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Why Do Countries Cooperate? The Effect of Cross-Border Pollution

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WHY DO COUNTRIES COOPERATE? THE EFFECT OF CROSS-BORDER POLLUTION

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Abstract

As evidence regarding the consequences of climate change grows, the need to act cooperatively becomes increasingly apparent. International environmental agreements are one of many means being pursued to improve environmental management and combat climate change at large. This study examines factors that influence international environmental treaty participation among European countries. Using panel data on 35 European countries for 1980-1999, joint treaty participation is estimated as a function of various globalization variables with specific attention given to the effects of cross-border air pollution, foreign direct investment, and trade. These results suggest that cross-border air pollution does increase cooperation even after controlling for distance between countries. Specifically, these results suggest that countries that receive more cross-border pollution from another country (than they themselves send there) are more likely to jointly ratify environmental treaties with that country.

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Chapter 1: Introduction

Globalization improves the lives of many, whether through access to better economic opportunities, education, healthcare, or political systems. Yet it also harms the lives of many, and there is much debate about its social, economic, and environmental implications. One element of this debate concerns the effect of increased international commerce on the environment. Central to the relationship between international commerce and the environment are the implications of competition in environmental policy for foreign direct investment (FDI). As firms become mobile, competition between host countries can lead to sub-optimal emissions taxes. As discussed by Rauscher (1995, 1997), if firms seek to avoid emissions taxes (the "pollution haven effect"), governments may respond by lowering emissions taxes in order to attract FDI (the "race to the bottom"). This inefficiency creates incentive to coordinate environmental standards across countries, which can increase emissions tax rates and lower worldwide pollution levels (Davies and Naughton 2014). Set in this context, international environmental agreements (IEAs) may play an important role in shaping economic and environmental outcomes.

This study examines the effects of cross-border air pollution and international commerce on joint environmental treaty participation among European countries. I use regression analysis to answer the question, how does cross-border air pollution of sulfur oxides and nitrogen oxides affect joint environmental treaty participation between countries? Using panel data on European country pairs, this study estimates treaty

participation as a function of various globalization variables, with specific attention given to the effects of cross-border air pollution, FDI, and trade on treaty participation.

While previous studies have considered international competition in environmental policy and others have examined the relationship between FDI and the environment, few have fully integrated these two ideas. This paper provides an empirical contribution towards filling this gap. Furthermore, while other studies have examined factors that influence environmental treaty participation by individual countries, none have used cross-border air pollution data to study cooperation between countries via joint environmental treaty participation.[1] By using data on country pairs, this study is able to focus on factors that drive environmental cooperation between countries as opposed to treaty participation by individual countries. Understanding the incentives behind joint treaty participation can provide insight regarding the contentious relationship between globalization and the environment, particularly with respect to the roles of international commerce and environmental policy.

The remainder of this paper proceeds as follows. Chapter 2 discusses the relationship between globalization, climate change, and international environmental agreements. Chapter 3 reviews theoretical and empirical literature on IEA effectiveness and participation, and discusses a theoretical model of pollution tax competition. Chapter 4 describes the empirical approach and data used. Chapter 5 discusses empirical results, and Chapter 6 concludes and discusses possibilities for future research. In Chapter 7, I offer additional comments on the relationship between international commerce and the

[1] Roberts et al. (2004) and Egger et al. (2011) estimate models determining treaty participation by individual countries, but neither of theses studies allow for strategic interactions between countries.

environment within the context of globalization and climate change, as well as make suggestions as to what can be done—beyond participation in environmental agreements—to address climate change and other social, economic, and environmental issues within this context.

Chapter 2: Globalization and the Environment: the case for IEAs

2.1 Global Pollution and Climate Change

In *Making Globalization Work,* former chief economist at the World Bank and Nobel Prize winning economist Joseph Stiglitz (2006, 161) suggests that "the world is currently engaged in a grand experiment, studying what happens when you release carbon dioxide and certain other gases into the atmosphere in larger and larger amounts." We have never done this before, and there is consensus among scientists that human-driven climate change is well outside the earth's natural range of climate variability (IPCC 2007). Global warming stems from the phenomenon that when sunlight hits the earth's surface it is reflected back into the atmosphere and absorbed by naturally present gases, including carbon dioxide. This trapped sunlight heats the atmosphere and the earth's surface, creating a 'greenhouse effect.' Without these gases it is estimated that the earth's temperature would be approximately 30 to 40 degrees Celsius cooler and the planet could not sustain life as we know it (IPCC 2007).[2] While this natural warming process is needed for life on earth, human activity disrupts the level of greenhouse gases (GHGs) in the atmosphere, which increases global warming and contributes to climate change.

Combatting climate change has become a global priority, and as such, a wide range of actions is being taken to mitigate its causes and develop solutions. Anthropogenic emissions and other sources of environmental degradation can be addressed, in part, through international environmental agreements. For example, the Kyoto Protocol and

[2] To preserve our planet as we know it, scientists argue we must reduce the amount of carbon dioxide in the atmosphere from its current levels of 400 parts per million to below 350 ppm (McKibben 2007).

Montreal Protocol set targets for emissions of GHGs and other harmful substances such as chlorofluorocarbons and hydrofluorocarbons. These treaties address emissions reductions as well as carbon capture and sequestration. Although forests and oceans are natural carbon sinks, rising temperatures reduce their ability to sequester carbon (EPA 2014a). This creates a positive feedback loop—global warming reduces the capacity of carbon sinks, which increases carbon dioxide levels in the atmosphere, which in turn leads to more global warming. Climate change is thought to be driven by many positive feedback loops. This process has far-reaching consequences and international environmental agreements are one of the means by which countries attempt to address them.

2.2 Local and Regional Pollution

While much of the research and debate about climate change focuses on carbon dioxide levels in the atmosphere, it is also important to study local and regional air pollutants such as sulfur oxides and nitrogen oxides. Doing so can provide insight regarding factors that may influence strategic interaction between countries. Sulfur oxides (SO_X) refer to many types of sulfur and oxygen containing compounds, including sulfur dioxide. In air pollution, sulfur dioxide is a toxic gas released by various industrial processes, including coal-fired power plants, and produced naturally by volcanoes (EPA 2014b). Nitrogen oxides (NO_X) refer to nitrogen and oxygen containing compounds, specifically nitrogen dioxide and nitric oxide. NO_X is a byproduct of combustion, such as by automobile engines and fossil fuel power plants, and is also produced naturally during

the electrical discharges of lightning (EPA 2014c). Together, SO_X and NO_X are byproducts of industrial production that react with water molecules and other compounds in the atmosphere to form smog and acid rain. These pollutants can travel great distances, affecting the country of origin and other countries as well.

The cross-border nature of SO_X and NO_X emissions provides grounds for countries to strategically interact via environmental treaties. Three international environmental agreements are in place to control SO_X and NO_X emissions.[3] The 1985 Helsinki Protocol is a protocol to the Convention on Long-Range Transboundary Air Pollution to regulate SO_X emissions. It required a 30 percent reduction of the 1980 SO_X emissions by 1990 and a 50 percent reduction by 1993 for participating countries. The 1994 Oslo Protocol supplements the Helsinki Protocol by setting individual SO_X reduction targets for each country and a longer timeline—extending the target dates from 2000 to 2010. Regarding NO_X emissions, the 1988 Sofia Protocol called for participating countries to reduce their emissions to 1987 levels by 1994, and provided other guidelines for controlling emissions. Although these agreements were written and signed at international meetings, countries are not bound by an agreement until they ratify it. Moreover, countries may withdraw from ratified agreements without legal consequence, which makes studying the incentives behind treaty participation all the more important. Examining the relationship between international commerce and the environment is one mean of doing so.

[3] Additional information on the environmental agreements used for the empirical analyses in this study can be found in Appendix A and Appendix B.

2.3 International Commerce and the Environment

Globalization allows countries to strategically interact—whether in response to transboundary environmental issues, through international commerce, or otherwise. One of the largest players influencing the nature of globalization—and the relationship with the environment—is the transnational corporation (TNC). While household names like Wal-Mart, Apple, Exxon-Mobil, and General Electric are some of the world's most visible TNCs, there are thousands of TNCs and hundreds of thousands of affiliates operating across the globe. Between 1970 and 2007, the number of TNC parent firms increased more than tenfold from about 7,000 to over 79,000, with nearly 800,000 foreign affiliates (UNCTAD, 2008). These firms make up approximately one-tenth of world GDP and one-third of total world exports (Clapp and Dauvergne 2011). Growth in the number of TNCs has also translated into rising FDI, which is investment made by a corporation in a home country into a host country. FDI flows have expanded rapidly from $82 billion in 1982 to a peak of $2.3 trillion in 2007 prior to the global financial crisis. In 2008, global FDI flows were approximately $1.8 trillion (Clapp and Dauvergne 2011). Like international trade, FDI can play a crucial role regarding how international commerce affects environmental management issues.

Economic literature on the relationship between international commerce and the environment came in two waves, with an initial surge in the 1970s and renewed interest in the 1990s, which was fueled by policy debates over the North American Free Trade Agreement (NAFTA) and the Uruguay Round of GATT negotiations. A main concern expressed in early work was that reducing barriers to trade and FDI would lead to

industrial flight from rich to poor countries as well as the creation of pollution havens in countries with lower environmental standards (Baumol 1971; Siebert 1977). Industrial flight occurs when a country raises its environmental standards, which then triggers the relocation of industry and FDI to countries with lower standards. Pollution havens arise when a country sets inefficiently low environmental standards in order to attract FDI, which leads industry to relocate and save on production costs. Pollution havens and industrial flight are thus two sides of the same coin. Together they can cause a 'regulatory chill,' which occurs when countries fail to raise environmental standards for fear of losing out on trade and investment opportunities (Clapp and Dauvergne 2011). For example, governments could tailor their emissions tax policies to attract FDI, which may come at the expense of their environment. These issues can leave countries with weak political institutions and domestic economies particularly vulnerable to environmental and labor abuses. Further discussion of the relationship between international commerce and the environment can be found in Chapter 7.

A related body of literature examines international environmental treaty participation among countries. Much of this literature focuses on the incentives for countries to cooperate via environmental treaties while other literature examines treaty effectiveness as opposed to participation. The next chapter discusses theoretical and empirical work on IEA effectiveness and participation, as well as a theoretical model of pollution tax competition.

Chapter 3: Literature Review

3.1 Introduction

This chapter discusses theoretical and empirical work on IEA effectiveness and participation. I begin by discussing the economic theory of environmental agreements and empirical work on IEA effectiveness. I then discuss theoretical literature on IEA participation—including a theoretical model of emission tax competition—which together provides a theoretical basis for countries to cooperate via IEAs. Finally, I discuss empirical work on IEA participation with specific attention given to the roles of international commerce and cross-border air pollution as determinants of participation.

3.2 IEA Effectiveness: Theory and Evidence

In economic theory, the environment is often characterized as a common resource. This classification can create a prisoners' dilemma and subsequently a tragedy of the commons in which the actions of self-interested individuals ultimately leads to the abuse of the common resource in question. While environmental agreements seek to combat such abuses, enforcing them can be difficult due to the prisoners' dilemma associated with IEA participation. Much of the literature on IEA participation focuses on the incentives for countries to cooperate via IEAs, while other literature examines treaty effectiveness as opposed to participation. Most theoretical economic models on treaty effectiveness suggest that IEAs fail at reducing emissions below business-as-usual levels (Barrett 1994a, 1997; Carraro and Siniscalco 1993; Finus and Maus 2008). This is largely due to

the voluntary nature of IEAs, their lack of enforceability, and the free rider problem associated with other countries' abatement efforts (Egger at al. 2011; Kellenberg and Levinson 2014).

Empirical work on IEA effectiveness provides mixed support for these theories.[4] Among studies that employ multiple regression analysis regarding the effectiveness of the Helsinki, Oslo, and Sofia Protocols, Murdoch et al. (1997) found that the Helsinki Protocol helped lower sulfur emissions but the Sofia Protocol did not affect NO_X emissions.[5] Murdoch et al. (1997) used a spatial lag model for data on 25 European countries from 1980-1990. In contrast, Naughton (2010) found no effect of the Helsinki or Oslo Protocols on sulfur emissions but found that the Sofia Protocol was effective at reducing NO_X emissions in Europe. Naughton (2010) also used a spatial lag model using two-stage least squares as well as year and country fixed effects for 16 European countries from 1980-2000. Maddison (2006) found that both the Helsinki and Sofia Protocols decreased per capita emissions for countries that ratified the treaties. Maddison (2006) used OLS and a spatial mixed model for data on 135 countries from 1990-1995.

Other studies that use multiple regression analysis also find varying degrees of effectiveness for the Helsinki, Oslo, and Sofia Protocols. Using OLS, fixed effects, and random effects for 19 European countries from 1980-1994, Ringquist and Kostadinova (2005) found that the Helsinki Protocol had no effect on sulfur emissions reduction in Europe. Similarly, Aakvik and Tjøtta (2011) use a difference-in-difference model on data

[4] See Houghton and Naughton (2014) for a detailed review of empirical literature on IEA effectiveness.
[5] The Helsinki and Oslo Protocols regulate sulfur emissions in Europe while the Sofia Protocol regulates NO_X emissions.

for 30 European countries from 1960-2002 to provide empirical evidence that neither the Helsinki nor Oslo Protocols are effective at reducing emissions once country-specific trends are taken into consideration. In contrast, Bratberg et al. (2005) find evidence that the Sofia Protocol increased NO_X emissions reduction by 2.1%, using a difference-in-difference model for 23 European countries from 1980-1996. Other studies reviewed by Houghton and Naughton (2014) and reported in Table A3 of Appendix A employ trend analyses to evaluate IEA effectiveness. Although each of the five studies evaluates a different IEA, all found evidence that IEAs are successful. See Appendix A for more information on empirical work on IEA effectiveness. Table A1 lists IEAs that have been evaluated by empirical studies, while Tables A2 and A3 outline empirical studies that employ multiple regression and trend analyses, respectively.

Clearly, empirical work on IEA enforcement provides mixed support for economic theories about IEA effectiveness. Kellenberg and Levinson (2014), who found that the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal was ineffective at reducing waste shipments among countries, argue that studying treaty effectiveness is challenging for a number of reasons. First, it is often the case that limited data are available from before IEAs were enacted, which limits researchers' ability to make before-and-after comparisons to evaluate treaty effectiveness. It is also difficult to measure counter-factual outcomes; that is, it is difficult to say what would have happened *without* a treaty in place. Regardless of IEA effectiveness, however, countries continue to enter into IEAs across the globe with countries having negotiated more than 1,200 multilateral environmental agreements, 1,500 bilateral environmental

agreements, and nearly 250 other environmental agreements (Mitchell 2002-2008). The surge in IEA membership is at odds with economic theory on IEA effectiveness, so the question remains as to why countries continue to participate.

3.3 IEA Participation: Theory and Evidence

In contrast to evaluating treaty effectiveness, a related body of literature focuses on the incentives for countries to participate in IEAs. Many of these incentives are related to international commerce—specifically foreign direct investment (FDI) and trade—and cross-border pollution between countries. Research by Rose and Spiegel (2009) suggests that membership in IEAs has surged because joining an IEA acts as a signaling effect for other forms of cooperation, particularly with respect to economic exchange. They hypothesize that countries are more willing to voluntarily submit to potentially costly environmental regulations if such participation can influence other outcomes such as membership in trade, investment, or political agreements. They employ a cross-sectional gravity model to test this theory empirically, and find that participation in IEAs is positively associated with the international exchange of assets. Using a sample of 221 country pairs from 2001 to 2003, Rose and Spiegel (2009) find evidence of increased cross-holdings of assets by country pairs if a bilateral environmental agreement is in place. That is, country pairs may raise bilateral capital flows if they are participating in a bilateral environmental agreement. If the country pair has a joint interest in the environment, then they should be able to maintain high levels of cross-holdings of assets, which can be reduced if one of the countries violates the IEA. Moreover, their research

suggests this result is consistent when both bilateral and multilateral environmental agreements are in place, which supports the idea that positive spillovers exist between environmental cooperation via joint IEA ratification and economic exchange.

Egger et al. (2011) reach a similar conclusion about the relationship between international commerce and environmental cooperation. They focus on the role of a country's international openness through trade and investment policies as indicators of participation in IEAs. Their findings support the theory that trade and investment liberalization increase IEA participation. In particular, they find that wealthier countries with a stronger leaning toward trade and investment liberalization are more likely than other countries to submit themselves to voluntary environmental standards—including emissions reduction—through membership in IEAs. However, their model does not consider strategic interactions between countries by way of joint treaty participation by country pairs, as they focus on whether openness to trade and investment liberalization are determinants of treaty participation by individual countries.

Other literature examines whether states or countries experiencing cross-border pollution have incentive to cooperate to reduce environmental degradation (Fredriksson and Millimet 2002; Fredriksson et al. 2004; Levinson (2003); Davies and Naughton 2014). Of the studies that use panel data, Fredriksson and Millimet (2002), Fredriksson et al. (2004), and Levinson (2003) find evidence that US states compete in environmental policy. Davies and Naughton (2014) employ a comparable empirical approach but use international data to examine the effect of cross-border pollution on international environmental treaty participation. While Davies and Naughton (2014) use weighting

schemes that decline in distance to proxy for cross-border pollution, the empirical model in this study uses pollution transfer coefficients to estimate joint treaty participation as a function of cross-border pollution and other explanatory variables.[6] Whereas distance is constant and symmetric between countries and is only a proxy for air pollution spillovers, the pollution transfer coefficient measures actual pollution spillover and accounts for the asymmetric nature of cross-border pollution between countries.[7] Similar to Davies and Naughton (2014), this study also considers competition for capital in relation to environmental treaty participation. This approach is informed by Davies and Naughton's (2014) theoretical model of emissions tax competition, which integrates ideas about competition in international environmental policy with ideas about the relationship between FDI and the environment, and is discussed below.

3.4 Theoretical Model of Emissions Tax Competition

Much of the theoretical literature on IEAs examines emissions tax policies, and poses the question of whether countries or states that experience cross-border pollution spillovers have incentive to cooperate in order to reduce overall environmental degradation (Davies and Naughton 2014; Fredriksson et al. 2004; Mitchell 2003). The theoretical framework for my thesis is based on Davies and Naughton (2014). If

[6] Regarding the relationship between distance and cross-border pollution, this study found that distance is negatively correlated with both the SO_X and NO_X pollution transfer coefficients. For the data used in this study, there is a negative correlation of -.2269 between distance and the SO_X transfer coefficient, and a negative correlation of -.2302 between distance and the NO_X transfer coefficient.

[7] Cross-border air pollution between countries is not symmetric. As such, the transfer coefficients used in the empirical analyses in this study allow for pollution spillover from country *i* to country *j* that are not equal to pollution spillover from country *j* to country *i*.

competition for FDI leads to inefficiently low emissions taxes, then their theoretical framework suggests that high cross-border pollution increases benefits to cooperation in emissions taxes.

Davies and Naughton (2014) employ a two-country model of tax competition for FDI, which gives rise to best response emissions tax functions.[8] These functions are depicted on Figure 1 where $t(t^*)$ represents the home country's best response to the host country's tax, t^*, and $t^*(t)$ represents the host country's best response to the home country's tax, t.[9] At the initial level of cross-border air pollution, measured by the transfer coefficient $a=a_1$, the non-cooperative Nash equilibrium occurs at point A while the cooperative outcome is at point C. Therefore, gains to cooperation can be thought of as moving from point A to C. Davies and Naughton's (2014) theoretical framework suggests that an increase of the transfer coefficient to $a=a_2$ will lead to even more competition in emissions taxes with the Nash outcome represented by point B.[10] Furthermore, they find that a higher transfer coefficient leads to higher cooperative tax rates, which is represented by point D. Therefore, as the emissions transfer coefficient increases, gains from cooperation are represented by the difference between points B and D. This result is similar to that of Cremer and Gahvari (2004), who found that cooperation in emissions taxes and commodity taxes above the Nash equilibrium level by countries experiencing cross-border pollution led to lower aggregate emissions and higher overall welfare.

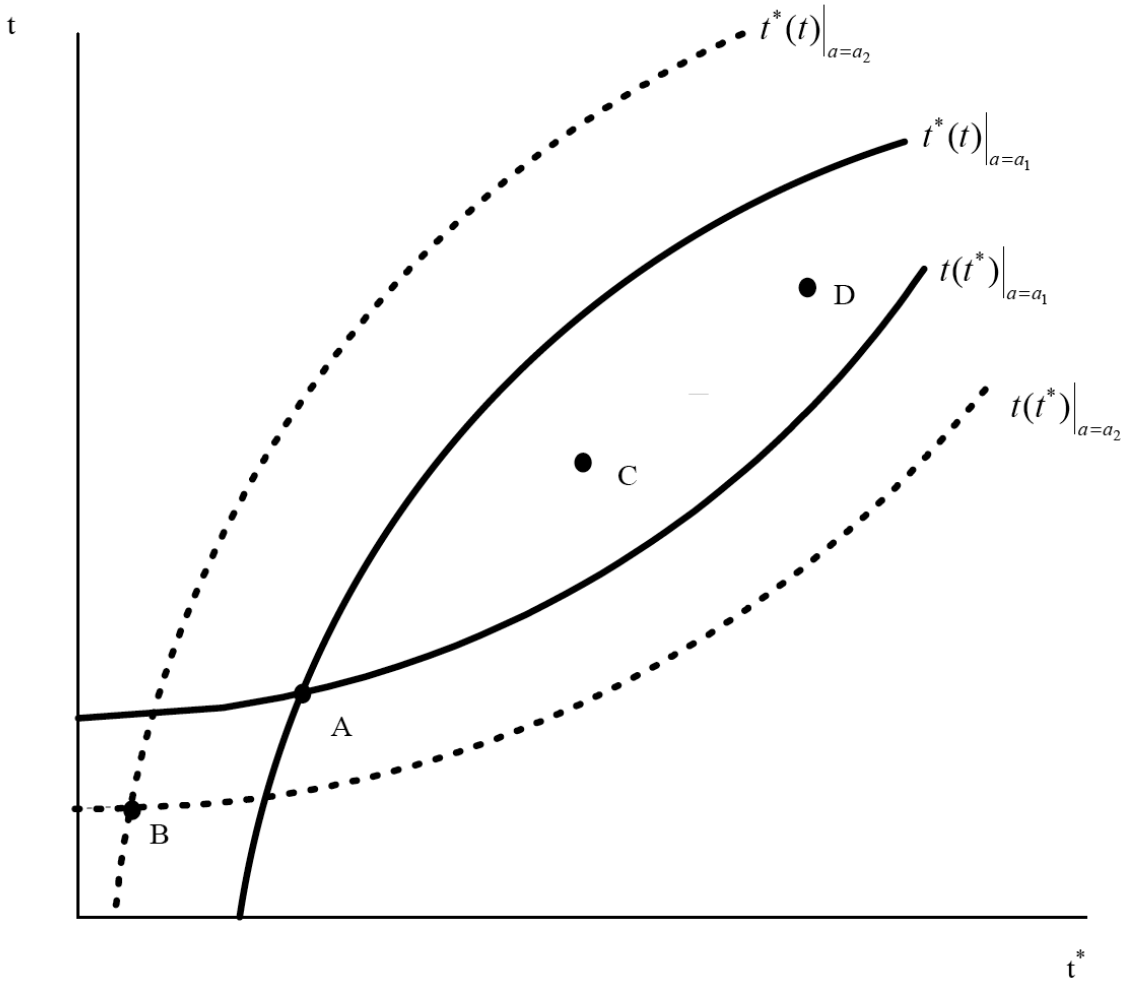
[8] This theoretical framework makes some fairly restrictive functional form assumptions by necessity. General theories of tax competition for FDI quickly lead to ambiguities that limit their usefulness (see Wilson 1999, Gresik 2001).

[9] The two-country models of FDI assume that one of the two countries is the source of FDI (the home country) and the other country is the host of FDI.

[10] With higher cross-border pollution the countries would like the benefits of hosting FDI given that they end up suffering much of the costs of emissions anyway.

The contribution of my thesis is empirical in nature. In their empirical model, Davies and Naughton (2014) proxy for cross-border pollution using different weighting schemes that were declining in distance, whereas my empirical model uses actual emissions transfer coefficients alongside distance.

Figure 1. Best-response emissions tax rates as *a* rises from a_1 to a_2



Source: Davies and Naughton (2014)
Note: Increasing emissions transfer coefficient (*a1* to *a2*) increases the gap between the competitive Nash equilibrium outcome (A to B) and cooperative outcome (C to D).

While Davies and Naughton's (2014) theoretical model may help explain regional IEA participation in which cross-border air pollution exists, it does not explain participation in IEAs when cross-border pollution is not an issue or for IEAs relating to global pollutants such as carbon dioxide or other greenhouse gases. Although the positive spillover effect described by Rose and Spiegel (2009) and Egger et al. (2011) also provides some theoretical and empirical basis for IEA participation, further review of empirical work on IEA participation is necessary.

3.5 IEA Participation: Additional Empirical Evidence

Much of the empirical work on IEA formation and participation focuses on either a single environmental agreement (bilateral or otherwise), a subset of agreements, or on a small subset of countries or regions. For example, Beron et al. (2003) and Murdoch et al. (2003) use spatial probit models to estimate strategic interaction between countries in the ratification of the Montreal and Helsinki Protocols, respectively. Beron et al. (2003) constructed a spatial lag using trade-based, emissions-based, and contiguity weighing schemes for data on the 89 largest countries in the world. They examine what they refer to as the 'power' effect to determine whether an individual nation's decision to ratify the protocol was influenced by the behavior of their largest trading partners. They hypothesized that if a nation felt strongly about ratifying a particular treaty, that country would not only ratify the treaty but also try to influence other countries to ratify it as well. However, they found no statistically significant evidence to support this. Beron et al. (2003) did find evidence that countries with stronger civil and political institutions were more likely to ratify the Montreal Protocol. This result is consistent with the theory that if

citizens prefer strong environmental standards, environmental treaty participation should increase when strong civil and political institutions are in place (Naughton 2010). Murdoch et al. (2003) estimate strategic interactions in the ratification of the Helsinki Protocol by using emissions-based weights for a cross-section of 25 European countries from 1980 to 1990. They model treaty participation as a two-stage game in which countries first decide whether or not to ratify the protocol, and then decide their level of participation by way of sulfur emissions reduction. Although the authors found positive and statistically significant interaction effects in the ratification stage of the game, they also observed that strategic responses by countries may differ across the different stages of the game.

Davies and Naughton (2014) improve on the studies by Beron et al. (2003) and Murdoch et al. (2003) in two key ways. First, they use panel data on 139 countries over a 20-year period from 1980 to 1999. Other studies that use panel data to estimate strategic interaction in environmental policy employ US state level data.[11] Davies and Naughton (2014) use an empirical approach similar to Fredriksson et al. (2004), who found that US states compete in environmental stringency as measured by an index developed by Levinson (2001) to measure state-level environmental compliance costs. Second, Davies and Naughton (2014) employ a more comprehensive measure of international environmental cooperation by using data on 110 treaties instead of just the Montreal or Helsinki Protocols. Davies and Naughton's (2014) theoretical model of emissions tax competition informs their empirical approach. They use different weighting schemes that are declining in distance to proxy for cross-border air pollution. They hypothesize that in

[11] Fredriksson and Millimet (2002), Levinson (2003), and Fredriksson et al. (2004) all find that US states compete in environmental stringency.

the presence of cross-border air pollution, proximate countries have greater incentives to cooperate via jointly ratified IEAs. They find statistically significant evidence of spatial spillovers in treaty participation among proximate countries.

Similar to Rose and Spiegel (2009), who found that openness to environmental cooperation acts as a signal for economic exchange, Davies and Naughton (2014) hypothesize that countries with higher trade and FDI will participate in more environmental treaties. Although they find statistical evidence that increasing trade increases IEA participation, their evidence regarding the effect of FDI on IEA participation is mixed. They also find that strategic responses in IEA participation are most evident in regional agreements, and vary between OECD and non-OECD countries. These results provide partial support for their emissions tax competition theory, and match the mixed results produced by other empirical work on IEA participation and effectiveness. Thus, there is still much room for further empirical research to test related theories.

The next chapter describes the empirical approach and data used in this study to test the hypothesis that cross-border air pollution increases cooperation between countries as measured by jointly ratified IEAs.

Chapter 4: Empirical Approach

4.1 Empirical Model

The empirical model used in this study is informed by Davies and Naughton's (2014) theoretical model of emissions tax competition. If competition among countries for FDI leads to inefficiently low emissions taxes, then data on environmental treaty participation should support the hypothesis that countries will gain from environmental cooperation. From previous literature, the incentive to cooperate increases as cross-border pollution increases (Davies and Naughton 2014). While Davies and Naughton (2014) used distance between countries to proxy for cross-border pollution, this study uses a cross-border pollution variable alongside distance. This allows me to examine the effect of cross-border pollution on treaty participation while controlling for distance. I expect countries that receive more cross-border pollution from another country (than they themselves send there) to be more likely to jointly ratify environmental treaties with that country. Similarly, if countries send more cross-border pollution to another country than they themselves receive from that country, they are expected be less likely to jointly ratify environmental treaties with that country.

An OLS model is estimated for the treaty cooperation index between countries *i* and *j* in year *t* as follows:

$$Ln(Index_{ijt}) = \beta_0 + \beta_1 TransferSOx_{ji} + \beta_2 Ln(SOx_{it}) + \beta_3 Distance_{ij} + \beta_4 Ln(FDI_{it}) + \beta_5 Ln(Exports_{it}) + \beta_6 Ln(GDPpercapita_{it}) + \beta_7 Ln(Population_{it}) + \beta_8 Freedom_{it} + \kappa_{ij} + \gamma_t + \epsilon_{ijt} \quad (1)$$

where $Ln(Index_{ijt})$ is the natural log of the number of treaties jointly ratified by each *i-j*

country pair in year *t*, $TransferSO_{Xji}$ is the air pollution transfer coefficients for SO_X from country *j* to *i*, and $Ln(SOx_{it})$ are country level SO_X emissions for country *i* in year *t.* I estimate a separate model using NO_X pollution transfer coefficients and country level emissions ($TransferNOx_{ji}$ and $Ln(NOx_{it})$, respectively). κ_{ij} captures country pair fixed effects controlling for time-invariant country pair characteristics, while γ_t captures year fixed effects. ε is the independently and identically distributed (i.i.d) error term, which represents idiosyncratic shocks uncorrelated across countries and over time. Each *i-j* country pair is included twice, as each country is included once as country *i* and again as country *j*. $Distance_{ij}$ is not included in the country pair fixed effects model, as it is symmetric and constant between country pairs over time. Although the pollution transfer coefficient is also constant over time, it is not symmetric between country pairs. That is, the pollution transfer coefficient from country *i* to *j* differs from the transfer coefficient from country *j* to *i*. As such, the transfer coefficient can be included in the country pair fixed effects model.

Following the theoretical framework discussed in Chapter 3, I predict a positive coefficient on the pollution transfer coefficient. Joint treaty participation by country *i* with country *j* is expected to increase as country *i* receives more cross-border pollution from country *j* (than country *i* sends to country *j*). Presumably, if all spillovers were captured by the transfer coefficient then distance should not matter to treaty participation. While I expect the pollution transfer coefficient to have a positive effect on joint treaty participation, previous literature suggests that country level emissions have an ambiguous effect on environmental treaty participation. Theory discussed in Beron et al. (2003) and Egger et al. (2011) suggests that countries with higher emissions will participate in fewer

environmental treaties but empirical work offers mixed support for this. For example, Beron et al. (2003) hypothesize that countries with higher country level emissions will participate in fewer environmental treaties but find no statistically significant evidence of this in their empirical analysis. Additionally, Egger et al. (2011) find that countries with higher emissions are less likely to commit to emissions reduction through participation in environmental treaties, but this effect is economically small.

While the pollution transfer coefficient and distance are constant over time, the remaining independent variables vary by country and across time. $Ln(FDI_{it})$ is the natural log of total inward FDI flow to country *i* at time *t*. Considering the theoretical tax competition model developed by Davies and Naughton (2014) and discussed in Chapter 3, I anticipate a positive coefficient on FDI. Some previous research (e.g. Cole at al. 2006, Rose and Spiegel 2009, Davies and Naughton 2014) suggests that FDI also responds to environmental regulation. I believe that is not an issue in my model because the environmental regulation variable is bilateral in nature rather than a more general measure of environmental regulation.

The effect of trade on joint treaty participation is estimated using $Ln(Exports_{it})$, which is the natural log of country *i*'s exports. According to previous literature, trade is often an indicator of cooperation so I expect countries with higher exports to participate in more IEAs, which will result in a positive coefficient on $Ln(Exports_{it})$. Other explanatory variables include GDP per capita, population, and a variable that measures political freedom. $Ln(GDPpercapita_{it})$ is the natural log of GDP per capita, $Ln(Population_{it})$ is the natural log of population in year *t*, and $Freedom_{it}$ is an index variable that measures political freedom in country *i*. Together, per capita GDP and

population control for size of the economy and average income. Following other studies, I expect to find that large economies are more likely to participate in international treaties. Therefore, positive coefficients are expected for $Ln(GDPpercapita_{it})$ and $Ln(Population_{it})$. Previous studies also find that if citizens prefer strong environmental standards, then political freedom should increase environmental treaty participation. As such, I anticipate a positive relationship between $Freedom_{it}$ and IEA participation.

In addition to the model specification that includes total inward FDI, separate models are estimated using bilateral inward FDI between *i-j* country pairs. These specifications are shown in section 5.3 of the results chapter.

4.2 Data

Treaty Participation Index

This study uses an unbalanced panel dataset for 35 European countries forming 1,190 country pairs for 1980 to 1999.[12] The dependent variable in the model is the natural log of the number of treaties jointly ratified by each *i-j* country pair in the dataset. I use ratified treaties instead of signed treaties because some treaties are signed but never ratified, and therefore do not go into effect. Treaty participation data are provided by Mitchell (2002-2008) through the International Environmental Agreements Database Project. Although data are available for more than 1,190 multilateral environmental agreements, 1,500 bilateral environmental agreements, and 250 other environmental

[12] Countries included in the dataset are: Albania, Armenia, Austria, Belarus, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom.

agreements, I use data for 110 treaties that have explicit environmental targets or requirements to be met by participating countries.[13] A detailed list of these 110 treaties including scope, type, and membership level for 1980, 1990, and 1999 can be found in Appendix B. Treaty types are also summarized in Appendix B. The treaties included in the study have wide application from air pollution and climate change to marine environment and nature. The use of a wide set of treaties presumes that in some cases bilateral pairs have more at stake in one environmental realm than in another and allows for the possibility that each country pair is most likely to cooperate in treaties most pertinent for that pair.

It is important to note that not all environmental treaties are of equal importance, I recognize, so summing the number of jointly ratified treaties is only a crude method for estimating environmental cooperation between countries. Future work on environmental treaty participation should consider using a more careful weighting of participation in different treaties. For the purpose of this study, however, joint treaty participation in these 110 treaties is used as a proxy variable to estimate environmental cooperation between country pairs.

Pollution Transfer Coefficients, Distance, and Emissions

Data for the pollution transfer coefficients are maintained by the Center on Emission Inventories and Projections (CEIP), which is part of the European Monitoring and Evaluation Programme (EMEP 2005). EMEP is a scientifically based and policy driven program under the Convention on Long-range Transboundary Air Pollution,

[13] These are the same 110 treaties used by Davies and Naughton (2014) and listed in Tables B1 and B2 of Appendix B.

which aims to foster international cooperation to solve transboundary air pollution problems. CEIP operates the EMEP emission database, which contains the emissions data used in this study. The pollution transfer coefficient measures cross-border air pollution of SO_X and NO_X from country *j* into country *i* as a percent of country j's emissions. Data on country level SO_X and NO_X emissions are measured in gigagrams and are reported by the Meteorological Synthesizing Centre West (MSC-W 2002). Distance, which Davies and Naughton (2014) used to proxy for cross-border air pollution, is measured as the simple distance between the most populated cities for each *i-j* country pair in the dataset. Data on distance between countries is maintained by CEPII, which is a French research center in international economics that produces studies, research, and databases on the world economy (CEPII 2013).

International Commerce: FDI and Trade

FDI flows are made up of capital provided—either directly or indirectly through related enterprises—by a foreign direct investor in a 'home' country to an FDI enterprise in a 'host' country, or capital received from an FDI enterprise in a 'host' country by a foreign direct investor in a 'home' country. The empirical model used in this study is informed by Davies and Naughton's (2014) theoretical model of emissions tax competition, which assumes that one of the two countries in the *i-j* country pair is the source of FDI (the home country) and the other country is the host of FDI. FDI that flows into a host country from a home country is considered inward FDI or inflow, and FDI that flows from a home country to a host country is considered outward FDI or outflow. FDI has three components: equity capital, reinvested earnings, and intra-company loans.

Equity capital is the investor's purchase of shares of an enterprise in another country; reinvested earnings comprise the investor's earnings that are not distributed as dividends by affiliates; and intra-company loans (or debts) refer to borrowing and lending between foreign direct investors (e.g. parent firms) and affiliates. Total inward FDI flow data for each country were obtained from the United Nations Conference on Trade and Development (UNCTAD 2008) and are measured in constant millions of US dollars. Regressions with a limited sample use bilateral FDI flow data maintained by the Organization for Economic Cooperation and Development (OECD) reported in current millions of US dollars. Some countries reported negative FDI flows, which indicates that at least one of the three components of FDI described above (equity capital, reinvested earnings or intra-company loans) is negative and is not offset by positive amounts of the other components.[14] To account for these negative values, all FDI variables were scaled up before logging in order to retain all available observations for analysis (see Table 1). World trade flow data are constructed from United Nations trade data by Feenstra et al. (2005) and are country *i*'s exports measured in thousands of constant 2005 US dollars.

Additional Explanatory Variables

GDP per capita and population data come from the Penn World Tables. GDP per capita is reported in constant 1996 USD and population is measured in thousands. Data on political freedom are from Freedom House (2005) and are the sum of freedom indices for each country in the dataset. $Freedom_{it}$ is measured as 14 – (CL+PR), where CL is the

[14] See the 2008 *World Investment Report* (UNCTAD 2008) for additional information about FDI flow variables.

civil liberties index and PR is the political rights index for country *i*. CL and PR vary between 1 and 7 with High CL and PR indicating low freedom. Table 1 and Table 2, shown below, contain variable descriptions and descriptive statistics.

Table 1 Variable Descriptions

Variable	Description	Source
$Index_{ijt}$	Number of treaties jointly ratified by *i-j* country pair	Mitchell (2002-2008)
$Ln(Index_{ijt})$	Natural log of $Index_{ijt}$	Mitchell (2002-2008)
$TransferSOx_{ji}$	Sulfur oxides pollution transfer coefficient. Cross-border pollution from country *j* into country *i* measured as a percent of country j's emissions	MSC-W (2002)
$TransferNOx_{ji}$	Nitrogen oxides pollution transfer coefficient. Cross-border pollution from country *j* into country *i* measured as a percent of country j's emissions	MSC-W (2002)
$Ln(SOx_{it})$	Natural log of SOx_{it}	EMEP (2005)
$Ln(NOx_{it})$	Natural log of NOx_{it}	EMEP (2005)
$Distance_{ij}$	Simple distance between most populated cities (1000 km)	CEPII (2013)
$Ln(FDI_{it})$	Natural log of FDI_{it}	UNCTAD (FDI Database)
$Ln(inward\ FDI_{jit})$	Natural log of inward FDI_{jit}	OECD (2013)
$Ln(Exports_{it})$	Natural log of $Exports_{it}$	Feenstra et al. (2005)
$Ln(GDPpercapita_{it})$	Natural log of $GDPpercapita_{it}$	Heston et al. (2002)
$Ln(Population_{it})$	Natural log of $Population_{it}$	Heston et al. (2002)
$Freedom_{it}$	$Freedom_{it}$ is measured as 14 – (CL+PR) where CL is the civil liberties index and PR is the political rights index for country *i*. CL and PR vary between 1 and 7. High CL and PR indicate low freedom.	Freedom House (2005)
SOx_{it}	Country level sulfur dioxide (SO_X), gigagrams	EMEP (2005)
NOx_{it}	Country level nitrogen oxides (NO_X), gigagrams	EMEP (2005)
FDI_{it}	[FDI flow –minimum FDI flow + 1], where FDI flow is in constant millions USD.	UNCTAD (FDI Database)
$Inward\ FDI_{jit}$	[FDI flow – minimum FDI flow + 1], where FDI flow is bilateral inward FDI into country *i* from country *j* measured in millions USD, current year	OECD (2013)
$Exports_{it}$	Country *i* exports, thousands, constant 2005 USD	Feenstra et al. (2005)
$GDPpercapita_{it}$	Country *i* GDP per capita, constant 1996 USD	Heston et al. (2002)
$Population_{it}$	Total country population, thousands	Heston et al. (2002)

Table 2 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
$Index_{ijt}$	11125	21.24	12.09	1	83
$Ln(Index_{ijt})$	11125	2.86	0.696	0	4.42
$TransferSOx_{ji}$	11125	0.01	0.033	0	0.527
$TransferNOx_{ji}$	11125	0.01	0.037	0	0.582
$Ln(SOx_{it})$	10420	5.80	1.563	-0.916	8.58
$Ln(NOx_{it})$	10438	5.81	1.243	2.186	8.047
$Distance_{ij}$	11125	1.68	0.972	0.060	6.91
$Ln(FDI_{it})$	11125	8.33	0.882	0	11.41
$Ln(inward\ FDI_{jit})$	3651	8.50	0.190	0	10.76
$Ln(Exports_{it})$	10766	24.31	1.592	18.90	27.40
$Ln(GDP\ per\ capita_{it})$	11125	9.34	0.572	7.36	10.23
$Ln(Population_{it})$	11125	9.34	1.317	5.43	11.91
$Freedom_{it}$	11125	10.20	2.498	2	12
SOx_{it}	10420	838.48	1033	0.4	5321
NOx_{it}	10438	652.06	738	8.9	3123
FDI_{it}	11125	6525.63	9892	1	90069
$Inward\ FDI_{jit}$	3651	4975.50	1192	1	47259
$Exports_{it}$	10766	9.28E+10	1.31E+11	1.61E+08	7.95E+11
$GDP\ per\ capita_{it}$	11125	13213	6536	1.57E+03	27623
$Population_{it}$	11125	23548	28425	228	148689

Chapter 5: Results

5.1 Introduction

Table 3 and Table 4 show results for estimating treaty participation using the SO_X and NO_X pollution transfer coefficients and country level emissions, respectively. I present results for pooled OLS, year fixed effects, and country pair fixed effects. The preferred specification is presented in column 3 with country pair fixed effects and is discussed in section 5.2 of this chapter. In the country pair fixed effects specification, we are able to examine how joint treaty participation for each country pair differs from average treaty participation for that unique country pair across the sample time period. Because the OLS and year fixed effects models do not control for time-invariant country pair characteristics, the coefficients may be biased in these models. As such, the country pair fixed effects model is the preferred specification.

The results presented in Tables 3 and 4 are for model specifications that include total inward FDI into country *i.* The empirical strategy adopted is consistent with literature on environmental treaty participation, where joint treaty participation is estimated as a function of cross-border air pollution, FDI, trade, and other country characteristics. The results presented in section 5.2 are consistent with findings of previous literature, and suggest that cross-border air pollution between two countries does increase cooperation between those countries even after controlling for country pair fixed effects. In particular, these results suggest that countries that receive more cross-border pollution from another country (than they themselves send there) are more likely to jointly ratify environmental treaties with that country. Conversely, the results suggest that

counties that send more cross-border pollution to another country (than they themselves receive) are less likely to enter into environmental treaties with that other country.

Additional model specifications are discussed in section 5.3. Table 5 and Table 6 show results using bilateral inward FDI flow into country *i* from country *j*. Preferred specifications are in columns 3 and 4, which compare results using bilateral FDI and total inward FDI. Much of the statistical significance found under the preferred model specification is lost when bilateral FDI is included instead of total inward FDI. This is likely due to the substantial decrease in sample size between the different model specifications, which can be attributed to the low number of observations available for the bilateral FDI variables.[15]

Table 3 SO_X transfer coefficient and emissions, total inward FDI

VARIABLES	(1) OLS	(2) Year FE	(3) Year & Country pair FE
$TransferSOx_{ji}$	0.006	-0.072	0.096*
	(0.193)	(0.192)	(0.057)
$Ln(SOx_{it})$	0.013**	0.020***	-0.009***
	(0.007)	(0.007)	(0.002)
$Distance_{ij}$	-0.262***	-0.268***	
	(0.009)	(0.009)	
$Ln(FDI_{it})$	0.045***	0.026***	-0.006**
	(0.008)	(0.009)	(0.003)
$Ln(Exports_{it})$	-0.169***	-0.209***	-0.012*
	(0.013)	(0.018)	(0.007)
$Ln(GDP\ per\ capita_{it})$	0.639***	0.729***	-0.013

[15] As shown in Tables 3 and 4, there are 10,124 and 10,142 observations for the preferred model specification that includes total inward FDI into country *i,* while there are 3,569 and 3,590 observations for the model specifications that include the bilateral FDI variables, as shown in Tables 5 and 6.

	(0.029)	(0.041)	(0.014)
Ln(Population$_{it}$)	0.188***	0.224***	0.018***
	(0.014)	(0.017)	(0.006)
Freedom$_{it}$	0.061***	0.061***	0.014***
	(0.004)	(0.004)	(0.001)
Constant	-1.416***	-1.454***	1.494***
	(0.133)	(0.136)	(0.057)
Observations	10,124	10,124	10,124
R-squared	0.350	0.369	0.954

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 NO_X transfer coefficient and emissions, total inward FDI

VARIABLES	(1) OLS	(2) Year FE	(3) Year & Country pair FE
TransferNOx$_{ji}$	-0.078	-0.252	0.131**
	(0.177)	(0.179)	(0.054)
Ln(NOx$_{it}$)	0.208***	0.278***	-0.020***
	(0.015)	(0.017)	(0.006)
Distance$_{ij}$	-0.266***	-0.269***	
	(0.008)	(0.009)	
Ln(FDI$_{it}$)	0.057***	0.021**	-0.006*
	(0.008)	(0.009)	(0.003)
Ln(Exports$_{it}$)	-0.177***	-0.132***	-0.013**
	(0.013)	(0.019)	(0.007)
Ln(GDP per capita$_{it}$)	0.554***	0.401***	0.006
	(0.028)	(0.044)	(0.015)
Ln(Population$_{it}$)	0.017	-0.068***	0.029***
	(0.017)	(0.025)	(0.009)
Freedom$_{it}$	0.049***	0.054***	0.014***
	(0.004)	(0.004)	(0.002)
Constant	0.093	0.886***	1.331***
	(0.159)	(0.188)	(0.076)
Observations	10,142	10,142	10,142
R-squared	0.360	0.384	0.954

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.2 Baseline Results

Focusing on results in column 3 of Tables 3 and 4 with country pair fixed effects, the coefficients explain changes in the log of joint treaty participation over the sample period 1980-1999. Based on these results, I find that countries that receive more cross-border pollution from another country (than they themselves send there) are more likely to jointly ratify environmental treaties with that country. In the pooled OLS and year fixed effects specifications, FDI has the expected positive effect on treaty participation. After controlling for country pair fixed effects, however, increasing FDI decreases joint treaty participation. While this is an economically small effect, it is statistically significant. Increasing exports has a small negative effect on joint treaty participation, though it is double the effect of FDI. This suggests that over the sample period 1980-1999 countries that opened up to international trade and investments at a more rapid rate cooperated less in the environmental arena. This could partly be explained by the fall of socialism and creation of new countries in Eastern Europe. These new economies have been focused on opening up to trade and investment and may on average be neglecting catching up in environmental treaty ratification.

Below, I discuss the specific effects of each explanatory variable on treaty participation. The results for all other independent variables are similar whether SO_X or NO_X transfer coefficients are included in the pooled OLS, year fixed effects, and country pair fixed effects models. Focusing on the country pair fixed effects model in column 3, there are statistically significant relationships between joint treaty participation and the pollution transfer coefficient, country level emissions, FDI, exports, population, and political freedom.

Pollution Transfer Coefficient

This study's main variable of interest for determining joint environmental treaty participation is the cross-border air pollution transfer coefficient. For the country pair fixed effects model, I find that an increase in cross-border air pollution increases joint treaty participation between countries. Over the sample period 1980-1999 countries that receive more cross-border pollution from another country (than they themselves send there) jointly ratify more environmental treaties with that country. When cross-border pollution of SO_X into country *i* from country *j* increases by 3.3 percent of country *j*'s emissions (the standard deviation), joint treaty participation by country *i* with country *j* increases by 0.32 percent (0.033*9.6%). A similar effect is found for the NO_X transfer coefficient. When cross-border NO_X pollution into country *i* from country *j* increases by one standard deviation of country *j*'s emissions (3.7 percent), joint treaty participation by country *i* with country *j* increases by .48 percent (0.037*13.1%). These results are consistent with the theory of emissions tax competition described by Davies and Naughton (2014) in Chapter 3, and support the hypothesis that countries that receive more cross-border pollution from another country (than they themselves send there) are more likely to ratify environmental treaties with that country.

Distance

$Distance_{ij}$ is not included in the country pair fixed effects model, as it is symmetric and constant for country pairs across time. However, it is important to note that the results of the pooled OLS and year fixed effects models support the hypothesis that distance between countries is negatively associated with treaty participation. As

distance between *i-j* country pairs increased by 1000 kilometers, joint treaty participation between these countries decreases by 26.6 percent and 29.6 percent for pooled OLS and year fixed effects models, respectively. In these model specifications, perhaps $Distance_{ij}$ also captures cross-border pollution effects since the transfer coefficients are statistically insignificant for both the SO_X and NO_X regressions.

Country Level Emissions

Similar results are found regarding the effect of country level emissions on joint treaty participation when either SO_X or NO_X variables are included. This is true for each model specifications in Tables 3 and 4. For the country pair fixed effects specification, an increase in country *i*'s SO_X emissions led to a small decreases in joint treaty participation for the *i-j* country pair. As SO_X emissions increased by 1 percent, participation decreases by .009 percent on average, holding all else constant. Similarly, a 1 percent increase in NO_X emissions led to a .02 percent decrease in treaty participation. In the pooled OLS and year fixed effects model, increasing country *i*'s SO_X emissions increased joint treaty participation by .013 and .020 percent, respectively. Similarly, a 1 percent increase in NO_X emissions increases participation by .208 percent and .278 percent in the pooled OLS and year fixed effects models. Although this effect is economically small, this finding matches that of Egger et al. (2011), who found that countries with higher emissions participate in fewer environmental treaties.

International Commerce: FDI and Trade

Results concerning the relationship between international commerce and environmental cooperation provide mixed support for theories and previous empirical findings about treaty participation. The results of the pooled OLS and year fixed effects models show that FDI is positively associated with joint treaty participation. In pooled OLS, increasing FDI by 1 percent increases joint treaty participation by .045 and .057 percent for SO_X and NO_X regressions, respectively. With year fixed effects, a 1 percent increase in FDI increased joint treaty participation by .026 and .021 percent when SO_X and NO_X variables are used. Although these effects are economically small, these findings suggest that FDI can foster environmental cooperation between countries. These results match those of Rose and Spiegel (2009) who found that country pairs raise bilateral capital flows (i.e. investment) when participating in a bilateral environmental agreement. These results are also similar to those of Egger et al. (2011) who found that wealthier countries with a stronger leaning toward investment liberalization are more likely than other countries to participate in IEAs. Likewise, Davies and Naughton (2014) found that FDI has either a positive effect on treaty participation or is insignificant, which partially supports the results of the pooled OLS and year fixed effects models in this study. However, the results of the country pair fixed effects model paint a different picture. In this model, an increase in total inward FDI into country *i* led to a small but statistically significant decrease in joint treaty participation by the *i-j* country pair. When FDI increased by one percent, joint treaty participation decreases by .006 percent on

average across the sample time period.[16] This effect is the same when either SO_X or NO_X variables are included in the model, and is a departure from the findings of previous empirical work mentioned above.

For all model specifications shown in Tables 3 and 4, exports are negatively associated with joint treaty participation. These results differ from the findings of Davies and Naughton (2014), Egger et al. (2011), and Rose and Spiegel (2009) who all found that increasing trade leads to higher environmental treaty participation. When the SO_X variables are included in the country pair fixed effects model, a 1 percent increase in country *i*'s exports decreases treaty participation by .012 percent for the *i-j* country pair. When NO_X variables are included, joint treaty participation decreases by .013 percent on average when exports rose by 1 percent. These results are at odds with much of the theoretical and empirical literature regarding the relationship between trade and environmental treaty participation, which suggest that countries that interact via economic exchange are influenced to cooperate in other ways, including in the environmental realm.

Additional Explanatory Variables: GDP per capita, population, political freedom

Although GDP per capita is not statistically significant in the country pair fixed effects model, the results of the pooled OLS and year fixed effects specifications match the expectation that increasing GDP per capita will increase joint treaty participation.

[16] The unexpected negative sign on total inward FDI flow may be caused by pooling rich and poor countries in the dataset. Although the empirical model controls for per capita GDP, which is one indicator of a country's wealth, future research should consider additional variables to account for wealth and income of countries in the dataset.

Increasing population also led to higher treaty participation in the country pair fixed effects model, though this effect is economically small. A 1 percent increase in population increases joint treaty participation by .018 percent when SO_X variables are used, and increases participation by .029 percent when NO_X variables are included. Together, GDP and population control for the size of a country's economy and per capita income. These results match previous findings that large economies are more likely to participate in international treaties. Similarly, increasing a country's level of political freedom also increases joint treaty participation by country pairs for each model specification shown in Tables 3 and 4. When either the SO_X or NO_X variables are included in the country pair fixed effects model, a 1 point improvement in the total political freedom index led to a 1.4 percent increase in joint treaty participation for the *i*-*j* country pair, holding all else constant. This small but statistically significant effect supports the idea that if citizens prefer strong environmental standards, political freedom should increase environmental treaty participation by countries.

5.3 Additional Results

This section presents results for additional model specifications that use alterative measures of FDI. The preferred specifications are found in columns 3 and 4, which show results using bilateral inward FDI into country *i* from country *j* and total inward FDI flow into country *i,* respectively. These results illustrate that many of the statistically significant variables found in previous model specifications are lost when bilateral FDI is included instead of total inward FDI. The drop in statistical significance may be due to the large decrease in sample size when bilateral FDI variables are used in place of total

FDI inflow. As shown in Tables 3 and 4, there are 10,124 and 10,142 observations for the preferred model specification that includes total inward FDI into country *i,* while there are 3,569 and 3,590 observations for the model specifications that include the bilateral FDI variables.

Table 5 SO_X variables, bilateral inward FDI versus total inward FDI

VARIABLES	(1) OLS	(2) Year FE	(3) Year & Country pair FE	(4) Year & Country pair FE
TransferSOx$_{ji}$	1.148***	1.133***	-0.031	-0.005
	(0.260)	(0.263)	(0.087)	(0.088)
Ln(SOx$_{it}$)	-0.063***	-0.053***	-0.015***	-0.013***
	(0.012)	(0.012)	(0.004)	(0.004)
Distance$_{ij}$	-0.156***	-0.159***		
	(0.019)	(0.019)		
Ln(inward FDI$_{jit}$)	0.218	0.210	-0.015	
	(0.151)	(0.146)	(0.012)	
Ln(FDI$_{it}$)				0.009***
				(0.003)
Ln(Exports$_{it}$)	-0.247***	-0.232***	0.008	0.011
	(0.024)	(0.027)	(0.009)	(0.009)
Ln(GDP per capita$_{it}$)	0.680***	0.639***	-0.039*	-0.044**
	(0.043)	(0.056)	(0.020)	(0.020)
Ln(Population$_{it}$)	0.252***	0.230***	0.008	-0.000
	(0.025)	(0.029)	(0.009)	(0.009)
Freedom$_{it}$	0.031***	0.030***	0.004*	0.002
	(0.007)	(0.007)	(0.002)	(0.003)
Constant	-1.091	-0.844	1.880***	1.739***
	(1.253)	(1.222)	(0.143)	(0.096)
Observations	3,569	3,569	3,569	3,569
R-squared	0.195	0.205	0.953	0.953

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6 NO_X variables, bilateral inward FDI versus total inward FDI

VARIABLES	(1) OLS	(2) Year FE	(3) Year & Country pair FE	(4) Year & Country pair FE
TransferNOx$_{ji}$	1.483***	1.460***	0.073	0.100
	(0.278)	(0.280)	(0.087)	(0.087)
Ln(NOx$_{it}$)	-0.019	0.057**	-0.056***	-0.057***
	(0.024)	(0.029)	(0.008)	(0.008)
Distance$_{ij}$	-0.150***	-0.151***		
	(0.019)	(0.019)		
Ln(inward FDI$_{jit}$)	0.216	0.206	-0.014	
	(0.150)	(0.144)	(0.011)	
Ln(FDI$_{it}$)				0.010***
				(0.003)
Ln(Exports$_{it}$)	-0.203***	-0.149***	-0.004	-0.003
	(0.024)	(0.030)	(0.009)	(0.009)
Ln(GDP per capita$_{it}$)	0.692***	0.520***	0.025	0.022
	(0.046)	(0.070)	(0.022)	(0.022)
Ln(Population$_{it}$)	0.168***	0.058	0.051***	0.046***
	(0.032)	(0.042)	(0.012)	(0.012)
Freedom$_{it}$	0.018***	0.018***	0.005*	0.002
	(0.007)	(0.007)	(0.002)	(0.003)
Constant	-1.616	-0.696	1.394***	1.272***
	(1.245)	(1.229)	(0.153)	(0.113)
Observations	3,590	3,590	3,590	3,590
R-squared	0.191	0.204	0.953	0.954

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 6: Conclusion

6.1 Discussion

Globalization and international commerce can have important implications for the environment and climate change at large, which countries seek to address, in part, through international environmental agreements. This paper has discussed some of the broader reasoning for countries to participate in IEAs from an environmental perspective, as well as economic literature on IEA effectiveness and participation. While there are strong environmental arguments in favor of IEAs, the theoretical and empirical literature suggest that IEAs are largely ineffective at reducing countries' emissions below business-as-usual levels. This raises questions about the incentives for countries to participate in IEAs. The economic literature offers theoretical and empirical evidence regarding the roles of international commerce—specifically trade and FDI—and cross-border air pollution in influencing IEA participation.

The empirical work presented in this paper provides partial support for economic theories and empirical work on IEA participation. On the one hand, this study has found evidence that cross-border air pollution between country pairs affects those countries' joint participation in IEAs after controlling for country pair fixed effects, or that distance captures these effects in the pooled OLS and year fixed effects regressions. Specifically, the results of the country pair fixed effects model specification suggest that countries that receive more cross-border pollution from another country (than they themselves send there) are more likely to jointly ratify environmental treaties with that country.

Overall, these results support the finding of Davies and Naughton (2014) that proximate countries are more likely to jointly participate in environmental treaties. On the other hand, little evidence was found to support the idea that increasing international commerce—specifically FDI and trade—leads to higher joint environmental treaty participation between countries. In fact, this study found that increasing trade and investments led to less treaty participation, although these effects were economically small.

There are various possible explanations for this. First, the lack of convincing evidence that international commerce improves environmental cooperation raises questions about greenwashing and treaty effectiveness; that is, is participation by countries in environmental treaties more about image or substance? Do countries enter into environmental agreements in order to be perceived as environmentally friendly—without actually meeting the specific terms of the treaties—or are legitimate strides being made to achieve treaty goals? If treaties aren't effective, what is the point of participating? Is it to receive the benefits of trade and investment that may come with the perception of being an environmentally friendly nation? As discussed in the literature review, research by Rose and Spiegel (2009) and Egger et al. (2011) suggests that membership in IEAs has surged because joining an IEA acts as a signaling effect for other forms of cooperation, particularly with respect to economic exchange, implying that countries are more willing to voluntarily submit to environmental regulations if

participation will influence other outcomes such as membership in trade, investment, or political agreements.[17]

Second, it is important to note that the trade and investment landscape has changed significantly since 1999, the last year analyzed by this study. The expansion of the European Union and other trade blocs following the dissolution of the Soviet Union, as well as unprecedented growth of FDI across the globe, have significantly altered the nature of international trade and investment. For example, FDI flows grew from $82 billion in 1982 to $2.3 trillion in 2007 prior to the global financial crisis. In 2008 global FDI flows were approximately $1.8 trillion (Clapp and Dauvergne 2011). Additionally, European and international environmental treaty participation, as well as membership in trade agreements, have greatly expanded since 1999. Given these changes, there are substantial opportunities for further research regarding the relationship between international commerce and the environment.

6.2 Future Research

Future research in this area would benefit greatly from more recent data on FDI, trade, and cross-border pollution. Additionally, the bilateral FDI data used for the empirical analyses in this study greatly limited the sample size, so the inclusion of bilateral data with more observations would be a significant improvement. Using bilateral FDI data would give researchers a better idea of the nature of cooperation

[17] This raises questions about endogeneity regarding the relationship between trade, investment, and treaty participation. That is, does the signaling effect work both ways? Can trade and investment policies influence treaty participation, or do participation in treaties affect trade and investment outcomes? More consideration should be given to this issue in future research.

between countries with respect to both international commerce and environmental treaties. It would also be interesting to examine treaty participation worldwide as a function of trade and FDI instead of limiting the study region to Europe. However, the focus of this study was to examine the effect of cross-border air pollution on treaty participation, and pollution transfer coefficient data were only available for the 35 European countries used in this study.

Although further research is needed to improve our understanding of the incentives for countries to participate in IEAs, this study's broad goal has been to provide insights regarding the motivations for IEA participation, specifically with respect to cross-border air pollution and international commerce. This was done through a review of prior theoretical and empirical work as well as additional empirical analyses from which future empirical work on IEA participation can build. In the next chapter, I offer additional comments on the relationship between international commerce and the environment within the context of globalization and climate change, as well as make suggestions for what could be done—beyond participation in environmental agreements—to address climate change and other social, economic, and environmental issues in this context.

Chapter 7: Afterword:

Globalization, Justice, and the Environment

This section explores the relationship between globalization and the environment, with specific attention given to the roles of international commerce and neoliberal economic globalization in shaping issues of social, economic, and environmental justice.

7.1 The Opportunity of Globalization

Most things we do in everyday life are affected by globalization. The food we eat, the clothes we wear, and the computer I'm writing this on. The fact that we experience globalization every day, for better or worse, warrants our intense examination of this phenomenon. Globalization improves and harms the lives of many, often simultaneously, and there is much debate about its social, economic, and environmental implications. In their book *Paths to a Green World,* authors Jennifer Clapp and Peter Dauvergne (2011, 20) define globalization as:

> a multidimensional process, broadly restructuring and integrating the world's economies, institutions, and civil societies. It is a dynamic, ongoing, and accelerating process that is increasing the links among actors, as well as the structures within which they operate, both within states and across borders.

Globalization itself has many meanings to many people, and there is much more to it than a single definition. Different definitions and perspectives on globalization exist because people experience the world in vastly different ways. For example, middle class Americans are largely isolated from those who may experience globalization in a

negative light. As such, there is often disagreement about what globalization is, who it benefits, and who it might harm. This makes addressing issues of social, economic, and environmental justice a complicated endeavor. That said, I'd like to propose a way of thinking about globalization to keep in mind as we move forward.

Globalization is an opportunity. It is an opportunity to improve access to health care around the world, spread democracy, and advocate for universal human rights. It is an opportunity to travel, learn new languages, and meet new people. It is an opportunity to improve social and economic livelihoods while striving for environmental sustainability. But globalization is also an opportunity to fail to do so. What, if any, are the consequences if we continue down the current path of globalization?

In *In Search of the Good Life,* author Rebecca Todd Peters (2004) develops a moral lens through which we can analyze globalization's current trajectory. Her work breaks through much of the noise surrounding globalization to make a clear, simple, and profound argument that humanity has a moral obligation—and perhaps more importantly moral agency or capacity—to change the nature of globalization and the ways in which it unfolds.[18] Peters argues that humans are fundamentally moral creatures, and that globalization must be grounded in values that prioritize a democratized understanding of power, encourage care for the planet, and enhance the social well being of people.

[18] Rebecca Todd Peters (2004) argues that: "moral agency is at the heart of ethical practice. Inherent in human nature is the capacity to make rational decisions about our behavior and actions in accordance with particular norms about what is right and wrong" (Todd Peters 2004: 23). She views moral agency as humanity's capacity to make such decisions and take action on issues of social, economic, and environmental justice.

7.2 Globalization, International Commerce, and the Environment

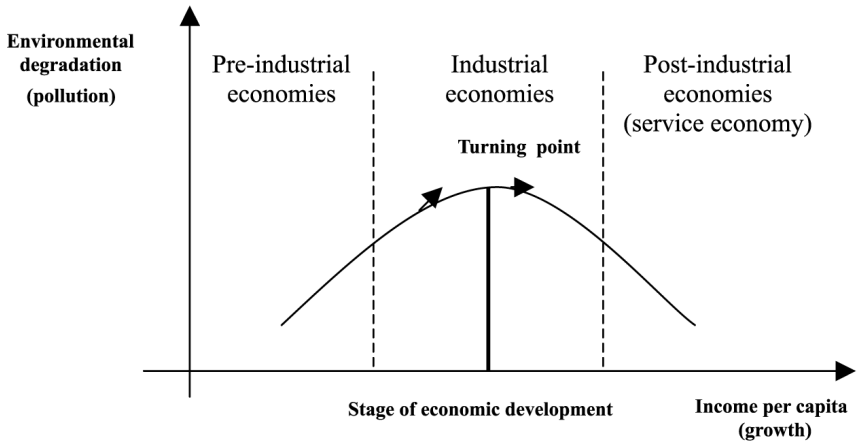
Peters characterizes neoliberalism as the dominant model of globalization unfolding in our world today. She argues that neoliberal globalization concentrates power among transnational corporations, corporate business leaders, and institutions such as the Organization for Economic Co-operation and Development (OECD), the International Chamber of Commerce, and the World Trade Organization (WTO). Grounded in neoclassical economics, neoliberalism stresses the role of individuals and private enterprise as drivers of economic growth. As neoliberal economic policies gained sway, particularly in the United States and England during the Reagan and Thatcher administrations, the increasing influence of transnational corporations corresponded with a decrease in the role of government. Neoliberal globalization is characterized by an integrated global economy centered around export-oriented trade, which neoliberals argue is best facilitated though low-barrier markets (i.e. deregulation) and a highly competitive private sector.[19]

Transnational corporations are driven by sales and profit. To consistently achieve higher sales and profits requires economic growth, which neoliberals argue is the bedrock of a healthy global economy. They argue that national economies, both rich and poor, benefit from a strong (and growing) global economy, which in turn leads citizens to demand cleaner environments. When TNCs and national economies are successful,

[19] The neoliberal model of globalization promotes competition in international commerce—specifically regarding trade and FDI (i.e. capital mobility)—which can have implications for the environment as discussed in Chapters 2 and 3 of this paper.

more funds are available to invest in cleaner technologies and better environmental management. As people get richer they desire cleaner environments, which they have the ability to achieve through their newfound wealth. This is the premise of the Environmental Kuznets Curve (EKC) hypothesis, which has been used to justify economic growth often at the expense of the environment. The EKC hypothesis predicts that environmental damage will increase until a given level of per capita income, or 'development,' and then begins to fall as income continues to rise, as shown in Figure 2 below (Kuznets, 1955).

Figure 2 Environmental Kuznets Curve



Source: Panayotou (1993)

Empirical evidence of the EKC is mixed, with some studies showing the EKC only holds for certain pollutants or in already developed countries such as those in the OECD (see Harbaugh et al. 2002; Stern 2004; Stern and Common 2001). Moreover, economists Antweiler, Copeland, and Taylor (2001) found that trade and economic growth can help or harm the environment depending on specific country conditions that

relate to the scale and composition of economic activity, as well as technologies used in that economy. For example, a country with lax environmental standards and a comparative advantage in a dirty industry will likely grow its economy through trade, which may come at the expense of its environment. Despite this, proponents of neoliberalism continue to argue that economic growth will ultimately create a cleaner environment. They argue that the neoliberal model of globalization actually promotes environmental stewardship and offers a path to economic success for developing countries.

The neoliberal perspective views transnational corporations as "engines of sustainable development" and key players in efforts to raise social, economic, and environmental standards (Clapp and Dauvergne, 161). Neoliberals argue that government intervention through the enforcement of IEAs, for example, creates inefficient markets that hinder market forces from solving environmental problems (e.g. developing cleaner energy technologies that pollute less). Although neoliberals acknowledge that TNCs and FDI can harm the environment, they assert that market mechanisms are the most efficient and effective way to achieve better environmental management practices in the end. They advocate for voluntary self-regulation with respect to their environmental practices—a viewpoint that is drawn into question by much of the theoretical and empirical literature on environmental treaty effectiveness.[20]

Critics of the neoliberal model of globalization argue that markets alone are not enough to address environmental problems, and therefore governments should create

[20] For theoretical and empirical literature on environmental treaty effectiveness, see Barrett 1994a, 1997; Carraro and Siniscalco 1993; Egger et al. 2011; Finus and Maus 2008; and Kellenberg and Levinson 2013.

regulatory framework in which markets and firms operate. Most governments strive to integrate themselves into the global economy by introducing policies to attract trade and FDI. Generally, the underlying goal is to foster macroeconomic growth in their economy, which may come at the expense of the environment. Governments seek to reconcile economic growth with environmental concerns by setting environmental standards for corporations. One example is the European Union Emissions Trading Scheme, which is an example of an IEA in which the European Union capped emissions levels and created a marketplace for Certified Emissions Reductions (CERs), or carbon credits. These credits represent the purchaser's right to emit one ton of carbon dioxide or other greenhouse gas with a one ton CO_2 equivalent, which can then be traded on the free market. The goal of such policies is to create an attractive investment climate that offers corporations proper incentives to simultaneously protect the environment and promote sustainable economic development.[21]

Richard Peet's *Unholy Trinity* provides historical and contemporary analysis of what he refers to as the 'global governance institutions'—the International Monetary Fund, World Bank, and World Trade Organization. These institutions have played significant roles in shaping the nature of globalization from the end of World War II onward and continue to be key players on the global scene. The IMF seeks to facilitate international trade and financial security among its 188 member nations. The World Bank funds numerous development projects around the world and runs the BioCarbon Fund, which finances projects that sequester or conserve carbon in forests and agro-

[21] See Newell and Paterson (2010) for further discussion of carbon markets and climate change.

ecosystems across the globe. Although there has been much criticism of the World Bank's role in such projects (and criticism of carbon markets in general), the World Bank still has an important role to play in improving social, economic, and environmental outcomes. Similarly, the WTO plays a crucial role in regulating trade and navigating the complicated relationship that exists between trade, economic growth, and the environment. Given that the WTO consistently favors trade and economic growth over environmental concerns, many have advocated for the creation of a World Environmental Organization to counterbalance the WTO.

Critics of the neoliberal model of globalization also argue that the long history of labor and environmental transgressions by transnational corporations should leave us highly skeptical of corporate motives, particularly regarding rhetoric on sustainability and sustainable development. They see this as greenwashing, which is more about the perception of 'going green' than legitimate consideration for the environment (Newell and Paterson 2010). This is evidenced by double standards of TNCs with respect to industrial flight and pollution havens, as well as continued labor and environmental abuses in industries such as mining, logging, oil extraction, and electronics (see Clapp and Dauvergne, 172).

In *Globalization and The Environment: Capitalism, Ecology, & Power,* Peter Newell makes an intriguing point that "unsustainable development is profitable" (Newell, 112). This idea is propagated by the neoliberal model of globalization, which arguably favors profit over equitable economic development, social justice, and environmental sustainability. Although many TNCs are making strides to improve labor

and environmental practices, Newell argues that corporate irresponsibility continues to be the norm in many parts of the world. This necessitates a more prominent role for government and civil society to guide the future path of globalization. Perhaps enforceable international environmental agreements can be a part of this process.

However, IEAs and other forms of government intervention do not go far enough to address environmental concerns. Neoliberals make a persuasive argument that governments can create inefficiencies and hinder market activity, which can ultimately lead to more environmental harm than good. Yet their argument that market forces alone will solve environmental problems does not hold water. Greenwashing by corporations is all too common and often overshadows legitimate efforts to address environmental concerns. Greenwashing can be combated in part by watchdog efforts by governments, NGOs, and social movements. In *Making Globalization Work,* former chief economist at the World Bank and Nobel Prize winning economist Joseph Stiglitz (2006) argues that the unprecedented levels of economic growth and wealth created by neoliberal globalization should be utilized to make the case for social, economic, and environmental justice. Moreover, he argues that democratic governments have learned to "temper the excesses of capitalism: to channel the power of the market, to ensure that there are more winners and fewer losers" (Stiglitz, 2006, 276). While this approach has worked relatively well in the Global North, we have largely failed to democratize power in the rest of the world. This has resulted in great economic inequality, environmental harm, and the disempowerment of many people in the Global South—particularly indigenous groups, women, and the poor. Actions in the Global North often

disproportionately affect these groups, whether by way of larger and more frequent environmental disasters such as tropical storms, floods, or droughts, or through the creation of pollution havens (Clapp and Dauvergne 2011).

7.3 Globalization and Climate Change: What's Next?

So, what should be done in response to economic globalization and climate change? Recall that globalization is an opportunity. It is an opportunity to build a world around principles of social, economic, and environmental justice as well as an opportunity to fail at this. First, we must work to empower those who are marginalized by the dominant neoliberal model of globalization. This can be achieved in part by democratizing power. The empirical findings of this study support the theory that countries with stronger political and civil institutions participate in more environmental treaties. As such, democratizing power is an important step to addressing environmental problems, which are often closely related to social and economic issues. Recognizing that humans have a moral obligation and capacity to change how globalization affects such groups is key to democratizing power. While democratizing power in the Global South must be a priority, we must also strengthen our democracies in the Global North. By democratizing power we give voice to those who are most vulnerable to the forces of climate change and economic globalization, be they in the Global North or South.

Second, we must rethink our concept of economic growth as good for development. Joshua Farley and Herman Daly are prominent ecological economists who

advocate for 'degrowth,' which views GDP as a measure of costs instead of benefits (Farley and Daly 2004). Bill McKibben, the founder of 350.org, makes a similar case in his book *Deep Economy: the Wealth of Communities and the Durable Future,* as do authors Peter Newell and Matthew Paterson in *Climate Capitalism: Global Warming and the Transformation of the Global Economy* (McKibben 2007; Newell and Paterson 2010). Newell and Paterson (2010) argue that until we recognize that there are ecological limits to growth, climate capitalism will become just another form of greenwashing. Farley, Daly, and McKibben argue that degrowth may cause hardship, but it is necessary to create an ecologically sustainable form of globalization.[22]

Finally, we must take a hard look at consumption habits and what we truly mean by sustainability. Capitalism often overlooks the social and environmental components of sustainability in favor of economic growth. To actually practice sustainability, we must address complacency and apathy in our everyday lives with respect to consumption habits.[23] For example, fossil fuel dependence drives anthropogenic climate change, and therefore it is imperative that we pursue sustainable and economically viable alternative energy sources. Demand for alternative energy increases as the economic and environmental costs of fossil fuel rise. With this, we see focused efforts to increase efficiency for all types of energy, as well as a shift toward clean and renewable energy sources such as hydropower, geothermal, wind, solar, and combustible renewables such as biofuels (Ladanai & Vinterback, 2009). These three things—empowering

[22] Farley, Daly, and McKibben also argue that we can experience an intense sense of fulfillment and well being by working cooperatively to overcome such hardships.

[23] For example, should I drive to work or walk half a block to the bus stop? Should I keep my house at a balmy 70 degrees in the middle of winter? These are only two examples, but meaningful actions to mitigate climate change and economic globalization must address such everyday consumption habits.

marginalized voices, rethinking economic growth, and reevaluating our mindset regarding sustainability and consumption, particularly with respect to energy use—must happen if we are to alter the path of globalization to reflect values of social, economic, and environmental justice.

Climate change and globalization are unique phenomena, and failing to act on them will result in consequences yet to be seen. This makes our challenges and opportunities to address them unique. Changing climates can have negative effects on various people across the globe, many of whom are marginalized within the current global economic system. Thus it becomes a question of justice and morality regarding the path of globalization we choose to take. Should this path be guided by moral values that prioritize a democratized understanding of power, encourage care for the planet, and enhance the social well being of people? I mentioned earlier that globalization provides an opportunity to travel, learn new languages, and meet new people. Combining my own experiences abroad with my academic experiences has helped me put a human face on globalization. If we can humanize globalization, it becomes easier to make a moral, economic, and ecological case for addressing issues of social, economic, and environmental justice, which I think are closely related to climate change. In doing so we can improve social and economic livelihoods while striving for environmental sustainability. To me this is the ultimate goal of globalization, and we must strive to bring together governments, the private sector, and civil society to engage in constructive actions to realize this opportunity.

APPENDIX A

Table A1 lists international environmental agreements that have been evaluated by empirical studies. Tables A2 and A3 outline empirical studies that employ multiple regression and trend analyses, respectively.

Table A1 International Environmental Agreements Evaluated by Empirical Studies

Agreement	Limits	Studies[ii]
1985 Helsinki Protocol	Sulfur emissions	7
1988 Sofia Protocol	NO_X emissions	4
1994 Oslo Protocol	Sulfur emissions	2
1995 Ban Amendment to the 1992 Basel Convention	Prohibits hazardous waste movement to non-party, non-OECD countries.	1
1972 Oslo Convention	Marine pollution dumping by ships and aircraft	1
1988 Polar Bear Management Agreement for the Southern Beaufort Sea	Different parameters of polar bear hunting	1
1998 Naryn/Syr Darya Basin Agreement	Water releases at Toktogul reservoir	1
1999 Gothenberg Protocol	Sulfur, NOx, VOCs and ammonia emissions	1
1999 North Sea as a MARPOL[i] Special Area and 2000 EU directive on Port Reception Facilities	Pollution by ships	1

Source: Houghton and Naughton (2014)
Notes:
[i] MARPOL – International convention for the Prevention of Pollution from Ships.
[ii] Some studies evaluate more than one IEA.

Table A2 IEA Effectiveness Studies Employing Multiple Regression Analysis

Author (year)	Agreement(s)	Empirical approach	Environmental variable *Y*	Sample	Findings
Murdoch et al. (1997)	1985 Helsinki, 1988 Sofia Protocol	Spatial lag model (ML)	Voluntary reductions in SO_2 and NO_X emissions	25 European countries, one time period 1980 to 1990	Helsinki protocol helped lower SO_2 emissions but the Sofia protocol did not affect NO_X emissions.
Murdoch et al. (2003)	1985 Helsinki Protocol	Joint spatial probit and spatial lag equations (FIML)	SO_2 emissions reduction	25 European countries, one time period 1980 to 1990	Voluntary cutbacks beyond the target motivate free riding.
Maddison (2006)	1985 Helsinki, 1988 Sofia Protocol	OLS & Spatial mixed model (ML)	Change in log of per capita SO_2 and NO_X emissions	135 countries, one time period 1990 to 1995	Helsinki and Sofia Protocols decreased per capita emissions for treaty signatories.
Naughton (2010)	1985 Helsinki, 1994 Oslo, 1988 Sofia Protocols	Spatial lag using 2SLS, year and country fixed effects	Log of per capita SO_2 and NO_X emissions	16 European countries, 1980-2000	No effect of Helsinki or Oslo Protocols on SO_2 emissions, but Sofia protocol reduced NO_X emissions level and trend on average.
Bratberg et al. (2005)	1988 Sofia Protocol	Difference-in-difference	First differences of log of NO_X emissions	23 European countries, 1980-1996	Sofia Protocol increased annual emission reductions by 2.1%.

Author (year)	Agreement(s)	Empirical approach	Environmental variable *Y*	Sample	Findings
Aakvik & Tjøtta (2010)	1985 Helsinki, 1994 Oslo Protocols	Difference-in-difference	First differences (annual changes) in log of sulfur emissions	30 European countries, 1960-2002	Neither protocol had a statistically significant effect on emissions once country-specific trends (linear or quadratic are included).
Ringquist & Kostadinova (2005)	1985 Helsinki Protocol	OLS, fixed effects, random trend	Percentage change in SO_2 emissions since 1980	19 European countries, 1980-1994	Helsinki protocol has made no difference in nations success at reducing SO_2 emissions.

Table A2 continued. IEA Effectiveness Studies Employing Multiple Regression Analysis
Source: Houghton and Naughton (2014)

Table A3 IEA Effectiveness Studies Employing Trend Analyses

Author (Year)	Agreement	Sample	Environmental variable *Y*	Findings
Skjaerseth (1992)	1972 Oslo Convention	Aggregated change in waste, some interval between 1976 & 1986	Waste dumped and waste incinerated at sea	Not perfect convention goal achievement but fairly successful.
Brower et al. (2002)	1988 Polar Bear Management Agreement for the Southern Beaufort Sea	Canadian and Alaskan portions of the southern Beaufort Sea, 1980-1998	Yearly polar bear harvest by sex and age group	Successful agreement—sustainable limits of total harvest and the harvest of females.
Bernauer & Siegfried (2008)	1998 Naryn/Syr Darya Basin Agreement	Toktogul reservoir (shared by Kazakhstan, Kyrgyzstan & Uzbekistan), 1980-2006	Monthly water release from Toktogul reservoir relative to 1998 targets	Higher compliance for some seasons than for others.
Kelly et al. (2010)	1999 Gothenberg Protocol	6 European countries, 1990-2010	Setting national emissions ceilings for NO_X, SO_2, VOC, NH_3	Major downward shifts in emissions forecasts were projected to lead to these six countries meeting the majority of the Protocol targets.
Largring et al. (2012)	1999 North Sea as a MARPOL Special Area and 2000 EU directive on Port Reception Facilities	North Sea for three periods: 1992-1998, 2000-2003, 2007-2010	Total number of oil slicks, total polluted surface & total polluted volume	Evidence that each of these IEAs improved water pollution in the North Sea.

Source: Houghton and Naughton (2014)

APPENDIX B

Table B1 summarizes the types of environmental treaties used for the empirical analyses in this study, and includes average participation by individual countries. Table B2 details the 110 treaties including scope, type, and membership level for 1980, 1990, and 1999.

Table B1 Types of treaties with average participation in 1980, 1990 and 1999

Type of Treaty	Number of Treaties	Average Participation in 1980	Average Participation in 1990	Average Participation in 1999
Marine	27	7.8	12.4	16.6
Nature	24	6.7	12.5	18.5
Fish	17	2.8	4.4	7.1
Nuclear	12	7.8	13.9	24.3
Air	11	0	3.9	28.7
Hazardous Materials	7	0	0	6.7
Freshwater	6	0.7	2.2	4.2
Military	3	22.7	31.7	56.3
Lead	1	32	35	41
Energy	1	4	5	8
Transboundary	1	0	0	22
Total	110			
Regional	66	3.2	5.5	8.7
Global	34	7.1	13.4	30.5
Global-Marine	10	17	24.9	31.8
Total	110			

Table B2 Treaty list including number of ratifying countries in years 1980, 1990 and 1999

Num	Scope	Type	Treaty Year	Treaty	Ratifying Countries 1980	1990	1999
1	Regional	Nature	1985	ASEAN Agreement On The Conservation Of Nature And Natural Resources	0	3	3
2	Regional	Nature	1968	African Convention On The Conservation Of Nature And Natural Resources	18	20	21
3	Regional	Nuclear	1996	African Nuclear Weapon Free Zone Treaty	0	0	11
4	Regional	Marine	1969	Agreement For Cooperation In Dealing With Pollution Of The North Sea By Oil	6	6	6
5	Regional	Fish	1949	Agreement For The Establishment Of A General Fisheries Commission For The Mediterranean	11	13	17
6	Global	Energy	1974	Agreement On An International Energy Programme	4	5	8
7	Regional	Nature	1973	Agreement On Conservation Of Polar Bears	4	4	5
8	Regional	Nature	1991	Agreement On The Conservation Of Bats In Europe	0	0	8
9	Regional	Nature	1990	Agreement On The Conservation Of Seals In The Wadden Sea	0	0	3
10	Regional	Fish	1929	Agreement Regarding The Regulation Of Plaice (Pleuronectes Platessa) And Flounder (Pleuronectes Flesus) Fishing In The Baltic Sea	3	4	4
11	Regional	Marine	1954	Agreement Relating To The Issue Of Permits For The Exploitation Of The Maritime Resources Of The South Pacific	3	3	3
12	Global	Hazardous Materials	1995	Amendment To The Convention On The Control Of Transboundary Movements Of Hazardous Wastes And Their Disposal	0	0	12
13	Global	Air	1990	Amendment To The Montreal Protocol On Substances That Deplete The Ozone Layer	0	2	100
14	Global	Air	1992	Amendment To The Montreal Protocol On Substances That Deplete The Ozone Layer	0	0	78
15	Global	Air	1997	Amendment To The Montreal Protocol On Substances That Deplete The Ozone Layer	0	0	28
16	Global-Marine	Marine	1978	Amendments To Annexes To The Convention On The Prevention Of Marine Pollution By Dumping Of Wastes And Other Matter Concerning Incineration At Sea	31	45	52
17	Regional	Fish	1976	Amendments To The Agreement For The Establishment Of A General Fisheries Commission For The Mediterranean	10	12	14
18	Regional	Marine	1980	Amendments To The Convention On The Protection Of The Marine Environment Of The Baltic Sea Area (Paragraph B Of Regulation 4 In Annex IV)	4	4	4
19	Regional	Marine	1995	Amendments To The Protocol For The Prevention And Elimination Of Pollution Of The Mediterranean Sea By Dumping From Ships And Aircraft	0	0	5
20	Regional	Nature	1953	Constitution Of The European Commission For The Control Of Foot And Mouth Disease	15	16	17
21	Regional	Marine	1937	Convention Between Denmark, Norway And Sweden Concerning The Preservation Of Plaice And Dab In The Skagerrak, Kattegat And Sound	3	3	3
22	Regional	Fish	1958	Convention Concerning Fishing In The Waters Of The Danube	1	1	4

Table B2 continued. Treaty list including number of ratifying countries in years 1980, 1990 and 1999

Num	Scope	Type	Treaty Year	Treaty	Ratifying Countries 1980	1990	1999
23	Global	Lead	1921	Convention Concerning The Use Of White Lead In Painting	32	35	41
24	Regional	Fish	1972	Convention For The Conservation Of Antarctic Seals	9	12	15
25	Regional	Fish	1982	Convention For The Conservation Of Salmon In The North Atlantic Ocean	0	7	8
26	Regional	Fish	1993	Convention For The Conservation Of Southern Bluefin Tuna	0	0	3
27	Regional	Marine	1989	Convention For The Prohibition Of Fishing With Long Driftnets In The South Pacific	0	0	5
28	Regional	Marine	1976	Convention For The Protection Of The Mediterranean Sea Against Pollution	8	12	15
29	Regional	Nature	1986	Convention For The Protection Of The Natural Resources And Environment Of The South Pacific Region	0	5	6
30	Regional	Freshwater	1976	Convention For The Protection Of The Rhine Against Chemical Pollution	2	4	4
31	Global	Nuclear	1986	Convention On Early Notification Of A Nuclear Accident	0	26	45
32	Global	Transboundary	1991	Convention On Environmental Impact Assessment In A Transboundary Context	0	0	22
33	Regional	Fish	1991	Convention On Fisheries Cooperation Among African States Bordering The Atlantic Ocean	0	0	7
34	Regional	Fish	1973	Convention On Fishing And Conservation Of The Living Resources In The Baltic Sea And Belts	4	5	9
35	Regional	Fish	1980	Convention On Future Multilateral Cooperation In Northeast Atlantic Fisheries	0	5	7
36	Regional	Fish	1978	Convention On Future Multilateral Cooperation In The Northwest Atlantic Fisheries	7	9	18
37	Global	Nature	1973	Convention On International Trade In Endangered Species Of Wild Fauna And Flora	49	82	98
38	Global	Nuclear	1994	Convention On Nuclear Safety	0	0	26
39	Global	Nuclear	1997	Convention On Supplementary Compensation For Nuclear Damage	0	0	2
40	Regional	Marine	1980	Convention On The Conservation Of Antarctic Marine Living Resources	0	24	27
41	Regional	Nature	1979	Convention On The Conservation Of European Wildlife And Natural Habitats	1	17	29
42	Global	Nature	1979	Convention On The Conservation Of Migratory Species Of Wild Animals	0	28	49
43	Regional	Nature	1969	Convention On The Conservation Of The Living Resources Of The Southeast Atlantic	9	12	13
44	Global-Marine	Marine	1967	Convention On The International Hydrographic Organization	41	46	43
45	Global-Marine	Marine	1962	Convention On The Liability Of Operators Of Nuclear Ships	3	6	5
46	Regional	Marine	1952	Convention On The Organization Of The Permanent Commission Of The Conference On The Exploitation And Conservation Of The Maritime Resources Of The South Pacific	4	4	4
47	Global	Nuclear	1980	Convention On The Physical Protection Of Nuclear Material	1	21	49

Table B2 continued. Treaty list including number of ratifying countries in years 1980, 1990 and 1999

Num	Scope	Type	Treaty Year	Treaty	Ratifying Countries 1980	1990	1999
48	Global	Hazardous Materials	1998	Convention On The Prior Informed Consent Procedure For Certain Hazardous Chemicals And Pesticides In International Trade	0	0	2
49	Global	Military	1977	Convention On The Prohibition Of Military Or Any Other Hostile Use Of Environmental Modification Techniques	9	15	16
50	Global	Military	1972	Convention On The Prohibition Of The Development, Production And Stockpiling Of Bacteriological (Biological) And Toxin Weapons, And On Their Destruction	59	80	97
51	Global	Military	1993	Convention On The Prohibition Of The Development, Production, Stockpiling And Use Of Chemical Weapons And On Their Destruction	0	0	56
52	Regional	Marine	1992	Convention On The Protection Of The Black Sea Against Pollution	0	0	6
53	Regional	Marine	1974	Convention On The Protection Of The Marine Environment Of The Baltic Sea Area	4	4	7
54	Regional	Marine	1992	Convention On The Protection Of The Marine Environment Of The Baltic Sea Area	0	0	6
55	Regional	Freshwater	1976	Convention On The Protection Of The Rhine Against Pollution By Chlorides	1	4	4
56	Global	Hazardous Materials	1992	Convention On The Transboundary Effects Of Industrial Accidents	0	0	13
57	Global	Nature	1933	Convention Relative To The Preservation Of Fauna And Flora In Their Natural State	7	6	7
58	Regional	Hazardous Materials	1995	Convention To Ban The Importation Into The Forum Island Countries Of Hazardous And Radioactive Wastes And To Control The Transboundary Movement And Management Of Hazardous Wastes Within The South Pacific Region	0	0	3
59	Regional	Fish	1983	Eastern Pacific Ocean Tuna Fishing Agreement	0	4	4
60	Regional	Freshwater	1996	European Agreement On Main Inland Waterways Of International Importance	0	0	8
61	Regional	Freshwater	1968	European Agreement On The Restriction Of The Use Of Certain Detergents In Washing And Cleaning Products	1	1	1
62	Regional	Nature	1968	European Convention For The Protection Of Animals During International Transport	14	17	19
63	Regional	Nature	1979	European Convention For The Protection Of Animals For Slaughter	0	9	13
64	Regional	Nature	1987	European Convention For The Protection Of Pet Animals	0	2	10
65	Global-Marine	Marine	1973	International Convention For The Prevention Of Pollution From Ships	7	13	20
66	Global-Marine	Marine	1954	International Convention For The Prevention Of Pollution Of The Sea By Oil	41	50	52
67	Global	Nature	1950	International Convention For The Protection Of Birds	3	4	4
68	Regional	Nature	1946	International Convention For The Regulation Of Whaling	22	38	44

Table B2 continued. Treaty list including number of ratifying countries in years 1980, 1990 and 1999

Num	Scope	Type	Treaty Year	Treaty	Ratifying Countries 1980	1990	1999
69	Global-Marine	Marine	1969	International Convention On Civil Liability For Oil Pollution Damage	33	51	67
70	Global-Marine	Marine	1971	International Convention On The Establishment Of An International Fund For Compensation For Oil Pollution Damage	14	29	45
71	Global	Hazardous Materials	1997	Joint Convention On The Safety Of Spent Fuel Management And On The Safety Of Radioactive Waste Management	0	0	13
72	Global	Air	1987	Montreal Protocol On Substances That Deplete The Ozone Layer	0	18	20
73	Regional	Nature	1956	Plant Protection Agreement For The Southeast Asia And Pacific Region	13	15	16
74	Regional	Freshwater	1991	Protocol Additional To The Convention For The Protection Of The Rhine From Pollution By Chlorides	0	0	4
75	Regional	Nature	1977	Protocol Amending The Benelux Convention On The Hunting And Protection Of Birds	1	1	1
76	Global-Marine	Marine	1983	Protocol Amending The Convention For The Prevention Of Marine Pollution By Dumping From Ships And Aircraft	0	9	9
77	Regional	Freshwater	1983	Protocol Amending The European Agreement On The Restriction Of The Use Of Certain Detergents In Washing And Cleaning Products	0	4	4
78	Regional	Fish	1952	Protocol Amending The International Convention For The High Seas Fisheries Of The North Pacific Ocean	0	0	1
79	Regional	Nature	1985	Protocol Concerning Protected Areas And Wild Fauna And Flora In The Eastern African Region	0	2	3
80	Regional	Nature	1995	Protocol Concerning Specially Protected Areas And Biological Diversity In The Mediterranean	0	0	6
81	Global	Nature	1990	Protocol Concerning Specially Protected Areas And Wildlife	0	0	2
82	Global	Air	1991	Protocol Concerning The Control Of Emissions Of Volatile Organic Compounds Or Their Transboundary Fluxes To The Convention On Long-Range Transboundary Air Pollution	0	0	15
83	Global	Air	1988	Protocol Concerning The Control Of Nitrogen Oxides Or Their Transboundary Fluxes To The Convention On Long-Range Transboundary Air Pollution	0	11	23
84	Regional	Marine	1989	Protocol For The Conservation And Management Of The Protected Marine And Coastal Areas Of The Southeast Pacific	0	0	2
85	Regional	Marine	1976	Protocol For The Prevention And Elimination Of Pollution Of The Mediterranean Sea By Dumping From Ships And Aircraft	8	12	15
86	Regional	Marine	1986	Protocol For The Prevention Of Pollution Of The South Pacific Region By Dumping	0	4	5
87	Regional	Marine	1980	Protocol For The Protection Of The Mediterranean Sea Against Pollution From Land-Based Sources	0	10	15

Table B2 continued. Treaty list including number of ratifying countries in years 1980, 1990 and 1999

Num	Scope	Type	Treaty Year	Treaty	Ratifying Countries 1980	1990	1999
88	Regional	Marine	1994	Protocol For The Protection Of The Mediterranean Sea Against Pollution Resulting From Exploration And Exploitation Of The Continental Shelf And The Seabed And Its Subsoil	0	0	2
89	Regional	Hazardous Materials	1989	Protocol For The Protection Of The Southeast Pacific Against Radioactive Contamination	0	0	2
90	Regional	Fish	1990	Protocol I To The Convention For The Prohibition Of Fishing With Long Driftnets In The South Pacific	0	0	1
91	Regional	Fish	1990	Protocol II To The Convention For The Prohibition Of Fishing With Long Driftnets In The South Pacific	0	0	2
92	Regional	Nuclear	1986	Protocol III To The South Pacific Nuclear Free Zone Treaty	0	1	3
93	Regional	Nature	1991	Protocol On Environmental Protection To The Antarctic Treaty	0	0	27
94	Global	Air	1994	Protocol On Further Reduction Of Sculpture Emissions To The Convention On Long-Range Transboundary Air Pollution	0	0	19
95	Global	Air	1998	Protocol On Heavy Metals To The Convention On Long-Range Transboundary Air Pollution	0	0	2
96	Global	Air	1998	Protocol On Persistent Organic Pollutants To The Convention On Long-Range Transboundary Air Pollution	0	0	2
97	Regional	Fish	1996	Protocol On The Conservation Rational Utilization And Management Of Norwegian Spring Spawning Herring (Atlanto-Scandian Herring) In The Northeast Atlantic	0	0	3
98	Regional	Hazardous Materials	1996	Protocol On The Prevention Of Pollution Of The Mediterranean Sea By Transboundary Movements Of Hazardous Wastes And Their Disposal	0	0	2
99	Global	Air	1985	Protocol On The Reduction Of Sulfur Emissions Or Their Transboundary Fluxes By At Least 30 Per Cent To The Convention On Long-Range Transboundary Air Pollution	0	12	18
100	Global-Marine	Marine	1992	Protocol To Amend The International Convention On Civil Liability For Oil Pollution Damage	0	0	13
101	Global-Marine	Marine	1992	Protocol To Amend The International Convention On The Establishment Of An International Fund For Compensation For Oil Pollution Damage	0	0	12
102	Global	Nuclear	1997	Protocol To Amend The Vienna Convention On Civil Liability For Nuclear Damage	0	0	2
103	Regional	Fish	1959	Protocol To The Agreement Concerning Measures For Protection Of The Stocks Of Deep-Sea Prawns (Pandalus Borealis), European Lobsters (Homarus Vulgaris), Norway Lobsters (Nephrops Norveaicus) And Crabs (Cancer Paqurus)	3	3	3
104	Global	Air	1997	Protocol To The United Nations Framework Convention On Climate Change	0	0	11
105	Regional	Nuclear	1985	South Pacific Nuclear Free Zone Treaty	0	4	4

Table B2 continued. Treaty list including number of ratifying countries in years 1980, 1990 and 1999

Num	Scope	Type	Treaty Year	Treaty	Ratifying Countries 1980	1990	1999
106	Global	Nuclear	1963	Treaty Banning Nuclear Weapon Tests In The Atmosphere, In Outer Space And Under Water	2	2	2
107	Regional	Nuclear	1967	Treaty For The Prohibition Of Nuclear Weapons In Latin America	22	23	27
108	Global	Nature	1977	Treaty On The International Recognition Of The Deposit Of Microorganisms For The Purposes Of Patent Procedure	5	18	39
109	Global	Nuclear	1968	Treaty On The Non-Proliferation Of Nuclear Weapons	69	90	117
110	Regional	Nuclear	1995	Treaty On The Southeast Asia Nuclear Weapon Free Zone	0	0	4

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