaty participation by less than one. This effect is a long-run effect driven by cross-sectional variation. The negative effect of FDI on treaty participation is evidence contrary to our theory. This result is

[26] A similar result is found in Blonigen, Davies, Waddell, and Naughton (2005) who find that when estimating FDI patterns, omission of either the spatial lag or the market potential can dramatically affect the estimated coefficient of the other variable.

at least in part driven by pooling data for poor and rich countries and we deal with this issue below. Consistent with the theory, the market potential is negative and significant indicating that countries closer to other markets are less likely to join treaties.

IV.II Differences Among Types of Treaties

Motivations that drive treaty participation are likely to vary by the types of environmental problems targeted by these agreements. For example, landlocked countries are likely relatively more concerned with air pollution than sea pollution. As a result, we refine our treaty participation variable by using subsets of the original 37 treaties—sea treaties, fish treaties, and air treaties.

In addition to repeating the results from Table 2's column (4) for all treaties, Table 3 also presents the results for the three different treaty participation variables as defined above. In each case, the spatial lag remains positive and significant as our theory predicts. While the coefficient on FDI remains negative for the sea and fish treaties, we now find the predicted significant positive coefficient for FDI in the air treaty participation equation. Finally, market potential is again negative and significant for the sea and fish treaties as predicted although it is weakly positive for air treaties.

Beyond these, our other explanatory variables show a fairly consistent pattern. Specifically, GDP, Area, and the EU dummy are generally positive and significant. Likewise, population and urbanization are consistently negative and significant. Finally, as expected, Landlocked is negative and significant in the fish treaties regression of column (3) suggesting that coastal economies are more likely to participate in these agreements. Thus, there is some evidence of variation in the factors influencing the number of treaties a country participates in depending on the type of environmental issues the treaty addresses.

IV.III OECD vs. Non-OECD Countries

Divergence in environmental policies across rich and poor countries has been a source of concern in the past. In line with this concern, environmental treaty participation is more prevalent by OECD countries since on average OECD countries participate in nineteen treaties while on average non-OECD countries only participate in ten. Thus, it is likely that underlying motivations for joining treaties for rich and poor countries may be different as well. To examine such differences Table 4 presents the regression results for OECD and non-OECD countries separately.

When we split the sample, we find several differences relative to the combined results in Table 3. First, while the spatial lag is positive and significant in the OECD results across the board, in non-OECD regressions it is insignificant. One likely reason for this is the large drop in the number of observations. A second reason, and one we explore in depth below, is that this spatial lag is only within the sample, i.e. it measures the response of OECD countries to other OECD countries and non-OECD responses to other non-OECD countries. If cross-group participation is important, then these spatial lags will not capture such effects. Furthermore, as seen below, the omission of these cross-group lags may be biasing these non-OECD coefficients towards zero.

The second difference is that, unlike the combined results, FDI is almost always positive and significant as predicted by theory. As discussed by Blonigen and Davies (2004), FDI data is skewed towards the rich OECD countries. As such, even after logging this variable, it can create misleading estimated coefficients when combining both rich and poor countries. Since, after splitting the rich and poor countries into different samples our FDI variable conforms to our predictions, it seems that similar issues arise in our data. The third key difference is that, although the market potential retains the same signs for the OECD countries as found in the combined sample, for the non-OECD countries it is positive and significant for all, sea and air treaties equations. This might be the case if the non-OECD countries use international treaty participation to appease wealthy potential trading partners. As such poor countries with larger market potential have more to gain by such overtures and therefore participate in more treaties.

In addition to these differences, other noteworthy differences exist in our other explanatory variables. First, OECD countries with higher area tend to participate in fewer treaties while larger non-OECD countries tend to join more treaties. So, the environmental resources effect outweighs the population density effect associated with the geographic area in the non-OECD countries. Since these economies are likely more dependent on natural resources, this is consistent with our priors. Second, urbanization tends to reduce treaty participation in OECD countries and increase it in non-OECD countries. The correlation between urbanization and education (which neither we nor other studies include) is fairly high. Thus, the positive coefficient on urbanization in non-OECD sample could be capturing the effect of education on treaty participation. Another difference is in the coefficient on the freedom index. Higher civil liberties and personal rights tend to increase treaty participation among rich countries but reduce it among poor countries. This might be the case if citizens in poor countries (which are on the upward sloping part of the environmental Kuznets curve) are more willing to sacrifice environmental quality for economic growth than their counterparts in rich countries (who are on the downward sloping portion).[27] If an increase in political freedom is indicative of government policies that better reflect the people's wishes, then just such a difference in coefficients would be expected. Fourth, while the EU countries tended to participate in more treaties than the average country in the full sample, when compared to OECD countries EU countries join fewer treaties than the average. Fifth, a diverse export base increases treaty participation in rich countries but reduces it in poor countries. Again, this might arise when an increase in export diversification reflects a fall the political influence of a given industry. In developing countries, exporters may prefer stronger environmental standards because of the "environmentally-friendly" verification this provides their exports to developed countries. Thus, a more diversified export base weakens the push for such standards. In developed countries, firms already meet many such conditions due to other local regulations. As such, if firms could coordinate, they might aim for a general weakening of standards. Thus, export diversification may reflect the inability of exporters to coordinate and lobby for their desired level of environmental regulations, i.e. more treaties are joined.

As noted above, the spatial lag in Table 4 is a weighted sum of treaty participation in the particular sample considered. This precludes the ability of poor countries to respond to the treaty participation of rich countries and vice versa. Table 5 reintroduces this interaction

[27] The environmental Kuznets curve relates income to pollution levels. Generally, an inverted U shape is found, i.e. as income rises pollution initially rises and then falls. See Graham (2000) for a discussion of the linkages between pollution, FDI, and the environmental Kuznets curve.

by including the spatial lag of non-OECD countries' treaty participation to the OECD equation and the spatial lag of OECD countries' participation to the non-OECD equation.

For the OECD results in columns (1) through (4), the results are similar to those from Table 4, i.e. we find a significantly positive OECD to OECD spatial lag across the board. Conversely, we find a significant non-OECD to OECD spatial lag which has a surprising negative coefficient for the fish treaties. This suggests that on the whole OECD countries pay little attention to what the poorer countries do when deciding on environmental treaty participation. If the FDI that OECD firms are looking to attract does not even consider the non-OECD countries as potential hosts, this result would make sense. As discussed by Carr, Markusen, and Maskus (2001) and Blonigen, Davies, and Head (2003), FDI in the OECD countries is generally of the horizontal type implying that it values highly skilled workers and access to wealthy consumers. As such, this would indeed suggest that such MNEs do not consider the non-OECD countries as suitable hosts for FDI.

Turning to the non-OECD results in columns (5) through (8), unlike Table 4, we now find two significantly positive within non-OECD spatial lag. Furthermore, in each specification we find a positive OECD to non-OECD spatial lags (for all treaties and fishing treaties). Thus, we again find evidence of competition between non-OECD countries although the evidence is somewhat weaker. In addition, we find that the poorer non-OECD countries tend to respond highly to their richer OECD counterparts. This provides further evidence that rich and poor countries have alternative motives to join treaties and that the "trading partner appeasement" story above may be an important factor in poor country's treaty-participation decisions. This possibility is reinforced by the fact that inclusion of the

OECD spatial lag eliminates the surprising positive market potential coefficient in two of the four non-OECD regressions.

IV.IV Robustness Checks

It is obviously important to ask to what extent our results are sensitive to the econometric specifications we have chosen. Therefore in this sub-section our goal is to give an overview of the various robustness checks we have undertaken (the results of which are available on request). First, our model uses the linear treaty participation variable but logs FDI, market potential, GDP, population and area. This is because these explanatory variables are highly skewed. As a robustness check for the functional form chosen we estimate log of treaty participation with the right-hand-side unchanged (a log-log model) and another specification of treaty participation without any logged variables (a lin-lin model). These regressions provide qualitatively similar results.

We also estimate models with continental fixed effects to control for regional heterogeneity across regions. For the full sample the qualitative nature of the results does not greatly change as we continue to find significantly positive spatial lags, a similar pattern in the signs of the coefficient for FDI, and a significantly negative coefficient on market potential. The sub sample regressions continue to show similarly signed coefficients to the reported results although the coefficients are not as significant. Specifications with country specific trends provide less significant but to large extent similar results both for the entire sample and for the OECD and non-OECD sub samples. Inclusion of the country fixed effects does not change the results for the full sample but yields less significant results for the sub-samples. This suggests cross-sectional variation plays a meaningful role in our results.

V. Conclusion

The potential inefficiencies caused by competition for mobile firms have become a contentious source of debate in policy, public, and academic circles. In this paper, we present a theoretic model that suggests that such inefficiencies might be greatest among nearby countries due to the presence of cross-border pollution. Therefore, the gains from cooperating through international environmental agreements are greatest among such countries. Using information on environmental treaty participation in 41 countries over a twenty year period, we find evidence that strategic interaction in environmental policies does indeed exist. By using data on treaty participation, this allows us to avoid the difficulties in comparing environmental policies across countries. Furthermore, by using panel data, we can control for year-specific effects and a greater number of other control variables than other studies of international treaty participation have.

The results from this estimation also yield several other interesting results. In particular, countries with more FDI tend to participate in more environmental treaties, something not entirely expected given the belief that a country's treaty participation discourages its inbound FDI. In addition, rich countries with greater market potential participate in fewer treaties whereas poor countries with greater market potential participate in more treaties. This suggests a link between trade and treaty participation that potentially indicates a need to coordinate international trade agreements with international environmental agreements.

Finally, we find that treaty participation by rich countries tends to increase treaty participation by other rich countries and by poor countries. Poor countries' treaty participation, on the other hand, tends to draw little if any response. This suggests that efforts to expand international environmental agreements may require participation of the rich countries in order to be effective on a worldwide scale. Thus, in an era when developing nations such as India and China are rapidly becoming the world's largest polluters, it may fall to the wealthy western nations to take the lead. Given the recent withdrawal of the US from the Kyoto agreement, our findings indicate a potentially bleak future for environmental agreements. Nevertheless, our hope is that these results prove useful in the developing policy and academic debate on globalization and the environment.

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Figure 1 Change in Equilibrium Taxes when a Rises from a_1 to a_2

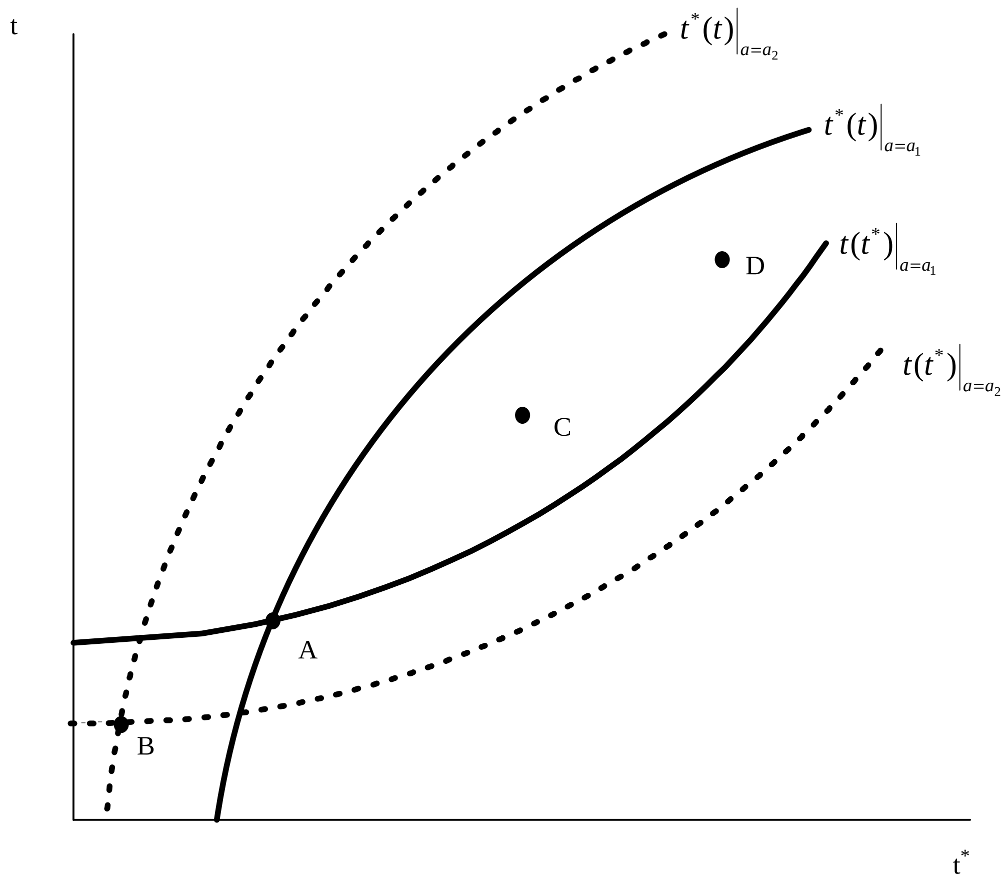

Table 1 Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
All Treaties	14.690	6.557	0	31
Sea Treaties	4.918	2.645	0	11
Fish Treaties	2.392	1.584	0	7
Air Treaties	1.506	1.057	0	3
Ln(FDI flow)	9.037	0.608	7.849	12.581
Ln(Market Potential)	8.098	1.315	4.441	10.604
Ln(GDP)	19.258	1.228	16.509	22.943
Ln(Population)	10.102	1.230	7.789	14.039
Ln(Area)	12.834	1.930	6.471	16.653
Urbanization	0.695	0.180	0.170	1.000
Unemployment	0.074	0.041	0.005	0.239
Freedom Index	9.655	2.846	0	12
Corruption	3.979	2.511	0	9
EU dummy	0.269	0.444	0	1
Landlocked	0.071	0.257	0	1
Export Diversification	0.473	0.158	0.125	0.774

Included countries (41): Argentina, Australia, Austria, Brazil, Canada, Chile, China, Colombia, Czech Republic, Denmark, Ecuador, Egypt, Finland, France, Germany, Hungary, Indonesia, Ireland, Israel, Italy, Japan, Korea, Republic of, Malaysia, Mexico, Netherlands, Norway, Pakistan, Peru, Philippines, Poland, Portugal, Russia, Singapore, Spain, Sweden, Switzerland, Thailand, Turkey, USA, United Kingdom, Venezuela.

Table 2 Full Sample Results for All Treaties

	(1) No Spatial Lag, Exogenous FDI	(2) No Spatial Lag, Endogenous FDI	(3) Spatial Lag, Exogenous FDI	(4) Spatial Lag, Endogenous FDI
Spatial Lag			0.630***	0.755***
			(0.073)	(0.068)
Ln(FDI)	0.341	-6.874***	0.207	-0.792*
	(0.317)	(1.608)	(0.299)	(0.478)
Ln(Market Potential)	0.920***	0.518**	-0.435*	-0.758***
	(0.174)	(0.252)	(0.226)	(0.224)
Ln(GDP)	3.183***	3.064***	2.559***	2.419***
	(0.571)	(0.779)	(0.542)	(0.552)
Ln(Population)	-2.570***	-1.455*	-1.615***	-1.276**
	(0.555)	(0.794)	(0.534)	(0.546)
Ln(Area)	0.800***	1.200***	0.351***	0.316**
	(0.116)	(0.180)	(0.121)	(0.123)
Urbanization	-1.525	-0.101	-1.704*	-1.547
	(1.009)	(1.409)	(0.950)	(0.971)
Unemployment	7.959**	9.710*	7.635**	7.807**
	(4.013)	(5.487)	(3.778)	(3.853)
Freedom Index	0.357***	0.095	0.154**	0.079
	(0.079)	(0.122)	(0.078)	(0.081)
Corruption	-0.192	-0.844***	-0.299***	-0.408***
	(0.122)	(0.218)	(0.116)	(0.122)
EU dummy	3.642***	4.441***	2.625***	2.530***
	(0.450)	(0.637)	(0.439)	(0.447)
Landlocked	-0.956	-0.824	-0.153	0.024
	(0.630)	(0.860)	(0.600)	(0.611)
Export Diversification	-4.309**	6.786*	-2.319	-0.430
	(1.979)	(3.601)	(1.877)	(1.996)
Constant	-45.496***	6.978	-31.243***	-21.347***
	(5.919)	(13.862)	(5.810)	(6.492)
Observations	635	635	635	635
R-squared	0.78	0.58	0.80	0.79

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

All specifications also include year-specific dummy variables.

Table 3 Full Sample Results for Different Treaties

	(1) All (37)	(2) Sea (12)	(3) Fish (10)	(4) Air (3)
Spatial Lag	0.755***	1.031***	0.564***	0.783***
	(0.068)	(0.120)	(0.080)	(0.064)
Ln(FDI)	-0.792*	-0.483	0.194	0.132***
	(0.478)	(0.306)	(0.164)	(0.047)
Ln(Market Potential)	-0.758***	-0.810***	-0.219***	0.038*
	(0.224)	(0.146)	(0.063)	(0.022)
Ln(GDP)	2.419***	1.304***	0.701***	0.214***
	(0.552)	(0.351)	(0.188)	(0.054)
Ln(Population)	-1.276**	-0.579*	-0.566***	-0.292***
	(0.546)	(0.348)	(0.183)	(0.054)
Ln(Area)	0.316**	-0.111	0.141***	0.050***
	(0.123)	(0.081)	(0.039)	(0.012)
Urbanization	-1.547	-1.264**	-0.175	-0.661***
	(0.971)	(0.634)	(0.334)	(0.098)
Unemployment	7.807**	1.537	3.145**	0.700*
	(3.853)	(2.470)	(1.323)	(0.376)
Freedom Index	0.079	-0.053	-0.007	0.002
	(0.081)	(0.052)	(0.028)	(0.008)
Corruption	-0.408***	-0.173**	-0.031	0.005
	(0.122)	(0.080)	(0.042)	(0.012)
EU dummy	2.530***	1.408***	0.688***	0.021
	(0.447)	(0.286)	(0.151)	(0.042)
Landlocked	0.024	0.455	-0.541**	0.087
	(0.611)	(0.394)	(0.212)	(0.058)
Export Diversification	-0.430	-0.187	0.679	0.266
	(1.996)	(1.267)	(0.683)	(0.191)
Constant	-21.347***	-5.874	-9.045***	-2.942***
	(6.492)	(4.032)	(2.176)	(0.683)
Observations	635	635	635	635
R-squared	0.79	0.48	0.59	0.93

Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$
All specifications also include year-specific dummy variables.

Table 4 OECD and Non-OECD Results for Different Treaties

	OECD				Non-OECD			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All (37)	Sea (12)	Fish (10)	Air (3)	All (37)	Sea (12)	Fish (10)	Air (3)
Spatial Lag	0.609***	0.474***	0.293***	0.759***	0.136	-0.174	0.034	0.267
	(0.138)	(0.154)	(0.100)	(0.134)	(0.118)	(0.136)	(0.143)	(0.165)
Ln(FDI)	0.365	-0.366	0.711***	0.196***	1.914**	1.269**	0.708***	0.409***
	(0.380)	(0.235)	(0.167)	(0.046)	(0.837)	(0.547)	(0.271)	(0.125)
Ln(Market Potential)	-1.545***	-1.073***	-0.795***	0.152***	1.700***	0.369**	0.126	0.180***
	(0.185)	(0.111)	(0.082)	(0.023)	(0.276)	(0.181)	(0.099)	(0.041)
Ln(GDP)	4.411***	2.593***	0.529*	0.180**	1.426	-0.009	1.838***	-0.227*
	(0.717)	(0.435)	(0.319)	(0.084)	(0.891)	(0.573)	(0.290)	(0.132)
Ln(Population)	-5.236***	-3.120***	-0.834**	-0.310***	-1.591**	0.008	-1.291***	-0.046
	(0.772)	(0.477)	(0.344)	(0.090)	(0.682)	(0.428)	(0.230)	(0.101)
Ln(Area)	-1.017***	-0.581***	-0.378***	0.034**	1.362***	0.369***	0.117*	0.123***
	(0.140)	(0.087)	(0.061)	(0.017)	(0.199)	(0.130)	(0.063)	(0.029)
Urbanization	-3.963***	-3.137***	-3.144***	-1.017***	3.205**	2.524**	0.843*	0.095
	(1.384)	(0.880)	(0.613)	(0.164)	(1.616)	(0.982)	(0.510)	(0.217)
Unemployment	12.451***	-6.109***	9.900***	0.273	12.732**	19.175***	0.974	-0.196
	(3.867)	(2.347)	(1.710)	(0.451)	(6.001)	(3.850)	(1.998)	(0.921)
Freedom Index	0.295*	0.082	-0.187***	0.057***	-0.232**	-0.122**	-0.035	0.010
	(0.161)	(0.101)	(0.072)	(0.019)	(0.090)	(0.058)	(0.028)	(0.012)
Corruption	-0.125	0.120	-0.446***	0.033**	0.020	0.051	0.240***	0.053**
	(0.140)	(0.084)	(0.061)	(0.016)	(0.164)	(0.099)	(0.053)	(0.024)
EU dummy	-1.313***	0.012	-0.389**	-0.099**				
	(0.411)	(0.247)	(0.180)	(0.048)				
Landlocked	-4.908***	-2.654***	-1.321***	-0.184***	2.882**	2.054**	-0.694	0.289
	(0.554)	(0.321)	(0.239)	(0.060)	(1.429)	(0.882)	(0.457)	(0.238)
Export Diversification	26.463***	14.329***	9.056***	0.773***	-9.123***	-2.817	-3.429***	0.969**
	(2.473)	(1.505)	(1.093)	(0.289)	(2.972)	(1.908)	(0.970)	(0.443)
Constant	-19.860***	-2.819	4.780	-4.097***	-49.417***	-17.723***	-28.618***	-2.401*
	(7.359)	(4.569)	(2.979)	(0.790)	(9.580)	(6.211)	(3.129)	(1.436)
Observations	373	373	373	373	262	262	262	262
R-squared	0.83	0.67	0.63	0.94	0.84	0.64	0.64	0.88

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 All specifications also include year-specific dummy variables.

Table 5 OECD and Non-OECD Results with Different Strategic Interaction Responses

	OECD				Non-OECD			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All (37)	Sea (12)	Fish (10)	Air (3)	All (37)	Sea (12)	Fish (10)	Air (3)
Spatial Lag	0.500***	0.530***	0.247**	0.759***	0.194*	-0.039	0.263*	0.072
	(0.151)	(0.165)	(0.098)	(0.134)	(0.111)	(0.130)	(0.137)	(0.128)
Non-OECD Spatial Lag	-0.150	0.145	-1.408***	0.026				
	(0.114)	(0.177)	(0.437)	(0.053)				
OECD Spatial Lag					0.826***	1.579***	2.047***	1.433***
					(0.159)	(0.305)	(0.343)	(0.153)
Ln(FDI)	0.176	-0.216	0.520***	0.202***	1.117	0.790	0.113	0.179*
	(0.433)	(0.279)	(0.170)	(0.051)	(0.768)	(0.508)	(0.257)	(0.097)
Ln(Market Potential)	-1.559***	-1.059***	-0.857***	0.153***	1.046***	-0.079	-0.057	0.032
	(0.184)	(0.112)	(0.082)	(0.023)	(0.285)	(0.189)	(0.094)	(0.035)
Ln(GDP)	4.144***	2.672***	0.330	0.184**	1.597*	0.107	2.010***	-0.190*
	(0.742)	(0.446)	(0.319)	(0.084)	(0.842)	(0.548)	(0.268)	(0.105)
Ln(Population)	-5.000***	-3.195***	-0.523	-0.314***	-2.091***	-0.271	-1.646***	-0.100
	(0.793)	(0.485)	(0.350)	(0.091)	(0.651)	(0.413)	(0.220)	(0.080)
Ln(Area)	-0.963***	-0.602***	-0.320***	0.031*	1.226***	0.262**	0.093	0.083***
	(0.149)	(0.090)	(0.062)	(0.018)	(0.190)	(0.125)	(0.058)	(0.024)
Urbanization	-4.235***	-3.159***	-3.237***	-1.022***	2.691*	2.111**	0.434	0.058
	(1.394)	(0.881)	(0.601)	(0.164)	(1.527)	(0.941)	(0.474)	(0.174)
Unemployment	11.531***	-6.090**	8.537***	0.307	8.234	16.084***	0.552	-0.769
	(3.907)	(2.355)	(1.728)	(0.458)	(5.741)	(3.733)	(1.838)	(0.737)
Freedom Index	0.291*	0.082	-0.140*	0.058***	-0.270***	-0.158***	-0.070***	0.009
	(0.160)	(0.101)	(0.072)	(0.019)	(0.085)	(0.055)	(0.026)	(0.010)
Corruption	-0.133	0.121	-0.454***	0.032*	0.163	0.125	0.311***	0.066***
	(0.139)	(0.084)	(0.060)	(0.016)	(0.157)	(0.096)	(0.051)	(0.019)
EU dummy	-1.160***	-0.020	-0.350**	-0.103**				
	(0.426)	(0.250)	(0.176)	(0.049)				
Landlocked	-4.775***	-2.713***	-1.196***	-0.195***	-0.252	0.184	-1.711***	-0.349*
	(0.563)	(0.329)	(0.238)	(0.065)	(1.486)	(0.921)	(0.458)	(0.202)

	OECD				Non-OECD			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All (37)	Sea (12)	Fish (10)	Air (3)	All (37)	Sea (12)	Fish (10)	Air (3)
Export Diversification	26.567***	14.141***	9.010***	0.765***	-8.540***	-2.564	-2.842***	1.050***
	(2.465)	(1.514)	(1.066)	(0.292)	(2.808)	(1.825)	(0.896)	(0.353)
Constant	-14.242*	-5.015	6.863**	-4.163***	-35.301***	-8.897	-21.850***	0.888
	(8.527)	(5.198)	(2.982)	(0.816)	(9.212)	(6.031)	(3.013)	(1.159)
Observations	373	373	373	373	262	262	262	262
R-squared	0.84	0.67	0.65	0.94	0.86	0.68	0.70	0.93

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 All specifications also include year-specific dummy variables.

Appendix A—Included Treaties

	Treaty	Type	Year of Signature	Parties
1	Agreement for the Establishment of the Indian Ocean Tuna Commission	Fish	1993	15
2	Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks	Fish	1995	23
3	Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas	Fish	1993	10
4	Convention for the Conservation of Antarctic Seals		1972	16
5	Convention for the Protection of the Ozone Layer	Air	1985	172
6	Convention for the Regulation of Whaling	Fish	1931	26
7	Convention for the Regulation of the Meshes of Fishing Nets and the Size Limits of Fish	Fish	1946	14
8	Convention on Biological Diversity		1992	176
9	Convention on Fishing and Conservation of the Living Resources of the High Seas	Fish	1958	37
10	Convention on International Trade in Endangered Species of Wild Fauna and Flora		1973	148
11	Convention on Long-Range Transboundary Air Pollution	Air	1979	44
12	Convention on Wetlands of International Importance especially as Waterfowl Habitat		1971	116
13	Convention on the Conservation of Antarctic Marine Living Resources	Fish	1980	29
14	Convention on the Conservation of Migratory Species of Wild Animals		1979	60
15	Convention on the Continental Shelf		1958	57
16	Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal		1989	132
17	Convention on the High Seas	Sea	1958	62
18	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	Sea	1972	77
19	Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques		1976	66
20	Convention placing the International Poplar Commission within the Framework of the Food and Agriculture Organization of the United Nations		1959	36
21	International Convention for the Conservation of Atlantic Tunas	Fish	1966	24
22	International Convention for the Prevention of Pollution from Ships (MARPOL)	Sea	1973	25
23	International Convention for the Prevention of Pollution from Ships (MARPOL) - Annex III: Hazardous substances carried in packaged form	Sea	1978	89
24	International Convention for the Prevention of Pollution from	Sea	1978	73

	Treaty	Type	Year of Signature	Parties
	Ships (MARPOL) - Annex IV: Sewage			
25	International Convention for the Prevention of Pollution from Ships (MARPOL) - Annex V: Garbage	Sea	1973	91
26	International Convention for the Prevention of Pollution of the Sea by Oil 1962 and 1969	Sea	1954	24
27	International Convention for the Protection of Birds		1950	10
28	International Convention for the Regulation of Whaling	Fish	1946	38
29	International Convention on Civil Liability for Oil Pollution Damage	Sea	1969	69
30	International Convention on Oil Pollution Preparedness Response and Co-operation	Sea	1990	41
31	International Convention on Salvage	Sea	1989	26
32	International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties	Sea	1969	72
33	International Convention to Combat Desertification in those Countries Experiencing Serious Drought and or Desertification		1994	157
34	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management		1997	9
35	United Nations Convention on the Law of the Sea	Fish&Sea	1982	130
36	United Nations Framework Convention on Climate Change	Air	1992	180
37	International Plant Protection Convention		1951	109

Appendix B—Data Description and Sources

Variable	Description	Source
Treaty participation	Number of treaties to which a country is a party	CIESIN
Ln(FDI)	Log of [FDI flow –minimum FDI flow + 1], where FDI flow is in constant $millions.[28]	UNCTAD (FDI Database)
Ln(GDP)	Log of GDP ($, constant)	Heston et al., 2002 (PWT 6.1)
Ln(Population)	Log of population (in 1,000s)	Heston et al., 2002 (PWT 6.1)
Ln(Area)	Log of area	World Bank (WDI 2004)
Urbanization	Urban population (% of total)	World Bank (WDI 2004)
Unemployment	Unemployment (% of total labor force)	World Bank (WDI 2004)
Freedom Index	14-(CL+PR), where CL is the civil liberties index and PR is the political rights index. CL and PR vary between 1 and 7 and higher numbers indicate lower freedom.	Freedom House
Corruption	1-CPI, where CPI is the corruption perceptions index, which decreasing in corruption.	Transparency International
EU dummy	European Union dummy	Generated by authors
Landlocked	Landlocked country dummy	CEPII
Export Diversification	1-DI, where DI is the export diversification index with higher numbers indicating narrower export base.	UNCTAD (Handbook of Statistics)
Ln(Market Potential)	Distance weighted average of other countries' GDP, matrix of weights is the non-row-standardized version of the one used in construction of the spatial lag.	GDP from Heston et al., 2002, distances from CEPII
Instruments for FDI:		
Ln(Trade Costs)	Log of Trade Costs= $\frac{1}{Openness}$, where $Openness = \frac{Exports + Imports}{Real\ GDP}$	Heston et al., 2002 (PWT 6.1)
Ln(Education)	Log of average years of schooling for those over age 25. (Data every five years, with linear interpolation by authors for in-between years.)	Barro and Lee (1996)
Ln(Investment Costs)	Log of measure of business environment risk. Composite measure of operations risk index, political risk index and remittance and repatriation factor index.	Business Environment Risk Intelligence S.A.

[28] The FDI flow is negative for some observations, thus to avoid dropping these in the log specification we scale up the variable.