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Trade and investment liberalization as determinants of multilateral environmental agreement membership

Peter Egger · Christoph Jeßberger · Mario Larch

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Abstract Environmental agreements represent voluntary coalitions which mostly regulate emissions and the exhaustion of natural resources. The analysis of why and under which conditions countries (or policy makers) may be inclined toward ratifying such agreements or not has been the focus of a body of theoretical work at the interface of environmental economics and the economics of coalition games. Traditional theoretical work predicted that environmental agreements are hard to sustain due to the lacking enforceability of associated contracts and the incentive to free-ride. This hypothesis is at odds with the enormous surge of such agreements in reality over the last few decades. Recent work by Rose and Spiegel (J. Money, Credit Bank. 41:337–363, 2009) suggests that environmental agreements will be signed and are stable, because they work as a signal and help economies to get access to export (and possibly other) credits. Hence, the reason for a ratification of such agreements is their interdependence with other policies, especially ones that are related to international business. This paper sheds light on the determinants of multilateral environmental agreement (MEA) participation. In particular, we pay attention to the role of a country's international openness by means of chosen trade and investment policies for such participation. The results support the view that wealthier countries with a strong inclination towards trade and investment liberalization are more in favor of commit-

P. Egger (✉)
KOF, ETH Zurich, CEPR, WIFO, CESifo, and GEP, Weinbergstr. 35, 8092 Zurich, Switzerland
e-mail: egger@kof.ethz.ch

C. Jeßberger
Ifo Institute for Economic Research and CESifo, Poschingerstr. 5, 81679 Munich, Germany
e-mail: jessberger@ifo.de

M. Larch
Faculty of Law and Economics, Chair of Empirical Economics, University of Bayreuth, Universitätsstraße 30, RW-Building, Room 1.74, 5447 Bayreuth, Germany
e-mail: mario.larch@uni-bayreuth.de

ting themselves voluntarily to environmental standards, pollution reduction, and other means of environmental protection through MEA memberships than other countries, all else equal.

Keywords Environmental economics · Environmental agreements · Multilateral agreements · Dynamic panel data · Count data

JEL Classification C23 · C25 · Q50 · Q56 · F18

1 Introduction

> . . . environmentalist non-governmental organizations view free trade pure with suspicion. (Frank Trentman, Free Trade Nation, Oxford University Press, 2008, p. 23)

Freeness of trade and multinational investment are often seen as major obstacles to the protection of natural resources and the avoidance or reduction of emissions.[1] Yet, parallel to the spread of bilateral and multilateral trade and investment agreements, we observed an enormous surge of memberships in *bilateral* and—more importantly—in *multilateral* environmental agreements (MEAs) over the last four decades.[2] The first MEA of our sample—the Agreement Concerning Co-operation in the Quarantine of Plants and Their Protection Against Pests and Diseases—has been ratified in 1960, it covered 8 countries and dealt with plant protection. Until 2006, another 353 MEAs have been enacted. By that year, the median country among the 186 most important economies was involved in no less than 51 MEAs. An obvious question to ask is whether the large number of environmental agreements has been ratified *in spite* or rather *because* of the almost ubiquitous liberalization of trade and investment.

From the perspective of traditional theoretical work on environmental coalitions (see Chander and Tulkens 1992; Finus and Rundshagen 1998a, 1998b; Finus et al. 2006; Hoel 1992; Hoel and Schneider 1997; Carraro et al. 2006; Murdoch and Sandler 1997; Naghavi 2005; Lange and Vogt 2003; Lise and Tol 2004; Barrett and

[1] For instance, Greenpeace (2003a, p. 1) argues that "*The free trade agenda is increasing the production and consumption of natural resources at a rapid rate. This is adding to the destruction of ancient forests, leading to overfishing, as well as creating more and more pollution. WTO rules are also being used to undermine global environmental agreements, principles and standards*". Moreover, Greenpeace (2003b, p. 1) notes that "*Trade rules can undermine environmental rules, laws and regulations. [. . .] Because of this, countries are less likely to take action under certain global environmental agreements.*" Finally, they state that "*Free trade is accelerating the use of natural resources such as water, forests, fisheries, and minerals, much faster than they can be regenerated.*" While these remarks mostly pertain to the consequences of membership in the World Trade Organization (WTO)—and, hence, multilateral trade liberalization—environmental activists have similar reservations vis-à-vis the formation of preferential trade agreements (see Hanyona 2000; Hochstetler 2002, 2003).

[2] MEAs may be grouped into five categories relating to the target of environmental protection: biodiversity; atmosphere; land; chemicals and hazardous wastes; and regional seas and related agreements. Their objectives and priorities vary significantly not only across these groups but even within them.

Stavins 2003; Barrett 1994, 2001; Buchholz et al. 2005) the surge in MEA memberships is puzzling. Such membership is voluntary and there is no supranational institution to enforce commitments expressed in the associated contracts. Hence, when interpreting environmental agreements as ones that are ratified in isolation of other means of economic policy, there is little reason for countries to adopt costly measures required to fulfill their voluntary contracts. However, environmental agreements are only one dimension of a large array of economic policies, among them other agreements regarding trade, investment, health, etc. With a manifold of international agreements, it may be optimal for a country to voluntarily commit itself to costly environmental protection if it can influence economic outcomes (e.g., through other agreements) which are only indirectly or not at all related to environmental issues. In that vein, Rose and Spiegel (2009) argue and illustrate that participation in *bilateral* environmental agreements provides a signal which leads to easier access to capital assets from partners in such agreements.

It is this paper's task to shed light on the determinants of a country's MEA memberships empirically. In particular, we investigate how trade liberalization, e.g., through membership in preferential trade agreements, or investment liberalization affect MEA membership. Clearly, membership in MEAs is mainly reflective of environmental protection. Are trade and investment liberalization stepping stones or stumbling blocks to MEA membership and, in turn, to environmental protection? We collect data on the universe of MEAs ratified between 1960 and 2006 to assess this question. Our results suggest that international economic coalitions about trade *and* cross-border direct investment stimulate MEA memberships. This provides broad support for the arguments of Rose and Spiegel (2009): An increasing dependence of countries upon each other through the process of globalization stimulates or raises the pressure to agree upon eventually costly environmental protection.

The remainder of this paper is organized as follows. The subsequent section provides a review of previous research on the ratification of environmental agreements. Section 3 explores key features of the data on MEA membership in a large panel of countries and years. In particular, this section will illustrate that such memberships are highly persistent so that dynamic methods should be applied in empirical work. Different impacts provoking countries to ratify MEAs are discussed in Sect. 4, and Sect. 5 briefly introduces the econometric methods applied to estimate the regression parameters of interest. Section 6 presents and discusses the findings and quantifies the impact of trade and investment liberalization on MEA memberships. The last section concludes with a summary of the most important results.

2 Previous work on environmental agreement membership

For convenience, let us structure the discussion of the state of the debate about environmental agreement membership along the lines of theoretical and empirical work.

2.1 Economic theory of environmental agreements

Economic theory emphasizes the public good character of a clean environment. One reason why environmental agreements are hard to reach is the prisoners' dilemma associated with the public good character of the environment. As an example, Weikard et al. (2006) analyze the stability of coalitions for greenhouse gas abatement under different sharing rules applied to the gains from cooperation. Due to the prisoners' dilemma, only coalitions with a few members turn out to be stable under different sharing rules. Among many other theoretical works (see Sect. 1), this demonstrates the difficulty to ratify MEAs.

Other papers emphasize the role of communications and negotiations in order to overcome the prisoners' dilemma associated with the signature or ratification of MEAs (see Carraro 1998; Bloch and Gomes 2006; Caparrós et al. 2004; Carraro et al. 2005).[3]

In contrast to the above work, Breton et al. (2008) focus on the dynamics of international environmental agreement memberships in a dynamic game of emissions. Their model of the evolution and stability of such agreements can lead to different steady states of full cooperation or partial cooperation, which are stable over time, and also to situations without feasible or stable agreements. The outcome depends on the number of initially cooperating countries, the level of pollution, and the way and extent to which defectors may be punished.

Rose and Spiegel (2009) study the consequences of the interaction between economic and non-economic relations for environmental agreement membership. An increase in the number of environmental agreements has a positive impact on cross-holding assets. A larger number of such agreements represents a non-economic commitment to joint interests which is a credible signal for a country's discount rate. In turn, this facilitates economic exchange in general and stimulates the cross-holding of assets in specific.

2.2 Empirical analysis of environmental agreements

Previous empirical work on the formation of environmental coalitions and agreements either focused on single multilateral agreements or on a subset of the existing bilateral or multilateral agreements. Others focus on a small subset of countries or regions (see Beron et al. 2003; Murdoch et al. 2003; Davies and Naughton 2006; Rose and Spiegel 2009; Frankel and Rose 2002; Altamirano-Cabrera and Finus 2006; Tobey 1990; van Beers and van den Bergh 1997, 2000; Sugiyama and Sinton 2005; Swanson and Mason 2002).

For instance, Beron et al. (2003) develop a correlated probit model to study the probability to ratify the Montreal Protocol for the 89 largest countries of the world economy. They distinguish above all between "*power*" and "*spillover*" determinants of these countries. Power is reflected in the influence a country has on the net benefit of ratifying the Montreal Protocol similar to positive network correlations. "*Spillovers*" allow to internalize partly the detrimental effect of an emission of

[3] These theoretical models form the basis of some climate change simulation models—such as the CLIMNEG World Simulation Model (CWS) (see Eyckmans and Tulkens 2003), the Stability of Coalitions Model (STACO) (see Finus et al. 2006), or the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) (see Swanson and Mason 2002; Tol 1997, 2001). These models suggest that the detection of environmental depletion through climate change, the corresponding influences on the economy, and the value of cooperation facilitate the ratification of environmental agreements.

ozone-depleting substances on other countries than the emitting one. The higher the contemporary emissions of a country the higher its relative cutback of emissions will be and the more important its role in emission-reducing agreements should be. Accordingly, "*spillovers*" generate correlations in the decisions through trade with other countries. However, Beron et al. (2003) did not find evidence of a role for "*power*", contrary to the hypotheses. But they admit that further research would be needed to explore this matter.

Murdoch et al. (2003) focus on the ratification of the Helsinki Protocol (which regulates sulfur emissions in Europe) in 1990. They derive hypotheses about environmental treaty participation in a two-stage game. In a first stage, countries decide whether to participate in an agreement at all or not. In a second stage, they determine the level of participation or the extent of concessions made, i.e., emissions reduced. Empirically, they employ a spatial probit model to estimate the probability of participation in the Helsinki Protocol for 25 European countries to estimate the first-stage part of their theoretical model. Their results suggest that a higher level of a country's pollution and the marginal costs of emission reductions exert a significant positive impact on the probability of participation. Other variables do not display a significant impact in the spatial binary choice model.

In a working paper, Davies and Naughton (2006) analyze the role of cross border pollution as an incentive to cooperate with neighboring countries in multilateral environmental agreements. In particular, they hypothesize that the probability of an environmental agreement in place declines with geographical distance between two countries. They estimate the role of determinants of membership based on 41 countries, 37 international environmental agreements, and the period 1980–1999. Using a spatial model for normally distributed, unlimited independent variables, and cross-sectional data, they find evidence of increased cooperation among proximate countries. Moreover, an increase in inward FDI or OECD membership raise the probability of participation in one of the 37 agreements.

Rose and Spiegel (2009) study the economic benefits of non-economic partnerships such as environmental agreements. Using a sample of 221 country-pairs and the period 2001–2003, they provide empirical evidence of the increased cross-holdings of assets at the country-pair level if an environmental agreement is in place. Hence, countries may raise bilateral capital flows when participating in environmental agreements. Their evidence suggests that this is true for both bilateral and multilateral environmental agreement participation.

3 Data on MEA participation

Before turning to regression analysis, it is advisable to study features of the data on MEA participation which will represent the dependent variable of our empirical models. The basis of our MEA data forms the Socioeconomic Data and Applications Center's (SEDAC) database on environmental agreements which is maintained by the Center for International Earth Science Information Network (CIESIN 2006). Among all existing MEAs, we focus on ones dealing with anyone of the five core issues: biodiversity, atmosphere, land, chemicals and hazardous wastes, and regional

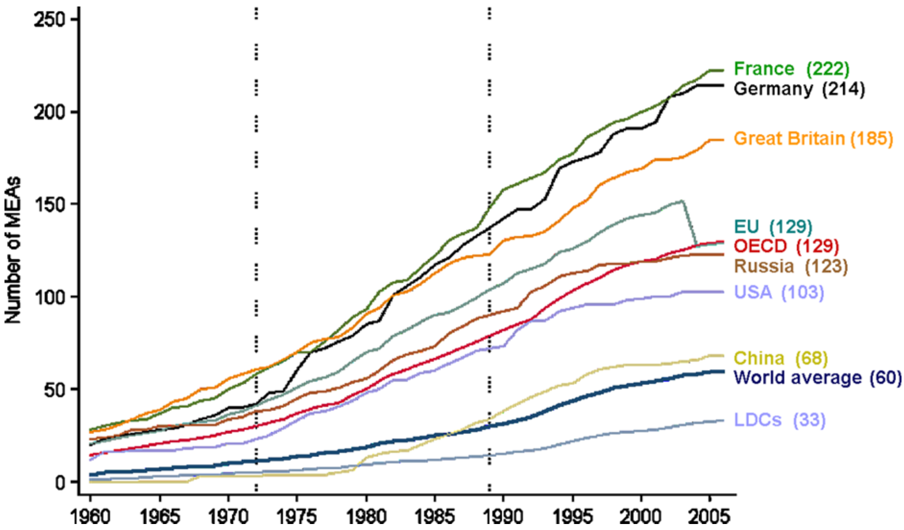

Fig. 1 Time course of the number of MEAs between 1960 and 2006

seas and related agreements. Hence, we abstract from other agreements which regulate economic, social, cultural, space, or noise issues. It turns out that SEDAC's database is not complete and contains some errors. Therefore, we augmented and updated the information by using data from Mitchell (2003, 2007).[4] This augmented data set covers the universe of MEAs addressing the considered issues. Altogether, 353 such agreements have been ratified among subsets of the 186 countries between 1960 and 2006. The dependent variable we focus on varies across countries and years. It is a count of the number of agreements a country is a member of in a year within the considered time span. Since this variable is strictly non-negative, methods for unlimited dependent variables are unlikely appropriate for empirical analysis.

After 1972, the year of the Stockholm Conference, the number of MEAs has risen tremendously. Among others, because of the ratification of the Montreal Protocol, the number of MEA memberships has also increased after 1989. Figure 1 illustrates that MEA participation is not only but mainly a phenomenon in the developed part of the world. Please notice that the number of MEAs of the European Union (EU) declines in 2004.[5] The reason for this has to do with the Eastern Enlargement of the European Union which will be discussed later by means of Figs. 2 and 3.

[4]We gratefully acknowledge provision of the data by Ron Mitchell. As in the original data-set, only the entry into force of MEAs is recorded. Hence, countries do not leave MEAs.

[5]In Fig. 1, we show the number of MEAs ratified by individual countries as well as country aggregates. Among the latter are the European Union (EU), the Organization of Economic Cooperation and Development (OECD), the least developed countries (LDCs), and the world as a whole. Aggregates are represented by the respective countries' average number of MEAs in each year. As definitions of these aggregates can change over time, the corresponding number of MEAs can form a—to some extent—unsteady but persistent trend. For instance, within our data, the EU started with 6 members in 1969, enlarged to 10 members in 1983, and finally contains 25 members in 2006. LDCs are defined in accordance with the classifica-

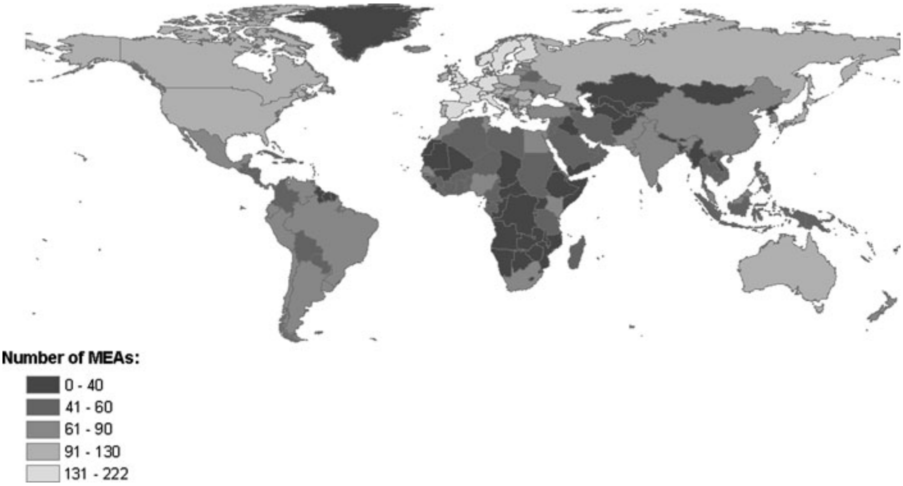

Fig. 2 Number of MEAs in 2006—The World

Beyond the evolvement of MEA membership over time, we provide further details on the geographical spread of MEAs with the help of maps. In particular, we display MEA membership—according to the definitions stated above—for both the world and Europe in the year 2006. The figures clearly illustrate that there is a region-specific impact influencing countries toward participation in MEAs.[6] Obviously, countries in Europe ratify a good deal more MEAs than countries in Africa or Asia (cf. Fig. 2). A closer look on Europe illustrates the discrepancies between countries in different developing stages (see Fig. 3). Particularly Western European economies are much more inclined to participate in MEAs than Central and Eastern European ones. Consequently, in 2004, the enlargement of the EU by Central and Eastern European countries, Cyprus, and Malta is responsible for the decline in the average number of MEAs of the EU.

At this point, in general, correlations between MEAs and economic, political, and environmental determinants are easily to identify. But less obviously is the extent of the "*connectedness*" of countries due to trade or investment agreements and the accordant impact on MEA participation.

4 Determinants of MEA membership

We use a set of explanatory variables to capture the most important determinants of MEA membership. In line with the aforementioned theoretical work on environmental agreements, we include and distinguish between three groups of explanatory variables: economic, political, and environmental covariates.

tion of United Nations' Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries, and Small Island Developing States (UN-OHRLLS).

[6] Please notice that there are a few white areas in the maps indicating missing countries in our data.

Fig. 3 Number of MEAs in 2006—Europe

4.1 Economic determinants

As for the *economic* determinants of MEA membership, we include real gross domestic product (GDP) as a measure of a country's economic mass from Maddison's (2003) historical time-series which is available for a large set of countries and years. To cover more recent years, we extrapolate GDP data by using indices of the growth of GDP at real US dollars from the World Bank's World Development Indicators 2008. Similarly, we gather information about population size from these two sources. The inclusion of log population together with log GDP accounts for size as well as income per capita in the empirical models. In the tables, we use acronyms LGDP and LPOP to refer to log GDP and log population, respectively.

Furthermore, we include a binary variable LDC which is unity for the least developed countries and zero otherwise. This indicator is provided by the United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries, and Small Island Developing States (UN-OHRLLS). Among the 186 countries in our data-set, 48 are LDCs according to that definition.

Finally, we include two economic determinants of primary interest to our study: a measure of a country's trade liberalization (i.e., the inverse of trade costs) and the number of bilateral investment treaties. We refer to the former as TRADE LIBERAL and to the latter as INVEST LIBERAL. TRADE LIBERAL measures the importance of bilateral and multilateral trade costs—most importantly for us, it is a measure of bilateral and multilateral trade facilitation, especially but not only, through preferential trade agreement (PTA) membership. INVEST LIBERAL is a measure of a country's investment liberalization through bilateral investment treaties (BITs). While INVEST LIBERAL simply reflects the number of BITs of a country, TRADE LIBERAL respects direct and indirect consequences of trade costs—such as PTA membership for trade—as pointed out by work in international economics (see Anderson 1979; Anderson and van Wincoop 2003). We use the logarithm of total (direct and indirect) consequences of trade frictions and trade liberalization as a measure of TRADE LIBERAL.

TRADE LIBERAL is a constructed variable from a non-linear regression model, following the approach to estimate gravity models by Anderson and van Wincoop (2003). We calculate TRADE LIBERAL annually by using the corresponding values of exporter and importer GDP and trade costs as well as PTA membership. Nominal bilateral goods exports of country i to country j in year t in US dollars, X_{ijt}, may be expressed in the following way (see Feenstra 2004, for a discussion):

$$X_{ijt} = \frac{GDP_{it}GDP_{jt}}{GDP_{Wt}} t_{ijt}^{1-\sigma} \Pi_{it}^{1-\sigma} P_{jt}^{1-\sigma}, \quad (1)$$

where $GDP_{it} \equiv \sum_j^N (X_{ijt})$, $GDP_{jt} \equiv \sum_i^N (X_{jit})$ denotes nominal GDP of countries i and j, respectively, in year t, N denotes the number of countries in the world economy, and $GDP_{Wt} \equiv \sum_i^N \sum_j^N (X_{ijt})$ is world GDP in year t. $\sigma > 1$ is the constant elasticity of substitution among products/varieties, t_{ijt} are economic trade costs (including PTA membership indicators and other variables), and Π_{it}, P_{jt} are so-called *multilateral resistance terms*—measuring country i's outward and country j's inward multilateral trade costs, respectively, in year t. For our purpose, we calculate

$$\text{TRADE LIBERAL}_{it} = \ln \sum_{\substack{j=1 \\ j \neq i}}^{N} \left(\frac{GDP_{it}GDP_{jt}}{GDP_{Wt}} t_{ijt}^{1-\sigma} \Pi_{it}^{1-\sigma} P_{jt}^{1-\sigma} \right), \quad (2)$$

which is the predicted sum of exports of country i to all countries in the world (i.e., the data-set) in year t.

Empirically, $\frac{GDP_{it}GDP_{jt}}{GDP_{Wt}}$ is observable, but $t_{ijt}^{1-\sigma} \Pi_{it}^{1-\sigma} P_{jt}^{1-\sigma}$ is not. We adopt the common assumption to model trade costs as

$$t_{ijt}^{1-\sigma} = \exp\left[\sum_k^K (\delta_k \tau_{k,ijt}) \right], \quad (3)$$

where K denotes the number of trade cost or trade facilitation variables $\tau_{k,ijt}$ included in $t_{ijt}^{1-\sigma}$, and δ_k is a parameter of the k'th variable. While $\tau_{k,ijt}$ is observed, δ_k has to be estimated. Estimates of δ_k are obtained from a gravity regression model, after including a stochastic term in (1); see Appendix A.2 for details. For convenience and in line with the literature (see Anderson and van Wincoop 2003), continuous variables in $\tau_{k,ijt}$ such as bilateral geographical distance enter in logarithmic form while indicator variables such as bilateral PTA membership enter as they are. Similar to $t_{ijt}^{1-\sigma}$, $\Pi_{it}^{1-\sigma}$, and $P_{jt}^{1-\sigma}$ are unobserved. Yet they can be solved as solutions of a non-linear system of $2N$ equations which are based upon knowledge of GDPs and estimates of $t_{ijt}^{1-\sigma}$ (see Appendix A.2 for details). We use data on nominal exports X_{ijt} in US dollars from the United Nations World Trade Database, information on PTA membership from the World Bank, and variables on other trade costs (such as geographical distance, adjacency, or common language) from a data set made publicly available by the Centre d'Études Prospectives et d'Informations Internationales (CEPII). Ultimately, with estimates of $t_{ijt}^{1-\sigma}$, $\Pi_{it}^{1-\sigma}$, and $P_{jt}^{1-\sigma}$, we can estimate TRADE LIBERAL. We can also compute counterfactual values of TRADE LIBERAL which are based on the assumption that ceteris paribus all PTAs would be abandoned world-wide.[7] The difference between the vector of TRADE LIBERAL with PTAs and the counterfactual vector of TRADE LIBERAL without PTAs is a measure of the combined bilateral and multilateral consequences of PTA membership on a country's log exports. With this difference and a parameter estimate of TRADE LIBERAL in the specification of MEA memberships at hand, we can compute the total impact of PTA membership on MEA membership (see Tables 7 to 10 in Sect. 6.2).

The impact of INVEST LIBERAL on MEA membership is straightforward. INVEST LIBERAL reflects a country's number of BITs in a given year.[8] Information on the number of BITs for each country and year is taken from the United Nations Conference of Trade and Development Treaty Database (UNCTAD 2007). Similar to MEA and PTA membership, the number of BITs varies considerably over time. If all BITs were abandoned in all years in a counterfactual situation, INVEST LIBERAL would represent a vector of zeros. Accordingly, after having estimated the parameter of INVEST LIBERAL in a specification of MEA memberships, we can compare the predicted number of MEA memberships for each country in a situation with BITs (and INVEST LIBERAL) as observed as compared to one without any BITs.

4.2 Political determinants

We have experimented with a variety of political indicators from various sources in the specification. For example, we included variables measuring the autocracy of a country, the durability of a country's political regime, and a variable measuring the political competition in the government of a country. These variables are based on the data collected in the Polity IV Project (see Marshall and Jaggers 2007). Most of them did not exhibit sufficient variation over time to be included in the empirical model and led to poor convergence properties of the GMM estimators.

Here, we only present results which involve the index of political freedom (PFI) as constructed by the Fraser Institute (see Gwartney et al. 2007) as a political determinant of MEA membership. This index ranges from 1 to 10, with higher values indicating greater political freedom. Hereby, we confirm the results of Congleton (1992) and Neumayer (2002) who found a positive systematical impact of political institutions on environmental regulations.

[7] Abandoning PTAs will not only affect $t_{ijt}^{1-\sigma}$ but also $\Pi_{it}^{1-\sigma}$ and $P_{jt}^{1-\sigma}$ and even GDP. All of that has to and will be taken into account when calculating counterfactual TRADE LIBERAL.

[8] It would be possible to allow for bilateral and multilateral effects of such treaties similar to trade costs as in TRADE LIBERAL. However, unlike with trade costs there is no closed-form solution to capture bilateral and multilateral (direct and indirect) effects of bilateral investment treaties. Also, we would not expect similar strong multilateral effects of bilateral investment treaties as of preferential trade agreements.

4.3 Environmental determinants

Finally, we include two environmental determinants of MEA membership: a country's CO_2 emissions per capita (CO2 EMISSIONS) and a country's endowment with agricultural land (in percent of its total land area; AGRLAND). Both of them are taken from the World Bank's World Development Indicators 2008. We also experimented with other variables such as total CO_2 emissions from fossil-fuels (thousand metric tons of carbon), CO_2 emissions from solid fuel consumption (metric tons of carbon), CO_2 emissions from liquid fuel consumption (metric tons of carbon), CO_2 emissions from gas fuel consumption (metric tons of carbon), CO_2 emissions from cement production (metric tons of carbon), CO_2 emissions from gas flaring (metric tons of carbon), CO_2 emissions (metric tons of carbon), CO_2 emissions from gas flaring, combustible renewables and waste (percent of total energy), combustible renewables and waste (metric tons of oil equivalent), electric power consumption (kWh or kWh per capita), energy imports (net percent of energy use), energy use (kg of oil equivalent per capita), forest area (sq. km), land area (sq. km), organic water pollutant emissions (kg per day or kg per day per worker), permanent cropland (percent of land area), surface area (sq. km), and water pollution (percent of total organic water pollutant emissions) of the chemical industry, clay and glass industry, food industry, metal industry, paper and pulp industry, textile industry, wood industry, and other industries. All of them are available to download from the World Bank's World Development Indicators. However, these environmental variables are highly collinear with the included covariates (such as CO2 EMISSIONS and AGRLAND) and they do not contribute significantly to the explanatory power of the model.[9]

Please notice that not all of the mentioned possible determinants of MEA participation are available for all of the 186 countries. After dropping those countries for which determinants are missing, we are left with 105 economies of which 17 are LDCs according to the definition of UN-OHRLLS. The subsequent regression results are based on these 105 economies (see Table 1).

5 Econometric model

The descriptive features of the data on a country's participation in MEAs over time display a strong persistence. In any given period, the number of MEAs a country participates in has a strong impact on its subsequent involvement in MEAs. Hence, apart from fundamental economic, political, or environmental determinants of MEA membership, a country's MEA history should be allowed to play a role.[10] This feature may be captured by the inclusion of a lagged dependent variable in the econometric model. We do so by following Blundell et al. (2002) to model the dynamics of the number of MEAs a country participates in as a linear feedback model (LFM). The

[9]Results are available from the authors upon request.

[10]If history matters, cross-sectional evidence on the determinants of MEA participation is difficult to interpret since the estimated responses may reflect short-run or long-run effects.

Table 1 Statistics of balanced data

Variable	Observations	Mean	Std. dev.	Min	Max
YEAR	4935	1983	13.5660	1960	2006
NUMBER OF MEAs (y_{it})	4935	35.0315	36.4441	0	222
LGDP	4935	23.6735	2.1325	17.8967	30.0656
LPOP	4935	9.3836	1.4536	6.2085	14.0895
TRADE LIBERAL	4935	1.3396	1.8038	−4.1154	5.2542
INVEST LIBERAL	4935	9.9377	18.8965	0	131
LDC	4935	0.1603	0.3669	0	1
PFI	4935	3.8524	1.9589	1	9.6
CO2 EMISSIONS	4935	3.7618	4.4578	−0.0197	27.7664
AGRLAND	4935	42.4408	21.3902	0.6278	91.7850

LFM assumes that the conditional mean of a dependent count variable is linear in the history of the process.[11]

Let y_{it} denote the number of MEAs country i, $i = 1, \dots, N$, is a member of in year t, $t = 1, \dots, T$. Further, let x_{it} represent a vector of K explanatory variables. The conditional mean in the LFM is then defined as

$$\begin{aligned} E(y_{it}|y_{it-1}, x_{it}, v_i) &= \gamma y_{it-1} + \exp\bigl(x'_{it}\beta\bigr)v_i \\ &= \gamma y_{it-1} + \mu_{it}\nu_i, \end{aligned} \tag{4}$$

where $\nu_i \equiv \exp(\eta_i)$ is a permanent scaling factor for the individual specific mean, and γ and β are parameters to be estimated. The LFM can be motivated as an entry-exit process with the probability of exit equal to $(1 - \gamma)$. Note that $\mu_{it}\nu_i$ is non-negative, so that the mean value for y_{it} is bounded below by γy_{it-1}.

To avoid simultaneity bias, every explanatory variable enters in their first lag into our regressions. By this means, we are able to cancel out the Granger feedback system between the number of MEAs and trade and investment treaties.[12] Using the lagged values of the explanatory variables relies on the plausible assumption that past values of the explanatory variables influence future development of the number of MEAs but does not affect past ones. Using this time structure, we make sure that the impact of trade and investment treaties goes in the right direction.

For estimation, we apply a quasi-differencing transformation following Wooldridge (1997). This GMM estimator can deal with potentially endogenous regressors where $E(x_{it}u_{it}) \neq 0$. Hence, as for example, TRADE LIBERAL or INVEST LIBERAL may be endogenous, we employ the following valid moment conditions:

[11] For a good overview article of GMM for panel count data models, see Windmeijer (2000, 2008) and Windmeijer and Santos Silva (1997).

[12] Rose and Spiegel (2009) show a positive impact of environmental agreements on bilateral trade flows. We use the number of MEAs as the dependent variable and trade as the explanatory one.

$E(q_{it}|y_{it-2}, x_{it-2}) = 0$, where q_{it} are the regression residuals due to the transformation (for more details, see Appendix A.1).

We apply several generalized method of moments (GMM) estimators. First, we use a one-step estimator, where the moments weighting matrix does not depend on the parameters to be estimated. In order to gain in efficiency, we also apply an efficient two-step GMM which uses the estimates from the one-step estimator for the moments weighting matrix. Additionally, we apply a continuously updated GMM estimator that directly accounts for the dependence of the moments weighting matrix on the parameters in the optimization (see Hansen et al. 1996).[13]

As demonstrated by Windmeijer (2002), the two-step GMM estimator can be severely biased downward in small samples, i.e., for small N. This small sample bias also applies to the continuously updating GMM estimator. We therefore use a finite sample correction in order to account for the small sample bias by applying block-bootstrapping.[14] Further details on the applied estimators can be found in Appendix A.1. Because results of the block-bootstrapping approach are very close to parameter estimates as well as significance levels of the one-step estimator, we primarily refer to one-step estimation results.

6 Results

This section is structured as follows. We will first summarize the parameter estimates of four different GMM estimators based on the aforementioned empirical specification of MEA participation. Then we will ask how important interconnectedness through trade and investment policy is for MEA participation in quantitative terms. Clearly, the non-linear nature of the econometric model does not allow for a straightforward answer to that question which only rests upon parameter estimates. To shed light on the matter, let us focus on the role of trade liberalization and undertake some radical experiments. First, let us abandon all PTAs concluded world-wide in all years covered in our data set. Second, let us abandon all BITs in the same way. These experiments are helpful to quantify the relative as well as the absolute role of trade and investment liberalization for MEA participation.

6.1 Parameter estimates

Our results are summarized in Tables 2, 3, 4. In every table, there are four columns. The first column refers to results based on the one-step GMM estimator, labeled “ONE-STEP”, column two reports estimates based on the efficient two-step GMM estimator, denoted by “TWO-STEP”, the third column summarizes findings based on the continuously updated GMM estimates, labeled “CUGMM”, and the last column

[13] Additionally to the efficiency, an advantage of the continuously updated estimator is that it is invariant to curvature altering transformations of the population moment conditions (see Hall 2005).

[14] For the one-step and two-step GMM estimators, we relied on the ExpEnd GAUSS routines which are made publicly available by Windmeijer (2002). An alternative possibility to account for the small sample bias was proposed by Windmeijer (2005).

Table 2 Baseline parameter estimates

	ONE-STEP	TWO-STEP	CUGMM	BOOT-STRAP
Lagged dependent variable:				
y_{it-1}	0.1797***	0.1805***	0.1796***	0.1856***
	(10.7874)	(61.3027)	(189.5914)	(8.2044)
Economic determinants:				
LGDP_{it-1}	0.5831***	0.5835***	0.5430***	0.5706***
	(8.9630)	(133.3069)	(115.8703)	(6.2472)
LPOP_{it-1}	0.0662	0.0725***	0.8542***	0.0575
	(0.9534)	(7.8487)	(48.3054)	(0.9184)
TRADE	0.3568***	0.3573***	0.4470***	0.3478***
LIBERAL_{it-1}	(6.0775)	(47.9151)	(334.3223)	(5.0946)
INVEST	0.0061***	0.0061***	0.0035***	0.0060***
LIBERAL_{it-1}	(5.3570)	(34.8477)	(68.5053)	(4.7232)
LDC_{it-1}	0.0792	0.0905	1.8611***	0.0268
	(0.2288)	(0.3333)	(6.5934)	(0.1023)

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 105 countries and 4,725 observations in all four models. The parameters are estimated over the period 1962–2006. Once and twice lagged levels of the dependent and the independent variables are used as instruments (i.e., values of 1960 and 1961 are used as instruments for 1962). The p-value of the Sargan test statistic of over-identifying restrictions is 0.1563 in the ONE-STEP model

reflects block-bootstrap results, denoted "BOOTSTRAP", which correct the small-sample bias in the estimates of the standard errors of the other estimators.

In all our specifications, the instruments turn out to be valid at conventional significance levels according to the Sargan over-identification test. We further tested for first-order and second-order serial correlation. With residuals of the quasi-differenced transformation following Wooldridge, we expect first-order but not second-order serial correlation. We confirm this pattern largely in our estimates.

The lagged dependent variable, labeled as "y_{it-1}", exhibits a positive parameter estimate which is significantly different from zero in all models. This suggests that there is indeed strong persistence in the number of MEAs joined by countries. Neglecting this persistence and sluggish adjustment in response to changes in its determinants would likely invalidate estimates based on static models of MEA membership.

An increase in economic mass, as captured by LGDP, leads to an increase in the number of MEAs ratified by a country. Holding population constant, this suggests that marginally wealthier countries are more inclined toward MEA participation than less wealthier ones. This statistically significant result occurs in all model estimations and is consistent with the Environmental Kuznets Curve which assumes an inverted U-shaped relationship between the level of GDP and environmental pollution. Smaller values of GDP are associated with less production, and hence less pollution. As GDP rises, an increase in production brings about more pollution. With even

Table 3 Parameter estimates including political determinants

	ONE-STEP	TWO-STEP	CUGMM	BOOT-STRAP
Lagged dependent variable:				
y_{it-1}	0.1725***	0.1727***	0.1347***	0.1849***
	(10.3005)	(53.6281)	(100.5466)	(6.4990)
Economic determinants:				
LGDP_{it-1}	0.5768***	0.5783***	0.4608***	0.5463***
	(8.6261)	(100.9385)	(86.6106)	(5.7752)
LPOP_{it-1}	0.0674	0.0718***	0.9579***	0.0649
	(0.9721)	(8.1776)	(46.3741)	(1.0241)
TRADE	0.3496***	0.3487***	0.3785***	0.3327***
LIBERAL_{it-1}	(5.7095)	(43.7934)	(310.7697)	(4.7985)
INVEST	0.0059***	0.0059***	0.0065***	0.0059***
LIBERAL_{it-1}	(5.3410)	(32.0974)	(88.1588)	(4.5845)
LDC_{it-1}	0.1008	0.1137	1.0589***	0.0382
	(0.2917)	(0.4210)	(3.7494)	(0.1385)
Political determinants:				
PFI_{it-1}	0.0096***	0.0095***	0.0025***	0.0239
	(8.9747)	(31.9805)	(27.9396)	(0.9910)

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 105 countries and 4,725 observations in all four models. The parameters are estimated over the period 1962–2006. Once and twice lagged levels of the dependent and the independent variables are used as instruments (i.e., values of 1960 and 1961 are used as instruments for 1962). The p-value of the Sargan test statistic of over-identifying restrictions is 0.1518 in the ONE-STEP model

higher GDP, producers may face pressure toward reducing pollution in spite of higher production volumes. Then it may be opportune to engage in multilateral agreements. Our results are supportive to this positive nexus between GDP and a country's willingness to reduce pollution, indicated by a higher count of MEAs.[15]

Results do not support an important role for log population (LPOP). Controlling for a country's economic mass in terms of LGDP a change in population size has no significant impact on the number of MEAs ratified by the average country. In contrast, political freedom affects MEA membership positively and significantly. Hence, a higher degree of political stability and democracy tends to stimulate a country's willingness to engage in international agreements such as MEAs, all else equal. In line with our expectations, a higher degree of pollution in terms of CO_2 emissions reduces a country's willingness to commit itself to less pollution through MEAs. However, the negative estimate of CO_2 EMISSIONS is not significantly different

[15]Please notice that this conclusion cannot be contradicted by the insignificant impact of LDC on MEA memberships if controlling for other determinants (cf. LDC in Tables 2 to 4).

Table 4 Parameter estimates including environmental determinants

	ONE-STEP	TWO-STEP	CUGMM	BOOT-STRAP
Lagged dependent variable:				
y_{it-1}	0.1785***	0.1768***	0.1385***	0.1904***
	(9.1892)	(44.3985)	(64.0840)	(6.1541)
Economic determinants:				
LGDP_{it-1}	0.5826***	0.5879***	0.7244***	0.5593***
	(8.2293)	(74.0002)	(100.7637)	(5.4012)
LPOP_{it-1}	0.0518	0.0581***	0.3919***	0.0460
	(0.7663)	(6.9987)	(39.4304)	(0.6796)
TRADE	0.3397***	0.2759***	0.3919***	0.3283***
LIBERAL_{it-1}	(5.7570)	(44.2835)	(58.1982)	(4.8224)
INVEST	0.0060***	0.0030***	0.0001***	0.0060***
LIBERAL_{it-1}	(5.6497)	(33.5298)	(23.0466)	(4.6575)
LDC_{it-1}	0.1099	0.1248	0.5887*	0.0471
	(0.3230)	(0.4642)	(2.1911)	(0.1780)
Political determinants:				
PFI_{it-1}	0.0092***	0.0091***	0.0080***	0.0238
	(8.6713)	(35.0827)	(116.5932)	(0.9368)
Environmental determinants:				
CO2	−0.0080	−0.0085***	−0.0306***	−0.0091
EMISSIONS_{it-1}	(−0.8530)	(−6.7420)	(−39.7536)	(−0.6205)
AGRLAND_{it-1}	−0.0026	−0.0024***	0.0037***	−0.0021
	(−0.8803)	(−5.3820)	(21.1946)	(−0.6117)

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 105 countries and 4,725 observations in all four models. The parameters are estimated over the period 1962–2006. Once and twice lagged levels of the dependent and the independent variables are used as instruments (i.e., values of 1960 and 1961 are used as instruments for 1962). The p-value of the Sargan test statistic of over-identifying restrictions is 0.1544 in the ONE-STEP model

from zero at conventional levels (cf. ONE-STEP or BOOTSTRAP results in Tables 2 to 4).

Results stated above are based on MEAs unclassified with respect to their environmental issue. To shed light on different cluster-specific relationships between trade and investment liberalization, we also ran separate regressions with different clusters of MEAs, namely the ones dealing with biodiversity, atmosphere, land, chemicals and hazardous wastes, and seas.[16] Table 5 provides descriptive details about the re-

[16]This classification is analogous to the MEA clusters of the United Nations Environment Programme (UNEP 2001).

Table 5 Statistics of balanced data for different clusters of MEAs

Variable	Obs.	Mean	Std. dev.	Min	Max
CLUSTER BIODIVERSITY	4935	3.9645	4.4206	0	27
CLUSTER ATMOSPHERE	4935	3.7929	5.4179	0	30
CLUSTER LAND	4935	2.8845	2.7611	0	21
CLUSTER CHEMICALS	4935	8.4548	8.4908	0	48
CLUSTER SEAS	4935	12.8917	15.2388	0	94

garded MEA clusters. Here, maximum numbers of MEAs suggest that countries are most likely to sign and ratify MEAs in the context of maritime issues (CLUSTER SEAS), followed by MEAs dealing with chemicals and hazardous wastes (CLUSTER CHEMICALS). Less MEAs have been ratified with respect to biodiversity, atmosphere, or land. Table 6 summarizes one-step dynamic GMM regression results akin to the ones in the first column of Table 4. For convenience, we repeat the one-step results from Table 4 in the first column of Table 6.

Basically, results in Table 6 draw a similar picture to the one obtained in Table 4. A coefficient which is significantly different from zero in the benchmark estimates in the first column always exhibits a similar sign in the cluster-specific regressions. Most of the determinants show a similar qualitative and quantitative point estimate across the different clusters. For instance, better economic (GDP) and political (PFI) circumstances move countries to ratify more MEAs. TRADE LIBERAL has a positive and highly significant effect with similar magnitude in all regressions, except for the cluster atmosphere. However, for this cluster, we had to set the lag length of the instrument for the number of MEAs strictly to two to achieve convergence. Since MEAs in this category are very persistent, the instrument explained almost all of the variation in the number of atmosphere MEAs. This becomes evident having a look at the parameter of the lagged dependent variable which is close to unity for that MEA cluster. Hence, these results have to be taken with a grain of salt. INVEST LIBERAL indicates a positive impact in all clusters. The corresponding parameter is positive, highly significant, and of similar magnitude in the regressions of the clusters biodiversity, land, and chemicals and hazardous wastes. But it does not have a significant impact on atmosphere—probably due to econometric reasons regarding the persistence of the dependent variable—and on maritime issues (cf. the last column of Table 6). Finally, if anything, a higher degree of per capita CO_2 emissions leads to a lower number of MEAs, as we can find negative and significant impacts of CO_2 EMISSIONS in the clusters land and chemicals and hazardous wastes.

Above all, our results can support the notion that a country's interconnectedness in terms of trade and investment raises its incentive to engage in MEAs, also. Both investment liberalization, captured by INVEST LIBERAL, and trade liberalization, reflected in TRADE LIBERAL, lead to an increase in the number of MEAs. While the immediate effect on MEAs due to the number of BITs is directly reflected in the parameter estimate of INVEST LIBERAL, the role of PTAs is not immediately obvious from the parameter of TRADE LIBERAL. The reason is that PTAs are related to TRADE LIBERAL in a highly non-linear way. There is a positive effect of PTA on

Table 6 Parameter estimates for different clusters of MEAs

	Number of MEAs	Bio-diversity (number of MEAs)	Atmo-sphere (number of MEAs)	Land (number of MEAs)	Chemicals (number of MEAs)	Seas (number of MEAs)
Lagged dependent variables:						
y_{it-1}	0.1785***					
$y_{it-1}^{BIODIVERSITY}$		0.0248				
$y_{it-1}^{ATMOSPHERE}$			0.9997***			
y_{it-1}^{LAND}				0.0359		
$y_{it-1}^{CHEMICALS}$					0.1088***	
y_{it-1}^{SEAS}						0.1283***
Economic determinants:						
$LGDP_{it-1}$	0.5826***	0.7783***	0.8787	0.2248***	0.7265***	0.6430***
$LPOP_{it-1}$	0.0518	0.0196	−0.0478	0.2399**	0.0070	0.0773
TRADE $LIBERAL_{it-1}$	0.3397***	0.5522***	0.6090	0.2265**	0.5300***	0.4185***
INVEST $LIBERAL_{it-1}$	0.0060***	0.0061***	0.0034	0.0035***	0.0022***	0.0006
LDC_{it-1}	0.1099	0.7622**	−0.1381	−0.1566	−0.1816	0.0781
Political determinants:						
PFI_{it-1}	0.0092***	0.0245***	0.0343	0.0023	0.0060**	0.0023
Environmental determinants:						
CO_2 $EMISSIONS_{it-1}$	−0.0080	−0.0153	0.1078	−0.0087**	−0.0180*	0.0019
$AGRLAND_{it-1}$	−0.0026	0.0016	−0.0063	0.0031	0.0012	0.0002

Notes: *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 105 countries and 4,725 observations in all six ONE-STEP regressions. The parameters are estimated over the period 1962–2006. Once and twice lagged levels of the dependent and the independent variables are used as instruments (i.e., values of 1960 and 1961 are used as instruments for 1962)

TRADE LIBERAL,[17] which is fully in line with findings reported in the literature on the consequences of trade liberalization for trade flows (for instance, see Baier and Bergstrand 2007, 2009). Consequently, a significant positive impact of PTA membership on TRADE LIBERAL together with a positive significant parameter of TRADE LIBERAL implies a positive effect of PTA membership for MEA participation.

Altogether, the results support the view that wealthier countries with a strong inclination toward trade and investment liberalization are more in favor of committing themselves voluntarily to environmental standards, pollution reduction, and other

[17] The corresponding parameter is 0.022.

Table 7 Trade liberalization in the EU

EU	Difference in prediction and counterfactual prediction		Prediction of MEA	Counterfactual prediction of MEA
	Short run	Long run		
Mean	12	15	112	100
Min	1		11	10
Max	28		240	212
Std. dev.	7		61	55

Table 8 Trade liberalization in the NAFTA

NAFTA	Difference in prediction and counterfactual prediction		Prediction of MEA	Counterfactual prediction of MEA
	Short run	Long run		
Mean	2	2	75	73
Min	1		59	58
Max	2		99	97
Std. dev.	1		21	21

means of environmental protection through MEA memberships than other countries, all else equal. At least to some extent, this finding is at odds with concerns of environmental activists whereby the globalization of goods trade and investments would be unambiguously detrimental for pro-environmental movements and environmental protection.

6.2 The role of preferential trade liberalization for MEA participation

Shutting down PTAs affects TRADE LIBERAL through three types of channels. First of all, it changes nominal exports in (1) directly through the trade cost term $t_{ij}^{1-\sigma}$. Second, it affects exports indirectly (and in the opposite way) through both exporter and importer multilateral resistance terms Π_i and P_j, respectively. Third, by affecting exports it exerts an indirect effect on exporter, importer, and world GDP. Since GDPs and the number of PTAs concluded across the years, TRADE LIBERAL is a time-variant variable and the impact on TRADE LIBERAL of abandoning PTAs counterfactually is heterogeneous across the years. The time-specific effect of TRADE LIBERAL is then scaled by the corresponding parameter estimate. However, notice that even a homogeneous change in TRADE LIBERAL across countries and years would turn into heterogeneous effects on MEA membership by virtue of the non-linear nature of the econometric model. The impact of PTA membership on MEA participation is computed ceteris paribus as the difference between the model predictions for MEA participation with PTAs (see column 4 of Tables 7, 8, 9, 10) and the ones without any PTAs (see the last column of Tables 7, 8, 9, 10). For predictions as well as counterfactual predictions, we take ONE STEP estimates from Table 4 as a basis.

Table 9 Trade liberalization in the ROW

ROW	Difference in prediction and counterfactual prediction		Prediction of MEA	Counterfactual prediction of MEA
	Short run	Long run		
Mean	1	2	45	44
Min	0		5	5
Max	10		161	157
Std. dev.	2		31	30

Table 10 Trade liberalization in the WORLD

WORLD	Difference in prediction and counterfactual prediction		Prediction of MEA	Counterfactual prediction of MEA
	Short run	Long run		
Mean	4	5	62	58
Min	0		5	5
Max	28		240	212
Std. dev.	6		49	44

For the ease of presentation, let us focus on a quantification of PTA-induced effects on MEA participation in just one year, namely 2006, i.e., the last year in our data. Notice that the impact of PTA membership on the number of MEAs is larger in 2006 than in the 1960s, since the number of PTAs in place by 2006 was larger. Tables 7 to 10 summarize the quantitative effects of PTAs in that year. There are four tables, since we compute effects for different country-groups: European Union (EU[18]), North American Free Trade Area (NAFTA[19]), the rest of the world (ROW), and the whole world covered (i.e., 105 economies).

Each table has got four rows of data and four columns. The last two columns report absolute predictions of MEAs ratified with and without PTAs for the average country (in the top row) in each group considered in 2006.[20] For the mean, the first column is simply the difference between the last two columns in each table. This is, of course, not the case for the minimum predictions, maximum predictions, and standard deviations of predictions.

Please notice that the first column represents short-run—or contemporaneous—effects of PTA membership in 2006. Introducing all existing PTAs in 2006 relative to a situation without any PTAs leads to an increase of about 4 MEAs for the average country in the sample (see the upper left number in Table 10). The effect is much

[18]Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Sweden.

[19]Canada, Mexico, and the United States.

[20]We also report minimum and maximum effects along with the standard deviation of the effects across the countries in each group.

Table 11 Investment liberalization in the EU

EU	Difference in prediction and counterfactual prediction		Prediction of MEA	Counterfactual prediction of MEA
	Short run	Long run		
Mean	32	39	112	80
Min	0		11	9
Max	108		240	145
Std. dev.	30		61	35

Table 12 Investment liberalization in the NAFTA

NAFTA	Difference in prediction and counterfactual prediction		Prediction of MEA	Counterfactual prediction of MEA
	Short run	Long run		
Mean	12	15	74	62
Min	6		59	54
Max	24		99	75
Std. dev.	10		21	12

lower in absolute terms for countries in the ROW (see the upper left number in Table 9), and it is highest for EU member countries (see the upper left number in Table 7). The second column covers long-run effects. While short-run effects are defined as

$$\Delta y_{it}^{\text{short-run}} = \exp\left(x_{it}^{\text{counterfactual}}\hat{\beta}\right) - \exp\left(x_{it}^{\text{benchmark}}\hat{\beta}\right),$$

long-run effect are accumulated responses until a new steady-state effect is reached, and they are defined as

$$\Delta y_{it}^{\text{long-run}} = \frac{1}{1-\hat{\gamma}}\left[\exp\left(x_{it}^{\text{counterfactual}}\hat{\beta}\right) - \exp\left(x_{it}^{\text{benchmark}}\hat{\beta}\right)\right].$$

Among the four considered country-groups, the EU is the one with the largest number of PTAs with other countries, while the ROW is the one with the smallest number of PTAs. All things considered, our results point to a monotonic positive relationship between a country's degree of preferential trade liberalization and the extent of voluntary environmental commitments in terms of the number of MEAs ratified.

6.3 The role of bilateral investment treaties for MEA participation

In a similar vein, we may investigate the role of BITs for MEA membership. We shut down BITs as before and compare the outcome in a situation with BITs (where INVEST LIBERAL corresponds to the number of BITs in place in a given year) with one without BITs (where INVEST LIBERAL is a vector of zeros).

Tables 11, 12, 13, 14 summarize the quantitative effects of INVEST LIBERAL again for the year 2006. Notice that—similar to TRADE LIBERAL—the impact of

Table 13 Investment liberalization in the ROW

ROW	Difference in prediction and counterfactual prediction		Prediction of MEA	Counterfactual prediction of MEA
	Short run	Long run		
Mean	7	10	45	38
Min	0		5	5
Max	54		161	134
Std. dev.	10		31	23

Table 14 Investment liberalization in the WORLD

WORLD	Difference in prediction and counterfactual prediction		Prediction of MEA	Counterfactual prediction of MEA
	Short run	Long run		
Mean	13	16	61	48
Min	0		5	5
Max	108		240	145
Std. dev.	20		49	32

INVEST LIBERAL on MEA participation will be large in 2006 compared to 1960, since the number of BITs in place by 2006 is larger than the years before. There are again four tables summarizing the effects for EU, NAFTA, ROW, and WORLD. As explained above the last two columns report absolute predictions of MEAs ratified with and without INVEST LIBERAL for the average country (in the top row) in each group considered in 2006.[21] The first column is simply the difference between the last two columns in each table and represents short-run—or contemporaneous—effects of INVEST LIBERAL. Introducing all existing INVEST LIBERAL in 2006 relative to a situation with zero BITs leads to an increase of about 13 MEAs for the average country included (see the upper left number in Table 14). Similar to the case of PTAs, the effect of INVEST LIBERAL in absolute terms for countries in the ROW is well below the one for EU member countries, which is the highest.

Summing up Sects. 6.2 and 6.3, results suggest that for the average economy in the world (see Table 10 and Table 14) the number of MEAs ratified would be predicted to drop by more than one-fifteenth if all preferential trade agreements would be abandoned, and by more than one-fifth for the case of bilateral investment treaties. Even though the nexus between environmental protection and MEA participation is not trivial, we argue that such a large change in international cooperation in terms of environmental agreements could bring about detrimental effects for environmental protection.

[21] We also report minimum and maximum effects along with the standard deviation of the effects across the countries in each group.

Table 15 Average marginal effects of TRADE LIBERAL

	EU	NAFTA	ROW	WORLD
AME	66.23	55.09	55.28	84.55

Notes: Figures are percentage changes of MEA counts in response to a one-standard deviation change of TRADE LIBERAL

Table 16 Average marginal effects of INVEST LIBERAL

	EU	NAFTA	ROW	WORLD
AME	17.76	9.24	9.48	12.01

Notes: Figures are percentage changes of MEA counts in response to a one-standard deviation change of INVEST LIBERAL

6.4 Marginal effects of trade and investment liberalization for MEA participation

Besides counterfactual predictions, we also compute average effects of a one-standard deviation increase (AME) of TRADE LIBERAL and INVEST LIBERAL, alternatively, for the EU, NAFTA, ROW, and the whole world. Due to the corresponding β-coefficients, AMEs of TRADE LIBERAL (see Table 15) are higher than the ones of INVEST LIBERAL (see Table 16).

7 Conclusions

This paper investigates whether preferential liberalizations of trade or investment work as stepping stones or stumbling blocks to the formation of environmental agreements. While environmental activists seem to assume the former, we provide evidence supporting the latter from multilateral environmental agreements (MEAs) which regulate environmental protection (related to the five core issues biodiversity, atmosphere, land, chemicals and hazardous wastes, and regional seas and related agreements) between 1960 and 2006.

Our empirical analysis focuses on the determinants of the number of MEAs a country participates in. Such an analysis should respect two features of the data on MEAs. First, the number of MEAs a country is a member of is a discrete variable, a count. Second, MEA participation at the country level is a rather persistent phenomenon and calls for dynamic analysis. Accordingly, we base our inference on a dynamic (linear feedback) model for count data by Blundell et al. (2002). The obtained parameter estimates are used to assess the impact of trade and investment liberalization in the short run and the long run for all 105 countries in our sample (the *world*) and groups thereof.

The findings strongly support the view that both trade and investment liberalization stimulate MEA participation. Economically large countries and, especially, ones with many preferential trade agreements and bilateral investment treaties in place are more likely to ratify MEAs. Across country groups, their impact on MEA membership is strongest for the member countries of the European Union and it is weakest for (mostly least developed) countries in the rest of the world.

However, future research will be needed to look behind the number of MEAs as a measure of cooperation on environmental issues. It is not necessarily the case that a country's membership in more MEAs is indicative of higher environmental standards, nor is it clear that participating in the next MEA for a country that participates in many already is the same as entering the first one. However, as welcome research on such matters would be, it requires a major effort in terms of data collection.

Appendix

A.1 Econometric model

A complication in estimating the econometric model arises as the within group mean scaling estimator will be inconsistent for small T, since the lagged dependent variable is predetermined.[22] For estimation by the generalized method of moments (GMM), the LFM may be quasi-differenced (see Wooldridge 1997) with

$$q_{it} = \frac{y_{it} - \sum_{j=1}^{p} \gamma_j y_{it-j}}{\mu_{it}} - \frac{y_{it-1} - \sum_{j=1}^{p} \gamma_j y_{it-1-j}}{\mu_{it-1}}. \tag{A.1}$$

The quasi-differencing transformation following Wooldridge (1997) has the advantage that it can deal with potentially endogenous regressors. Regressors are endogenous when $E(x_{it}u_{it}) \neq 0$. Hence, for endogenous x_{it}, the following moment conditions are valid: $E(q_{it}|y_{it-2}, x_{it-1}) = 0$.

Define $\theta = [\gamma_1, \dots, \gamma_p, \beta']'$. Then the GMM estimator minimizes

$$\hat{\theta} = \arg\min \left(\frac{1}{N} \sum_{i=1}^{N} q_i(\theta)' Z_i \right) W_N^{-1} \left(\frac{1}{N} \sum_{i=1}^{N} Z_i' q_i(\theta) \right), \tag{A.2}$$

where q_i is the $T - p - 1$ vector of residuals $[q_{it}]$, Z_i is the matrix of instruments and W_N is a weights matrix. We use the full set of sequential instruments so that Z_i is given by

$$Z_i = \begin{bmatrix} y_{i1} & x_{i1} & x_{i2} & & & & & & \\ & & & \ddots & & & & & \\ & & & & y_{i1} & \cdots & y_{iT-2} & x_{i1} & \cdots & x_{iT-1} \end{bmatrix}. \tag{A.3}$$

The efficient weights matrix for the moments is defined as

$$W_N(\hat{\theta}_1) = \left(\frac{1}{N} \sum_{i=1}^{N} Z_i' q_i(\hat{\theta}_1) q_i(\hat{\theta}_1)' Z_i \right)^{-1}. \tag{A.4}$$

[22] That is, it is correlated with shocks in the past so that $E(x_{it}u_{it+j}) = 0$, $j \geq 0$, and $E(x_{it}u_{it-s}) \neq 0$, $s \geq 1$.

The one-step GMM estimator $\hat{\theta}_1$ uses $W_N = (\frac{1}{N}\sum_{i=1}^{N} Z_i' Z_i)^{-1}$ as the initial weights matrix. The asymptotic variance of $\hat{\theta}_1$ may be computed as

$$\hat{\text{var}}(\hat{\theta}_1) = \frac{1}{N}\big(C(\hat{\theta}_1)' W_N C(\hat{\theta}_1)\big)^{-1} W_N W_N^{-1}(\hat{\theta}_1) W_N C(\hat{\theta}_1)\big(C(\hat{\theta}_1)' W_N C(\hat{\theta}_1)\big)^{-1}, \tag{A.5}$$

where

$$C(\hat{\theta}_1) = \frac{1}{N}\sum_{i=1}^{N} \frac{\partial Z_i' q_i(\theta)}{\partial \theta}\bigg|_{\hat{\theta}_1}. \tag{A.6}$$

The efficient two-step GMM estimator $\hat{\theta}_2$ uses the efficient weights matrix $W_N(\hat{\theta}_1)$, where $q_i(\hat{\theta}_1)$ is based on the one-step estimates $\hat{\theta}_1$. The asymptotic variance of the efficient two-step GMM estimator is computed as

$$\hat{\text{var}}(\hat{\theta}_2) = \frac{1}{N}\big(C(\hat{\theta}_2)' W_N C(\hat{\theta}_2)\big)^{-1}. \tag{A.7}$$

Hansen et al. (1996) suggest to directly account for the dependence of W_N on θ in the optimization, an estimator known as the continuous updating GMM estimator in the literature. The main advantage of the latter estimator is that it is invariant to curvature altering transformations of the population moment conditions (see Hall 2005).

Because of the small sample bias of the two-step GMM estimator (see Windmeijer 2002), we additionally use a finite sample correction based on block-bootstrapping. In order to preserve the time-structure of the data, we construct our bootstrap samples by drawing from the pool of 105 countries 2,000 times with replacement, and then take for every drawn country all observations over time. We then calculate the mean and standard observations over the 2,000 bootstraps for every estimated coefficient, leading to our estimates for the block-bootstrap. As the draws are taken from the sample, the finite-sample properties of our sample are preserved for the bootstrapped standard errors. For more details on the properties of the bootstrap method, see, for example, Chap. 11 in Cameron and Trivedi (2005).

A.2 Multilateral resistance terms

Even though multilateral resistance terms are unobserved, they can be obtained as solutions to the system of non-linear equations of the form

$$\Pi_{it}^{1-\sigma} = \sum_{j=1}^{N}\big(P_{jt}^{\sigma-1}\theta_{jt} t_{ijt}^{1-\sigma}\big) \quad \forall i, t, \theta_{jt} = \frac{y_{jt}}{y_{Wt}} \; \forall j, t, \tag{A.8}$$

$$P_{jt}^{1-\sigma} = \sum_{i=1}^{N}\big(\Pi_{it}^{\sigma-1}\theta_{it} t_{ijt}^{1-\sigma}\big) \quad \forall j, t, \theta_{it} = \frac{y_{it}}{y_{Wt}} \; \forall i, t. \tag{A.9}$$

To solve for $\Pi_{it}^{1-\sigma}$ and $P_{jt}^{1-\sigma}$, we only need to know nominal GDPs and bilateral economic trade costs. However, while GDPs may be directly gathered from statistical sources, this is impossible for economic trade costs. Typically, trade economists model them as $t_{ijt} \equiv e^{\mathbf{z}'_{ijt}\boldsymbol{\beta}}$, where $\mathbf{z}_{ijt}$ is a vector of observable trade barrier variables and $\boldsymbol{\beta}$ is a corresponding vector of unobservable (but estimable) parameters relating the elements of $\mathbf{z}_{ijt}$ to t_{ijt}.

Specifically, we use the following observable variables as elements of $\mathbf{z}_{ijt}$: bilateral geographical distance between countries i and j; an indicator of contiguity of countries i and j which is unity if two countries have a common land border and zero otherwise; a common language indicator which is unity if countries i and j have a common official language and zero otherwise; a continent dummy which is unity if two countries are located at the same continent; a colony indicator which is unity if two countries had a colonial relationship in the past; a current colony indicator which is unity if two countries had a colonial relationship after World War II; an indicator which is unity if the two units i and j form one country (such as Denmark and Greenland); and a preferential trade agreement indicator which is unity if two countries belong to such an agreement in a given year.[23] All variables except for preferential trade agreement memberships are time-invariant and collected from the geographical data set made available by the Centre d'Études Prospectives et Internationales (CEPII). We estimate the parameters $\boldsymbol{\beta}$ by means of a cross-sectional regression model based on data of the year 2006.

Potential trade flows are defined as the model predictions using (1) and (A.8) and estimates of the parameters $\boldsymbol{\beta}$ from a cross-sectional model with fixed country effects for the year 2006. Notice that neighboring countries' weighted GDP and population exhibit time variation for two reasons: First, GDP and population change over time and so does weighted GDP and population; second, potential trade weights change since GDPs change, preferential trade agreement membership changes, and, indirectly, the multilateral resistance terms in (A.8) change through GDP and preferential trade agreement memberships.

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[23] We use information on preferential trade agreements as notified to the World Trade Organization. These data are augmented and corrected by using information from the CIA's World Fact Book and preferential trade agreement secretariat web-sites.

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