Environmental Economics and Multilateral Environmental Agreements

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For my parents and my wife

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Contents

List of Tables

List of Figures

Preface

> *"...Let me be clear: the MDGs [Millennium Development Goals] are a pledge. They are a commitment to the worlds most vulnerable people. Achieving the MDGs is a practical necessity. It is a moral imperative. And it is possible." (Ban Ki-moon, Secretary-General of the United Nations, Remarks to "State of the Planet 2010: Connecting Voices Globally to Meet the Challenges of Climate Change, Poverty and Economic Recovery" New York, 25 March 2010)*

These passionate words of Ban Ki-moon express both the urgency and feasibility of global solutions to global problems – among which environmental protection needs to be counted. Environmental sustainability is one of the eight Millennium Development Goals (see UN, 2000). And exactly for this purpose multilateral environmental agreements (MEAs) are aimed at fostering world wide cooperation. MEAs are voluntary, thus preserve sovereignty of the countries, are governed by international law, tie up different environmental issues more than two countries are concerned of, and symbolize a growing world wide interconnectedness in environmental protection which already began in the 19th century (cf. Mitchell, 2003 and 2007).

This dissertation consists of three empirical chapters. The first two works make use of the dynamic linear feedback model of Blundell, Griffith, and Windmeijer (2002) to analyze the history of MEAs, their nexuses to trade and investment liberalization, and the mutual relationships of MEA clusters[1]. In contrast to this, the third one makes a projection of atmosphere related MEAs applying a simulation based forecasting approach in the manner of Schmalensee, Stoker, and Judson (1998) and studies the impact of these MEAs on future CO_2 emissions.

Chapter 1 composes a comprehensive picture of determinants that affect multilateral environmental agreement membership. Rose and Spiegel (2009) can show that bilateral environmental agreements can boost capital assets of the involved partners. Thus, to cooperate on environmental issues is not an isolated action of countries protecting their resources or limiting their emissions. Voluntarily and jointly agreeing on environmental protection is part of an international integration process the world focuses, well-known as globalization. The related growing interconnectedness is reflected in a raising number of different international agreements regarding trade, investments, poverty control, health, etc. In chapter 1 we focus on a country's international openness by means of its trade and investment agreements and find that richer countries and countries which are more active in international trade and investment treaties, thus more open to world trade, are leading in forming multilateral cooperation with respect to environmental protection. Applying the dynamic linear feedback model of Blundell, Griffith, and Windmeijer (2002) among others we filter out significant influences of both trade and investment liberalization on a country's decision to ratify another MEA. On the basis of ONE STEP estimates we predict the effect on MEAs, for example, in the presence and absence of trade liberalization. Every country in the world would have ratified in mean 4 MEAs less (in the short run) or 5 MEAs less (in the long run) if trade liberalization through preferential trade agreements like the North American Free Trade Agreement (NAFTA) or the Central European Free Trade Agreement (CEFTA) had missed.

[1] cf. multilateral environmental agreements clusters of the United Nations Environment Programme (UNEP, 2001).

Table 1: Mutual influences of MEA clusters

	Biodiversity	Atmosphere	Land	Chemicals	Seas
Biodiversity			+		+
Atmosphere	+	+	+	+	
Land	+				
Chemicals	+	+	+	+	+
Seas	+	+	+	+	+

Chapter 2 addresses the different environmental issues MEAs rely on. The United Nations Environment Programme (UNEP, 2001) divides multilateral environmental agreements into five clusters with respect to their core convention: biodiversity, atmosphere, land, chemicals and hazardous wastes, and regional seas and related agreements. The question arises whether economic, political, and environmental determinants affect these clusters differently. Furthermore, like trade agreements and investment treaties are connected to environmental agreements (cf. Chapter 1), do multilateral environmental agreements of different clusters influence each other, too? In table 1 I subsume the mutual interdependencies of the different MEA clusters we reveal in chapter 2. Please read from left to right to see which cluster has an impact on which cluster. For example MEAs related to chemicals and hazardous wastes and MEAs classified with regional seas influence all other MEA clusters, meanwhile land related MEAs only affect biodiversity MEAs. And MEAs classified with land or biodiversity have no impact on themselves. Thus, for these MEA clusters we cannot measure a dynamic linear feedback of the regarded cluster. In a nutshell MEA clusters vary tremendously with respect to their mutual influences. Another benefit from classifying MEAs with different clusters is that thereby we are able to measure a significant impact of environmental determinants we could not verify by regressions covering all MEAs unclassified, such as in chapter 1. For example CO_2 emissions have a negative and significant impact on MEAs related to land and MEAs classified with chemicals and hazardous wastes. But interestingly CO_2 emissions influence atmosphere related MEAs positively. This means, while a country's level of CO_2 emissions lowers the possibility of that country to ratify another MEA in the context of land or chemicals and hazardous wastes, it ramps up the country's efforts in MEAs classified with atmosphere. Due to this, counties emitting much CO_2 seem to be aware of their contribution to global warming and consequently try to find other countries that signal the will to cooperate on abating it.

We know now what determinants drive MEA membership. But does the growing number of MEAs be of any worth in effective environmental protection, in particular in reducing CO_2 emissions? This question I am going to answer in chapter 3. Here I focus on the future set-up of atmosphere related MEAs until 2050 and make use of the interactions of per capita CO_2 emissions and GDP per capita via the Environmental Kuznets Curve. Employing a simulation based forecasting method and with the aid of IPCC IS92[2] growth rates for population and GDP I project CO_2 emissions with and without additionally controlling for the impact of atmosphere MEAs. Hereby I am able to filter out the CO_2 emission reduction effect which can be credited to multilateral environmental agreements classified with atmosphere. I can show that the desired impact of another Kyoto Protocol or a worldwide effective post Kyoto Protocol can be achieved with many small steps by a growing number of atmosphere MEAs. With different linear and non-linear projection approaches I span a corridor of potential CO_2 emission scenarios which are located near around the CO_2 emission projection of the IPCC A1B scenario[3]. Thus, a worldwide mod-

[2]cf. Pepper, Xing, Chen, and Moss (1992)

[3]cf. IPCC SRES (2000); IPCC TAR (2001); Pepper, Xing, Chen, and Moss (1992)

erate growing number of atmosphere MEAs can bring about sustainable developments and helps to succeed CO_2 emission goals world leaders assigned by means of the Copenhagen Accord[4] in 2009, i.e., to limit global temperature rise to below 2°C.

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[4] cf. UNFCCC (2009)

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Chapter 1

Trade and Investment Liberalization as Determinants of Multilateral Environmental Agreement Membership

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 towards concluding 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 (2009) suggests that environmental agreements will be concluded 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 conclusion of such agreements is their interdependence with other policies, especially ones that are related to international business. This chapter 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 committing themselves voluntarily to environmental standards, pollution reduction, and other means of environmental protection through MEA memberships than other countries, all else equal.

1.1 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

*This chapter is based on joint work with Peter Egger and Mario Larch.

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 concluded 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 signed *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, 1998b; Finus, van Ierland, and Dellink, 2006; Hoel, 1992; Hoel and Schneider, 1997; Carraro, Eyckmans, and Finus, 2006; Barrett and Stavins, 2003; Barrett, 2001; Barrett, 1994; Buchholz, Haupt, and Peters, 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 concluded in isolation

[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.

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 chapter'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 concluded 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 chapter is organized as follows. The subsequent section provides a review of previous research on the conclusion of environmental agreements. Section 1.3 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 section 1.4, and section 1.5 briefly introduces the econometric methods applied to estimate the regression parameters of interest. Section 1.6 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.

1.2 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.

1.2.1 Economic theory of environmental agreements

Economic theory emphasizes the public good character of a clean environment. One reason why environmental agreements are hard to conclude is the prisoners' dilemma associated with the public good character of the environment. As an example, Weikard, Finus, and Altamirano-Cabrera (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 section 1.1), this demonstrates the difficulty to conclude MEAs.

Other papers emphasize the role of communications and negotiations in order to overcome the prisoners' dilemma associated with the conclusion of MEAs (see Carraro, 1998;

Bloch and Gomes, 2006; Caparrós, Hammoudi, and Tazdaït, 2004; Carraro, Marchiori, and Sgobbi, 2005).[3]

In contrast to the above work, Breton, Sbragia, and Zaccour (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.

1.2.2 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,

[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, van Ierland, and Dellink, 2006), or the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) (see Swanson and Manson, 2002; Tol, 2001; Tol, 1997). 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 conclusion of environmental agreements.

Murdoch, and Vijverberg, 2003; Murdoch, Sandler, and Vijverberg, 2003; Davies and Naughton, 2006; Rose and Spiegel, 2009; Altamirano-Cabrera and Finus, 2006; Sugiyama and Sinton, 2005; Swanson and Mason, 2002).

For instance, Beron, Murdoch, and Vijverberg (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 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, Murdoch, and Vijverberg (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, Sandler, and Vijverberg (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.

1.3 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 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 concluded 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.

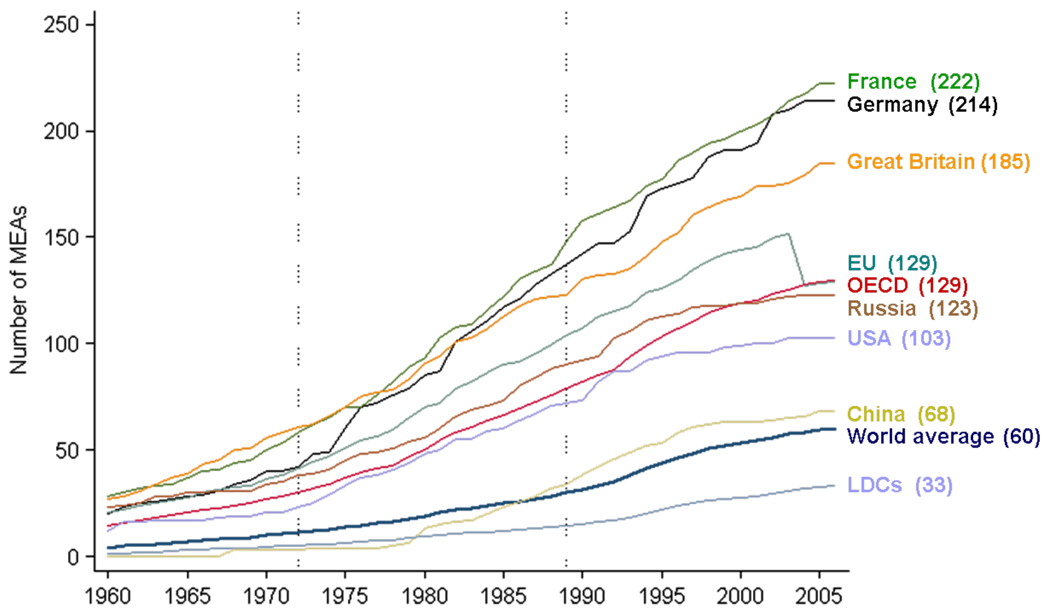

Figure 1.1: Time course of the number of MEAs between 1960 and 2006

After 1972, the year of the Stockholm Conference, the number of MEAs has risen tremendously. Inter alia because of the conclusion of the Montreal Protocol, the number of MEA memberships has also increased after 1989. Figure 1.1 illustrates that MEA participation is not only but mainly a phenomenon in the developed part of the world. Please notice that

[4]We gratefully acknowledge provision of the data by Ron Mitchell.

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 figures 1.2 and 1.3.

In addition to the development 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 towards participation in MEAs.[6] Obviously, countries in Europe ratify a good deal more MEAs than countries in Africa or Asia (cf. figure 1.2). A closer look on Europe illustrates the discrepancies between countries in different developing stages (see figure 1.3). 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.

[5]In figure 1.1 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 classification 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.

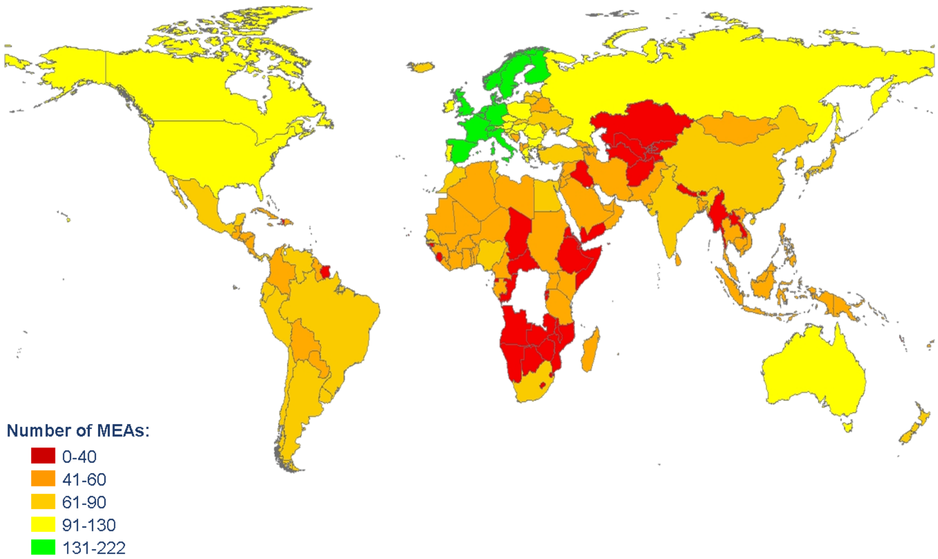

Figure 1.2: Number of MEAs in 2006 - The World

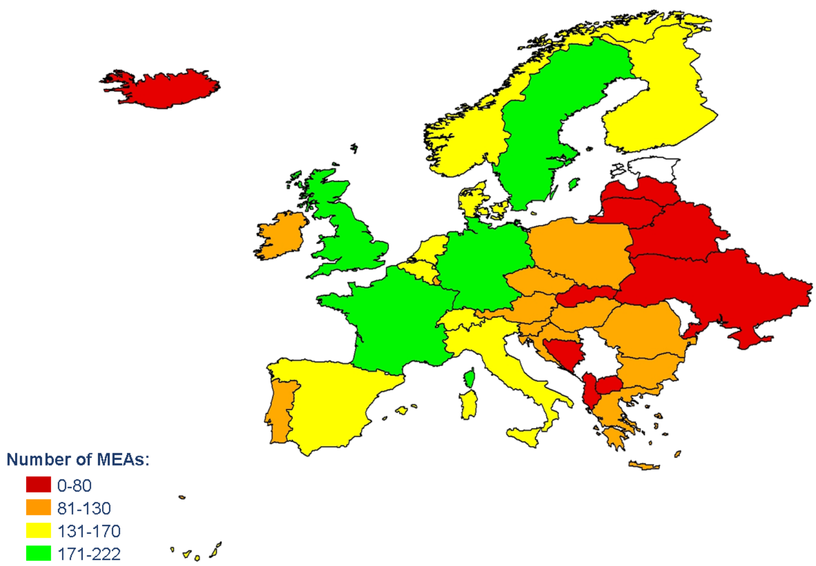

Figure 1.3: Number of MEAs in 2006 - Europe

1.4 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.

1.4.1 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 U.S. 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 else. 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 dataset, 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 U.S. dollars, X_{ijt}, may be expressed in the following way (see Feenstra, 2004, for a discussion):

$$X_{ijt} = \frac{GDP_{it} GDP_{jt}}{GDP_{Wt}} t_{ijt}^{1-\sigma} \Pi_{it}^{1-\sigma} P_{jt}^{1-\sigma}, \tag{1.1}$$

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

$$\text{TRADE LIBERAL}_{it} = \ln \sum_{j=1 j \neq i}^{N} \left(\frac{GDP_{it}GDP_{jt}}{GDP_{Wt}} t_{ijt}^{1-\sigma} \Pi_{it}^{1-\sigma} P_{jt}^{1-\sigma} \right), \tag{1.2}$$

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

$$t_{ijt}^{1-\sigma} = exp\left[\sum_{k}^{K}(\delta_k \tau_{k,ijt})\right], \tag{1.3}$$

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 (1.1), see Appendix 1.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 nonlinear system of $2N$ equations which are based upon knowledge of GDPs and estimates of $t_{ijt}^{1-\sigma}$ (see Appendix 1.A.2 for details). We use data on nominal exports X_{ijt} in U.S. 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 cum-PTA vector of TRADE LIBERAL and the counterfactual sine-PTA vector of TRADE LIBERAL 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 1.7 to 1.10 in Section 1.6.2).

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.

For estimation we apply a quasi-differencing transformation following Wooldridge (1997). This GMM estimator has the advantage that it can deal with potentially endogenous regressors where $E(x_{it}u_{it}) \neq 0$. Hence, as TRADE LIBERAL or INVEST LIBERAL may be endogenous, we employ the following valid moment conditions: $E(q_{it}|y_{it-2}, x_{it-2}) = 0$ (for more details see Appendix 1.A.1).

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[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.

1.4.2 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 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, Lawson, Sobel, and Leeson, 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.

1.4.3 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 1.1).

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

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

Table 1.1: 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

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, Griffith, and Windmeijer (2002) to model the dynamics of the number of MEAs a country participates in as a linear feedback model (LFM). The 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, $i = 1, ..., N$, is a member of in year t, $t = 1, ..., T$. Further, let x_{it} represent a vector of K explanatory variables. The conditional

[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.

[11] For a good overview article of GMM for panel count data models see Windmeijer (2008).

mean in the LFM is then defined as

$$E\left(y_{it}|y_{it-1},x_{it},v_i\right) = \gamma y_{it-1} + exp\left(x'_{it}\beta\right)v_i \qquad (1.4)$$
$$= \gamma y_{it-1} + \mu_{it}\nu_i,$$

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.

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, Heaton, and Yaron, 1996).[13]

[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.

[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).

As demonstrated by Windmeijer (2002), the two-step GMM estimator can be severely biased downwards 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 1.A.1.

1.6 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 nonlinear 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.

[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).

1.6.1 Parameter estimates

Our results are summarized in tables 1.2 to 1.4. 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 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 highly significantly different from zero in all models. This suggests that there is indeed strong persistence in the number of MEAs concluded 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 concluded by a country. Holding population constant, this suggests that marginally wealthier countries are more inclined towards 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

Table 1.2: 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:				
$LGDP_{it}$	0.5831***	0.5835***	0.5430***	0.5706***
	(8.963)	(133.3069)	(115.8703)	(6.2472)
$LPOP_{it}$	0.0662	0.0725***	0.8542***	0.0575
	(0.9534)	(7.8487)	(48.3054)	(0.9184)
TRADE $LIBERAL_{it}$	0.3568***	0.3573***	0.4470***	0.3478***
	(6.0775)	(47.9151)	(334.3223)	(5.0946)
INVEST $LIBERAL_{it}$	0.0061***	0.0061***	0.0035***	0.0060***
	(5.3570)	(34.8477)	(68.5053)	(4.7232)
LDC_{it}	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.

Table 1.3: 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:				
$LGDP_{it}$	0.5768***	0.5783***	0.4608***	0.5463***
	(8.6261)	(100.9385)	(86.6106)	(5.7752)
$LPOP_{it}$	0.0674	0.0718***	0.9579***	0.0649
	(0.9721)	(8.1776)	(46.3741)	(1.0241)
TRADE $LIBERAL_{it}$	0.3496***	0.3487***	0.3785***	0.3327***
	(5.7095)	(43.7934)	(310.7697)	(4.7985)
INVEST $LIBERAL_{it}$	0.0059***	0.0059***	0.0065***	0.0059***
	(5.3410)	(32.0974)	(88.1588)	(4.5845)
LDC_{it}	0.1008	0.1137	1.0589***	0.0382
	(0.2917)	(0.4210)	(3.7494)	(0.1385)
Political determinants:				
PFI_{it}	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.

Table 1.4: 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:				
$LGDP_{it}$	0.5826***	0.5879***	0.7244***	0.5593***
	(8.2293)	(74.0002)	(100.7637)	(5.4012)
$LPOP_{it}$	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***
$LIBERAL_{it}$	(5.7570)	(44.2835)	(58.1982)	(4.8224)
INVEST	0.0060***	0.0030***	0.0001***	0.0060***
$LIBERAL_{it}$	(5.6497)	(33.5298)	(23.0466)	(4.6575)
LDC_{it}	0.1099	0.1248	0.5887*	0.0471
	(0.3230)	(0.4642)	(2.1911)	(0.1780)
Political determinants:				
PFI_{it}	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
$EMISSIONS_{it}$	(-0.8530)	(-6.7420)	(-39.7536)	(-0.6205)
$AGRLAND_{it}$	-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.

with less production and, hence, less pollution. As GDP rises, an increase in production brings about more pollution. With even higher GDP, producers may face pressure towards 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 from zero at conventional levels (cf. ONE-STEP or BOOTSTRAP results in tables 1.2 to 1.4).

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 1.5 provides descriptive details about the regarded 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

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[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 1.2 to 1.4).

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

Table 1.5: 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

with chemicals and hazardous wastes (CLUSTER CHEMICALS). Less MEAs have been ratified with respect to biodiversity, atmosphere, or land. Table 1.6 summarizes one-step dynamic GMM regression results akin to the ones in the first column of table 1.4. For convenience, we repeat the one-step results from table 1.4 in the first column of table 1.6.

Basically, results in table 1.6 draw a similar picture to the one obtained in table 1.4. 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 1.6). 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, too. 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 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 towards trade and investment liberalization are more in favor of committing themselves voluntarily to environmental standards, pollution reduction, and other 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

[17] The corresponding parameter is 0.022.

Table 1.6: 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}	0.5826***	0.7783***	0.8787	0.2248***	0.7265***	0.6430***
LPOP_{it}	0.0518	0.0196	-0.0478	0.2399**	0.0070	0.0773
TRADE LIBERAL_{it}	0.3397***	0.5522***	0.6090	0.2265**	0.5300***	0.4185***
INVEST LIBERAL_{it}	0.0060***	0.0061***	0.0034	0.0035***	0.0022***	0.0006
LDC_{it}	0.1099	0.7622**	-0.1381	-0.1566	-0.1816	0.0781
Political determinants:						
PFI_{it}	0.0092***	0.0245***	0.0343	0.0023	0.0060**	0.0023
Environmental determinants:						
CO_2 EMISSIONS_{it}	-0.0080	-0.0153	0.1078	-0.0087**	-0.0180*	0.0019
AGRLAND_{it}	-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).

the globalization of goods trade and investments would be unambiguously detrimental for pro-environmental movements and environmental protection.

1.6.2 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 equation (1.1) 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 nonlinear nature of the econometric model. The impact of PTA membership in MEA participation is computed as the difference between the model predictions of MEA participation cum PTAs and the one without any PTAs. For predictions as well as counterfactual predictions we take ONE STEP estimates from table 1.4 as a basis.

Table 1.7: 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 1.8: 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

Table 1.9: 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 1.10: 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 1.7 to 1.10 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 concluded 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.

[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.

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 1.10). The effect is much lower in absolute terms for countries in the ROW (see the upper left number in table 1.9), and it is highest for EU member countries (see the upper left number in table 1.7).

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.

1.6.3 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 cum BITs (where INVEST LIBERAL corresponds to the number of BITs in place in a given year) with one sine BITs (where INVEST LIBERAL is a vector of zeros).

Table 1.11: 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 1.12: 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

Table 1.13: 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 1.14: 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

Tables 1.11 to 1.14 summarize the quantitative effects of INVEST LIBERAL again for the year 2006. Notice that – similar to TRADE LIBERAL – the impact of 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 concluded 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 1.14). 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 sections 1.6.2 and 1.6.3, results suggest that for the average economy in the world (see table 1.10 and table 1.14) 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

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

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.

1.7 Conclusions

This chapter investigates whether preferential liberalizations of trade or investment work as stepping stones or building blocs to the formation of environmental agreements. While environmental activists seem to assume the former, we provide evidence supporting the latter from all multilateral environmental agreements (MEAs) which regulate environmental protection 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, Griffith, and Windmeijer (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.

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Appendix - Chapter 1

1.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

$$q_{it} = \frac{y_{it} - \sum_{j=1}^{p} \gamma_j y_{it-j}}{\mu_{it}} - \frac{y_{it-1} - \sum_{j=1}^{p} \gamma_j y_{it-1-j}}{\mu_{it-1}}. \tag{1.5}$$

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: $E(q_{it}|y_{it-2}, x_{it-2}) = 0$.

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

$$\theta = \arg\min \left\{ \left(\frac{1}{N} \sum_{i=1}^{N} q_i' Z_i \right) W_N \left(\frac{1}{N} \sum_{i=1}^{N} q_i' Z_i \right) \right\}, \tag{1.6}$$

where q_i is the $T-p-1$ vector $[q_{it}]$, 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:

$$Z_i = \begin{bmatrix} y_{i1} & x_{i1} & x_{i2} & & & & & & \\ & & & \ddots & & & & & \\ & & & & y_{i1} & \cdots & y_{iT-2} & x_{i1} & \cdots & x_{iT-1} \end{bmatrix}. \tag{1.7}$$

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

The efficient weights matrix for the moments is defined as

$$W_N(\hat{\theta}_1) = \left(\frac{1}{N} \sum_{i=1}^{N} Z_i' q_i(\hat{\theta}_1) q_i(\hat{\theta}_1)' Z_i \right)^{-1} . \tag{1.8}$$

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

$$\hat{\text{var}}(\hat{\theta}_1) = \frac{1}{N} \left(C(\hat{\theta}_1)' W_N C(\hat{\theta}_1) \right)^{-1} W_N W_N^{-1}(\hat{\theta}_1) W_N C(\hat{\theta}_1) \left(C(\hat{\theta}_1)' W_N C(\hat{\theta}_1) \right)^{-1} , \tag{1.9}$$

where

$$C(\hat{\theta}_1) = \frac{1}{N} \sum_{i=1}^{N} \left. \frac{\partial Z_i' q_i(\theta)}{\partial \theta} \right|_{\hat{\theta}_1} . \tag{1.10}$$

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

$$\hat{\text{var}}(\hat{\theta}_2) = \frac{1}{N} \left(C(\hat{\theta}_2)' W_N C(\hat{\theta}_2) \right)^{-1} . \tag{1.11}$$

Hansen, Heaton, and Yaron (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 2000 times with replacement, and then take for every drawn country all observations over time. We then calculate the mean and standard observations over the 2000 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 areas. For more details on the properties of the bootstrap method see for example Chapter 11 in Cameron and Trivedi (2005).

1.A.2 Multilateral resistance terms

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

$$\Pi_{it}^{1-\sigma} = \sum_{j=1}^{N} \left(P_{jt}^{\sigma-1} \theta_{jt} t_{ijt}^{1-\sigma} \right) \quad \forall\, i,t, \quad \theta_{jt} = \frac{y_{jt}}{y_{Wt}} \quad \forall\, j,t, \tag{1.12}$$

$$P_{jt}^{1-\sigma} = \sum_{i=1}^{N} \left(\Pi_{it}^{\sigma-1} \theta_{it} t_{ijt}^{1-\sigma} \right) \quad \forall\, j,t, \quad \theta_{it} = \frac{y_{it}}{y_{Wt}} \quad \forall\, i,t. \tag{1.13}$$

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 else; a common language indicator which is unity if countries i and j have a common official language and zero else; 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 equations (1.1) and (1.12) and estimates of the parameters $\boldsymbol{\beta}$ from a cross-sectional model cum 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 (1.12) change through GDP and preferential trade agreement memberships.

[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.

References - Chapter 1

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Chapter 2

Trade and Environmental Impacts on Clustered Multilateral Environmental Agreements

Abstract*

Different countries making common decisions on environmental policy and environmental regulation are the focus of multilateral environmental agreements (MEA). Whereas economic and political influences on MEAs have already been investigated, the level and direction of impacts by environmental determinants still remain unclear. As MEAs differ in their issue-area we classify the agreements with 5 clusters (biodiversity; atmosphere; land; chemicals and hazardous wastes; seas)† and estimate cluster specific environmental influences on the number of MEAs of a cluster. Additionally we analyze economic and political impacts and estimate bilateral effects between the clusters. It is this chapter's focus to shed light on the different pace of economic, political, and environmental determinants on environmental agreement participation as well as on mutual impacts of MEA clusters by means of a dynamic count data model for the number of MEAs of different clusters ratified at the country level.

2.1 Introduction

> *"The interconnectedness of the global environment is beyond dispute. [...]coordinated international action is essential to protecting Earth's climate, preserving its biodiversity, and managing its marine and other common resources." (World Resources Institute, International Environmental Governance, 2002, Chapter 7, p. 137)*

Trade and environment intersect in many different ways. A common assumption might be that strict environmental policy reduces trade flows in and out of the considered country. But Tobey's (1990) results were the first to cast serious doubt on the balance of trade argument against the imposition of stronger environmental control. In his empirical work

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*This chapter is based on joint work with Peter Egger and Mario Larch.

†Analogous to the multilateral environmental agreements clusters of the United Nations Environment Programme (UNEP, 2001).

he found that strict environmental policy has no measurable effect on the trade flows of heavily polluting industries. Later many other scientific approaches (among others see van Beers and van den Bergh, 1997 and 2000) were able to affirm his doubts empirically as well. So there should not be an economic threat for a country to introduce a strict environmental framework. Concerning the global threat of a progressing climate change and its dangers for the society, economy and environment the question arises: If strict environmental policy does not reduce trade flows, which are the determinants that can enhance strict environmental policy globally? It is obvious that global environmental policy needs global arrangements, namely multilateral environmental agreements (MEA). Due to this, we try to shed light on the most important economic, political, and environmental determinants and its impacts on MEAs to give an econometric answer to the above question.

As environmental pollution typically does not stop at the border it can have global impact or at least greater regional impact affecting more than two countries. For this purpose multilateral environmental agreements are instruments with which several countries can cooperate in environmental protection issues and which are governed by international law. Upon several countries have signed such an agreement it can become binding if they ratify it as well. But according to Ron Mitchell's statement, that *"the empirical basis for claims regarding the number of such agreements and their characteristics remain weak" (Mitchell, 2003, p. 431)* we try to close this gap with a count data model approach and different economic, political, and environmental determinants. Furthermore we seize the fact that MEAs are diverse in nature and thus need to be divided into clusters covering different environmental issues. Following the UNEP MEA Clusters[1] we make use of 5 clusters: *biodiversity*, *atmosphere*, *land*, *chemicals and hazardous wastes*, and *seas*. Besides the impacts of economic and political determinants on a country's decision to ratify MEAs we also focus on bilateral cluster specific impacts on the number of MEAs of another cluster. Our

[1] cf. multilateral environmental agreements clusters of the United Nations Environment Programme (UNEP, 2001).

analysis shows that not all clusters influence each other. Even though the bilateral effects are positive throughout, some are insignificant. For example *land* related MEAs have no effect on other clusters but the *biodiversity* one. On the other side MEAs classified with *chemicals and hazardous wastes* are highly reactive in terms of bilaterally stimulating a country to ratify MEAs of another cluster.

This chapter is organized as follows. By hands of five maps of the different MEA clusters we firstly show interesting insights that can be learned from a graphical study. After describing the applied econometric model from Blundell, Griffith, and Windmeijer (2002) we depict in the next section which variables will be used for our regressions and divide them into three key categories of exogenous influences. In section 2.5 we carefully examine our regression results with different settings of lagged dependent variables for the linear feedback model and finally we conclude.

2.2 Descriptive statistics

The following maps show the distribution of the number of MEAs of all countries in the world ratified until 2006. This MEA data is composed of two sources. First we started with data from the Center for International Earth Science Information Network (CIESIN), Data-base from Socioeconomic Data and Applications Center (SEDAC)[2]. Then by courtesy of Ron Mitchell[3] we were able to widen and to round out the CIESIN SEDAC data set in more recent years up to 2006. In order to be able to compare the maps visually we apply a mathematical rule to categorize the countries' number of MEAs into the respective

[2]see Center for International Earth Science Information Network (CIESIN) (2006).

[3]see Mitchell (2007).

color. Using the 0-20, 20-40, 40-60, 60-80, and 80-100 quantiles, the dark red and red colored countries have ratified less than the median number of MEAs. Counties around the median number of MEAs are yellow and all countries with a higher and the highest number of MEAs are colored in green and dark green, respectively. This is true for all the five maps representing the number of MEAs in 2006 of the clusters *biodiversity*, *atmosphere*, *land*, *chemicals and hazardous wastes*, and *seas*.

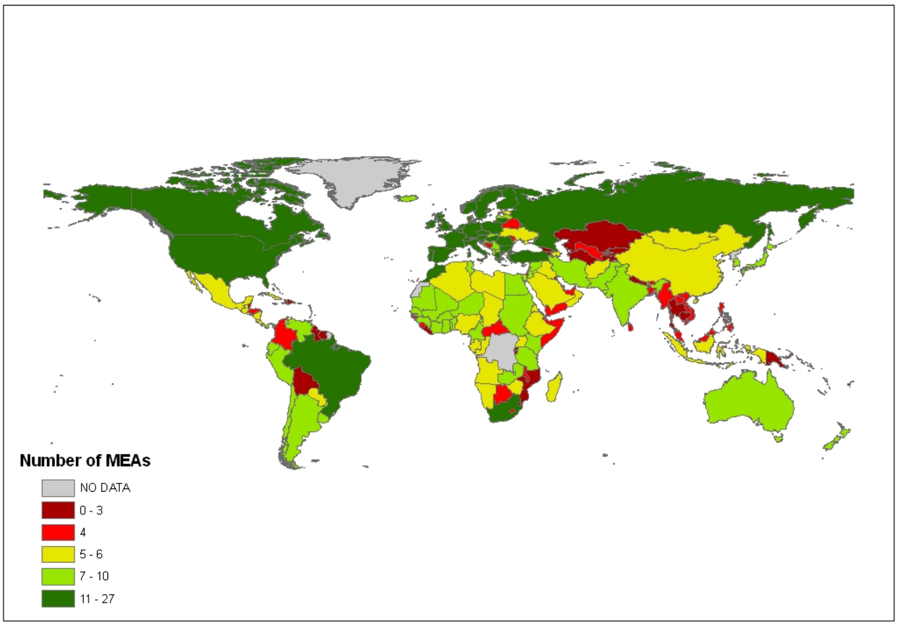

Figure 2.1: The number of multilateral environmental agreements in 2006 - Cluster: Biodiversity

Looking at the key of all five maps the great difference in the maximum number of MEAs, and also in the median number of MEAs, between the clusters is clearly to see. Agreements related to the cluster *land* reach only to a maximum of 21, but there is at least one country which ratified up to 94 MEAs in terms of the cluster *seas*. Looking at every cluster separately in the cluster *biodiversity*, both France and Sweden ratified the most MEAs until 2006. Whereas Germany and Luxembourg are the ones which have the highest number

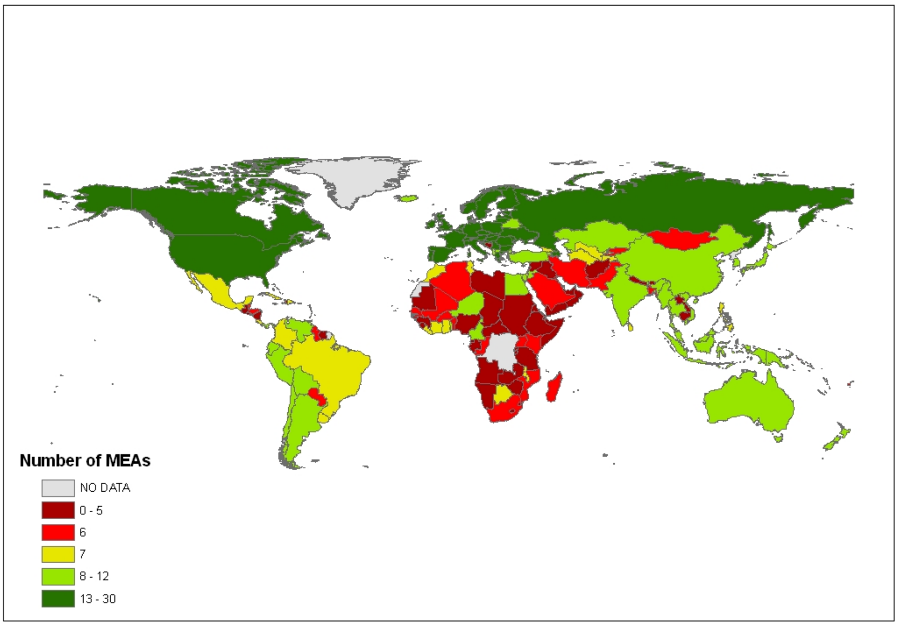

Figure 2.2: The number of multilateral environmental agreements in 2006 - Cluster: Atmosphere

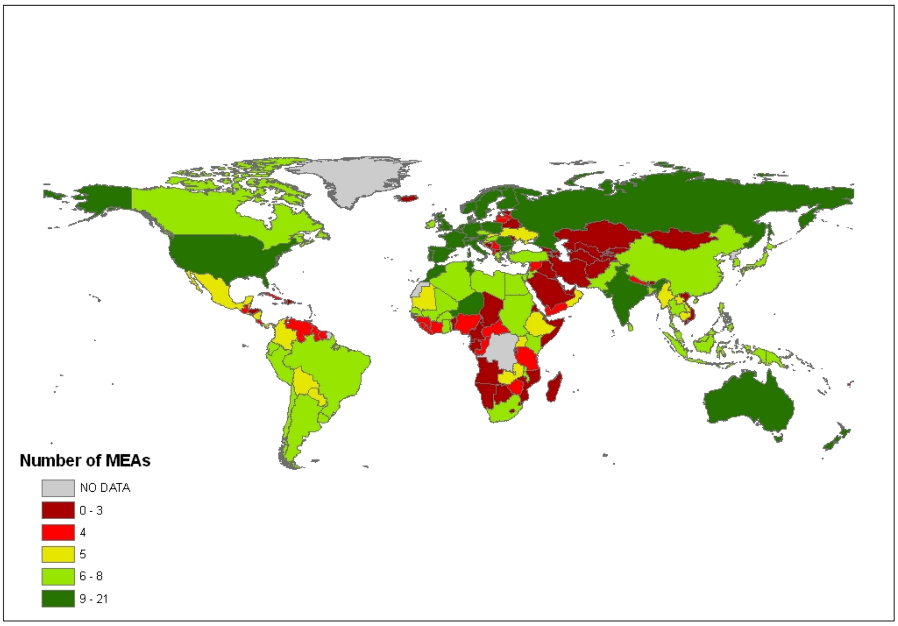

Figure 2.3: The number of multilateral environmental agreements in 2006 - Cluster: Land

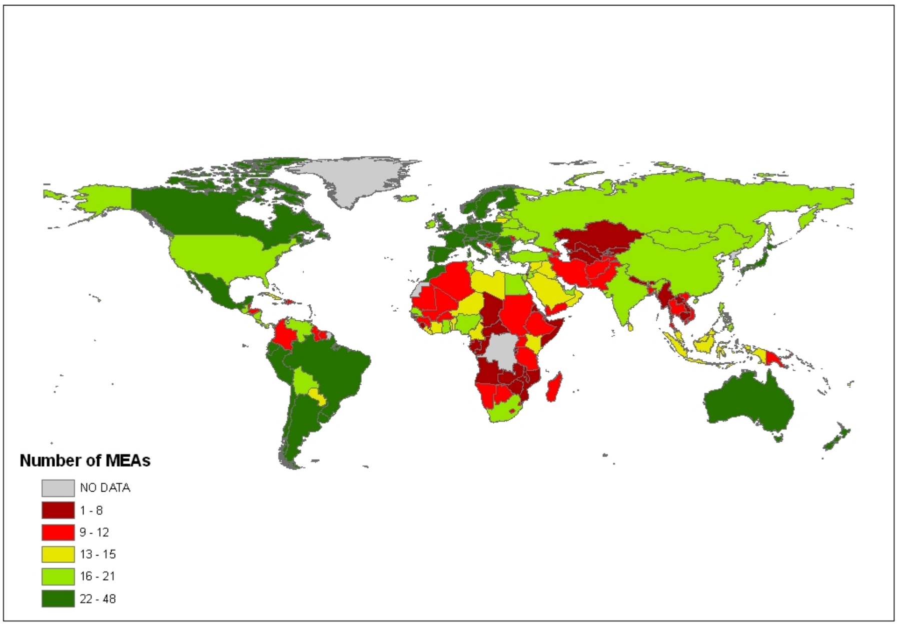

Figure 2.4: The number of multilateral environmental agreements in 2006 - Cluster: Chemicals and hazardous wastes

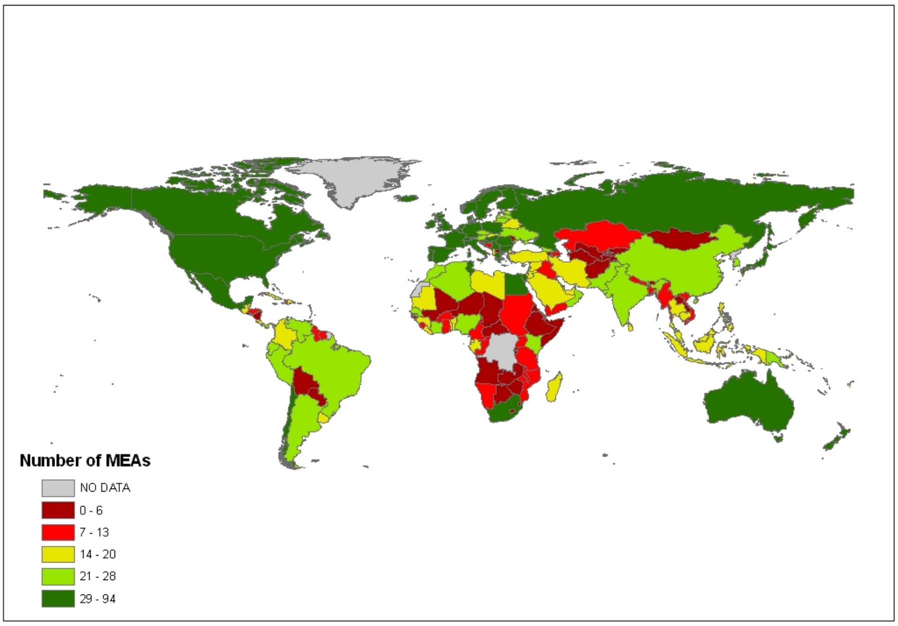

Figure 2.5: The number of multilateral environmental agreements in 2006 - Cluster: Seas

of MEAs in the *atmosphere* cluster. Germany has also ratified the most MEAs in the clusters *land* and *chemicals and hazardous wastes*. Then, in the cluster *seas* again France is the country that shows the highest number of MEAs in 2006. Another interesting aspect is that besides the European countries the United States, Canada, Japan, Korea, India, Australia, New Zealand, Russia, Egypt, Argentina, Chile, Ecuador, and Peru are always to find in the top group of countries (green or dark green). The dominating role of Europe is still obvious but the environmental effort of these countries in terms of ratifying MEAs in all different clusters is remarkable.

2.3 Econometric model

The count of a country's ratification of MEAs over time display strong persistence. For every country and in every year, the number of MEAs a country participates in follows a quite nice MA(1) term with slowly decreasing correlation over time and a sharp decline in partial autocorrelation after a high value in the first period. This is true regarding all MEAs unclassified as well as a specific MEA cluster. Hence, a country's MEA history should definitely be used for explaining the current number of MEAs of a country by including a lagged dependent variable in the econometric model while solving for resulting endogeneity. Due to this, we apply Blundell, Griffith, and Windmeijer (2002) to model the dynamics of the number of MEAs a country ratifies as a dynamic linear feedback model (LFM). This means, we make use of the feedback information of lagged values of the dependent variable. Here the conditional mean of a dependent count variable is assumed to be linear in the history of the process.[4]

[4] see also Windmeijer (2008).

The conditional mean in the standard LFM is defined as

$$\begin{aligned} E\left(y_{it}|y_{it-1}, x_{it}, v_i\right) &= \gamma y_{it-1} + exp\left(x'_{it}\beta\right) v_i \\ &= \gamma y_{it-1} + \mu_{it}\nu_i, \end{aligned} \tag{2.1}$$

where y_{it} denotes the number of MEAs country i, $i = 1, ..., N$, has ratified in year t, $t = 1, ..., T$. x_{it} represents a vector of K explanatory variables and $\nu_i \equiv exp(\eta_i)$ is a permanent scaling factor for the individual specific mean. The parameters γ and β are to be estimated. As the number of MEAs is predetermined, i.e., correlated with past shocks but not current ones,

$$E\left(x_{it}u_{it+j}\right) = 0, \quad j \geq 0,$$
$$E\left(x_{it}u_{it-s}\right) = 0, \quad s \geq 1,$$

we can instrument the contemporaneous values with its second lags and thus solve the endogeneity problem. According to Windmeijer (2008) the LFM can also be motivated as an entry-exit process with the probability of exit equal to $(1 - \gamma)$. Moreover the mean value for y_{it} is bounded below by γy_{it-1} as $\mu_{it}\nu_i$ is non-negative.

In a second step, to imply the effects of clusters on each other, we extend the LFM using the superscript c for cluster.

$$\begin{aligned} E\left(y^c_{it}|y^c_{it-1}, x_{it}, v_i\right) &= \gamma y^c_{it-1} + \tau y^{C\neq c}_{it-1} + exp\left(x'_{it}\beta\right) v_i \\ &= \gamma y^c_{it-1} + \tau y^{C\neq c}_{it-1} + \mu_{it}\nu_i \end{aligned} \tag{2.2}$$

Here, the parameter τ is to be estimated additionally. It measures the impact of the lagged number of MEAs of all other clusters or the bilateral impact of the lagged number of MEAs of one other cluster.

We compared different estimation methods where it turned out that, in context of MEAs, the results of the one-step estimator using Wooldridge moment conditions should be applied instead of other generalized method of moments (GMM) estimators. Corresponding to the indication by Windmeijer (2002) we found out that the efficient two-step GMM estimator which uses the estimates from the one-step estimator for the moments weighting matrix and the continuously updated GMM estimator that directly accounts for the dependence of the moments weighting matrix on the parameters in the optimization (see Hansen, Heaton, and Yaron, 1996) could be severely downward biased because of our small sample, i.e., the small N. And using a finite sample correction with block-bootstrapping in order to solve for the small sample bias could only reproduce the one-step estimator results (cf. chapter 1).

2.4 Determinants of ratifying MEAs

Many excellent theoretical papers analyze environmental agreements by use of stylized emission abatement costs and benefits or climate change damage costs and side payments. Others apply a payoff share of the public good "clean environment" (among many others see Barrett, 1994; Barrett, Stavins, 2003; Carraro, Eyckmans, Finus, 2006; Finus, Rundshagen, 1998a, 1998b; Lange, Vogt, 2002). However, costs and side payments as well as payoff shares are hard to measure. Hence, in our empirical investigation we rely on more fundamental variables, such as economic, environmental, and political determinants, that are likely to be correlated with costs and side payments as well as payoff shares and therefore determine the decision to join or form a MEA. Table 2.1 lists the variables that are used to capture the most important impacts on MEAs.

Table 2.1: Statistics of balanced data

Variable	Obs.	Mean	Std. Dev.	Min	Max
YEAR	5170	1983	13.5660	1960	2006
NUMBER OF MEAs	5170	32.2445	34.4753	0	212
CLUSTER BIODIVERSITY	5170	4.0178	4.4381	0	27
CLUSTER ATMOSPHERE	5170	3.8143	5.4397	0	30
CLUSTER LAND	5170	2.8845	2.7611	0	21
CLUSTER CHEMICALS	5170	8.5178	8.5266	0	48
CLUSTER SEAS	5170	12.9727	15.3181	0	94
CLUSTER $\neq$ BIODIVERSITY	5170	28.2267	30.3859	0	185
CLUSTER $\neq$ ATMOSPHERE	5170	28.4302	29.6939	0	186
CLUSTER $\neq$ LAND	5170	29.3226	32.1034	0	195
CLUSTER $\neq$ CHEMICALS	5170	23.72669	26.3782	0	164
CLUSTER $\neq$ SEAS	5170	19.2718	19.9618	0	123
Economic determinants:					
LGDP	5170	23.5477	2.1554	17.8967	30.0656
LPOP	5170	9.3292	1.4516	6.2086	14.0895
TRADE LIBERAL	5170	1.4270	1.8332	-4.1154	5.2542
INVEST LIBERAL	5170	9.6680	18.5627	0	131
LDC	5170	0.1818	0.3857	0	1
Political determinants:					
PFI	5170	4.9579	1.9583	1	9.6
Environmental determinants:					
PLANT SPECIES	5170	52.8575	111.4035	0	683
AGRRAW	5170	9.4035	13.1677	0	88.7417
CO_2 EMISSIONS	5170	3.6872	4.4801	-0.0197	27.7664

2.4.1 Economic determinants

The number of multilateral environmental agreements and the number of MEAs of the different clusters are applied as described above in section 2.2. For example the variable CLUSTER BIODIVERSITY contains the country specific and yearly number of MEAs related to *biodiversity*. Whereas CLUSTER $\neq$ BIODIVERSITY includes the number of all other MEAs but *biodiversity* MEAs, i.e., the country specific and yearly number of MEAs classified with *atmosphere*, *land*, *chemicals and hazardous wastes*, and *seas*.

To account for size and economic weight of a country we use population together with real gross domestic product (GDP) data from Maddison's (2003) historical time-series and extrapolate GDP and population data for more recent years by using indices of the growth of GDP at real U.S. dollars and of the population from the World Bank's World Development Indicators 2008, respectively. We include log population and log GDP in our empirical model which refer to the acronyms LPOP and LGDP in our tables.

Additionally we include the two economic determinants TRADE LIBERAL and INVEST LIBERAL to our study. INVEST LIBERAL is a measure of a country's investment liberalization that simply reflects the number of bilateral investment treaties (BITs) of a country. And TRADE LIBERAL measures the importance of bilateral and multilateral trade costs, among others through preferential trade agreement (PTA) membership, to account for direct and indirect consequences of trade costs. In a nutshell TRADE LIBERAL represents the trade liberalization of a country, i.e., the inverse of its trade costs[5]. Similar to LGDP and LPOP we use the log of these inverted trade costs for TRADE LIBERAL. Because TRADE LIBERAL or INVEST LIBERAL may be endogenous, we apply Wooldridge's quasi-differencing transformation. This GMM estimator has the ad-

[5] For more details on TRADE LIBERAL and INVEST LIBERAL see chapter 1, Anderson (1979), and Anderson and van Wincoop (2003).

vantage that it can deal with potentially endogenous regressors where $E(x_{it}u_{it}) \neq 0$ by using $E(q_{it}|y_{it-2}, x_{it-2}) = 0$ as a valid moment condition[6].

Finally we include a binary variable for least developed countries (LDC) to spot linkages between the number of MEAs and the development status of a country. This LDC variable is constructed employing data of the United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS).

2.4.2 Political determinants

To measure the influence of countries' institutions on MEA membership we apply an index of political freedom (PFI) which is constructed by the Fraser Institute (see Gwartney, Lawson, Sobel, and Leeson, 2007) and which ranges from 1 to 10. For example this index rates the legal structure and security of property rights as well as the access to sound money in a country. The higher the index, the greater the political freedom in that country.

2.4.3 Environmental determinants

Finally, we include three environmental determinants that are supposed to represent the most important environmental impact in the different MEA clusters.

[6]cf. Wooldridge (1997).

Cluster: Biodiversity

According to the Environmental Performance Index[7] of Yale and Columbia Universities two indicators are used representing *biodiversity* of a country: marine protected area and critical habitat protection. To capture comparable influences of critical habitat protection we apply threatened plant species (labeled as PLANT SPECIES) from the World Bank's World Development Indicators 2008 and extrapolate them for missing years. Unfortunately marine protected area is only available at one point in time and hence not usable for our quasi-differencing model approach. Interestingly the highest number of threatened plant species shows Malaysia in 2004, i.e. 683 threatened plant species, whereas 51% of the observed countries display less than 5 threatened plant species.

Cluster: Atmosphere

Obviously, the most interesting aspect to observe here are CO_2 emissions. From the World Bank's World Development Indicators 2008 we make use of CO_2 emissions, labeled as CO_2 EMISSIONS. We also experimented with CO_2 emissions per capita and CO_2 emissions per GDP but their results in the β parameters did not differ to those of the total CO_2 emissions of a country with respect to the influence on ratifying MEAs as we already measure GDP and population effects with LGDP and LPOP. In 1968 Senegal is the only country which reports a negative CO_2 EMISSIONS value. In all other years its emissions are positive. And it is no wonder that China shows the highest CO_2 EMISSIONS value ever in 2006.

[7] see E. C. Daniel, M. Levy, C. Kim, A. de Sherbinin, T. Srebotnjak, and V. Mara (2008).

Cluster: Land

As a *land* related environmental determinant we apply agricultural raw materials in % of merchandize exports from the World Bank's World Development Indicators 2008. This variable (AGRRAW) ranges from 0% to 88.74%, with an average of 9.4%. In our data Nepal and Singapore have the highest percentage rate of agricultural raw materials in 1960, while Burkina Faso, Benin, and the Central African Republic have the highest percentage shares in 2006. We also experimented with land area (in percent of total land area), the forest area of a country (in percent of total land area or in square kilometers), and a country's permanent cropland (in percent of total land area), but these variables are highly collinear with the included covariates (such as CO_2 EMISSIONS or PLANT SPECIES).

Cluster: Chemicals and hazardous wastes

To filter out a specific impact on environmental agreements inside the *chemicals and hazardous wastes* cluster we also apply CO_2 EMISSIONS. Unfortunately we did not find data of adequate many countries to measure a country's investments in recycling technology or recycling expenses, which we initially planed to use. But CO_2 EMISSIONS capture at least some aspects of *chemicals and hazardous wastes* specific multilateral environmental agreements as these agreements first of all refer to cleaner production and thus partly to lowering CO_2 emissions.

Cluster: Seas

Most MEAs in this cluster are multi-sectoral agreements based on precautionary and preventive approaches. With regard to fishing agreements, regression results of any environmental determinants should be a lot like the results computed for the *biodiversity* cluster. Due to this, we make use of the number of threatened plant species (PLANT SPECIES) as well as agricultural raw materials in % of merchandize exports (AGRRAW). Unfortunately we did not find easy accessible and keen data of fishing quantities which we initially preferred to apply, too. But PLANT SPECIES and AGRRAW capture also submarine threatened plant species and submarine agricultural raw materials like fishes. Thus, they should capture seas related environmental influences like CO_2 EMISSIONS do in the case of the *chemicals and hazardous wastes* cluster.

The data of the above mentioned determinants of MEA participation is not available for all 199 countries that are in our MEA data. As the applied LFM model dictates to use balanced data for estimations, we need to drop some countries and remain with 110 economies (see table 2.1) of which 20 are LDCs according to the UN-OHRLLS[8] definition. The subsequent regression results are based on these 110 economies.

2.5 Results

The results in table 2.2 serve as an overview to the following tables (tables 2.3 to 2.7). Within this table it is easy to compare the impacts of the different lagged dependent variables of the MEA clusters with a benchmark in the first column (representing the results for all MEAs unclassified). Likewise, the benefit of this table is to be able to compare visually more comfortably the different impacts of the exogenous variables on the five MEA clusters.

[8] United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States.

Frist of all the direction of a specific determinant's effect, except the occasional one, is always the same: Lagged dependent variables, economic determinants, and political determinants affect the number of MEAs beneficial, whereas environmental determinants, if they are significant, have a negative impact on the number of MEAs. Coefficients of LGDP and TRADE LIBERAL are large, positive, and significant for all MEA clusters. Only the setting with agreements related to *land* display smaller effects and a significant effect for TRADE LIBERAL only at the 10% significance level. For all other explanatory variables impacts vary between the MEA clusters. An interesting aspect is that for the clusters *biodiversity* and *land* the lagged dependent variable, i.e., the lagged number of MEAs inside the regarded cluster, has no significant impact on the number of MEAs of that cluster. This means, a country's history of MEAs related to *biodiversity* or *land* has no measurable notably impact on ratifying an additional *biodiversity* MEA or *land* MEA, respectively. But the number of all other MEAs very well has a positive significant influence on the respective number of MEAs. It seems like the effect of the lagged number of MEAs of the own cluster is compensated by a positive significant effect of LDC for the *biodiversity* cluster and by LPOP for the *land* cluster. Moreover, LDC has a significant impact only in the setting of all MEAs unclassified and MEAs related to *biodiversity* (see LDC in column 1 and 2 in table 2.2). Likewise, LPOP is positive and significant only in the regressions of *atmosphere* and *land* related MEAs (see LPOP in column 3 and 4 in table 2.2). This means, if a country is more densely populated it is more likely to ratify another MEA classified with *land* or *atmosphere*, and if a country is leased developed it is more likely to ratify another *biodiversity* MEA. Another interesting aspect of the lagged dependent variables is that MEAs classified with *chemicals and hazardous wastes* or *seas* are stimulated 10 times more by their own past number of MEAs than by the number of agreements in other environmental areas. For the cluster *atmosphere* this discrepancy is even higher. It may reflect the higher growth rates in these clusters including the fact that the time-dependent course of their cluster specific number of MEAs is different to time-dependent course of the number of MEAs of all other clusters but the regarded one. To résumé, the linear feedback of either the number of MEAs of the own cluster or the number of MEAs of the other clusters or both is apparent.

The significant positive impact of PFI in the setting with all MEAs and in the setting with *atmosphere* related MEAs and *seas* related MEAs is conformably to the results of Congleton (1992) and Neumayer (2002) who found a positive systematical impact of political institutions on environmental regulations. But this seems not to be the case for the *chemicals and hazardous wastes* cluster. Here the sign of the impact of PFI changes while the effect still remains significant (see PFI in column 5 in table 2.2). One interpretation might be the more democratic a country is organized the less active it is in terms of ratifying environmental agreements with respect to *chemicals and hazardous wastes*. This fits to the observation that only the leading countries of the world – which are mostly democratic – have access to nuclear power, thus, produce hazardous waste, and of course dislike to ratify agreements which may adjust these waste costs intensively. In the same fashion (as the impact of PFI is reversed in the cluster *chemicals and hazardous wastes*) the sign of INVEST LIBERAL switches in the cluster *seas* (see INVEST LIBERAL in the last column in table 2.2). Treaties to invest bilaterally may be beneficial to raise assets from other countries and to cooperate at a non-economic level, such as with environmental agreements in general (see Rose and Spiegel, 2009), but they also seem to be unfavorable for specific environmental agreements, i.e., MEAs classified with *seas*. The precautionary and preventive approach of such an environmental agreement seems to stand in contrast to a country's bilateral investment purposes. But the political freedom seem to be an important driver for these MEAs, as PFI shows the highes coefficient in the cluster *seas*. Another result stepping out of the line are CO_2 EMISSIONS. In the cluster *atmosphere* their effect is significant at the 5% level but switches to a positive sign (see CO_2 EMISSIONS in column 3 in table 2.2). Contrary to the interpretation that democratic countries may prefer not to ratify costly environmental agreements related to *chemicals and hazardous wastes* (see above), in the case of MEAs classified with *atmosphere* the level of CO_2 EMISSIONS plays a favorable role to encourage environmental agreement ratification. This indicates that CO_2 EMISSIONS, and climate change in particular, makes for a global concern many countries pay attention to and hence want to agree on multilaterally. The negative and significant effects of PLANT SPECIES and AGRRAW on the total number of MEAs, the number of MEAs of the cluster *biodiversity*, and the number of MEAs related to *seas* is very reasonable: The higher the number of threatened plant species the less likely a country ratifies a multilateral environmental agreement with respect to this topic. This may reflect again a country's kind of cost avoidance as it is often the case with voluntary environmental agreements. Likewise, agricultural raw materials (in % of merchandize exports) indicates a country's dependency to agricultural products, and according to this to fertile plains, which stands in contrast to natural abundant biodiversity or animal-rich and not nitrate poisoned rivers near farmlands.

Table 2.2: Parameter estimates with $E\left(y_{it}^{c}|y_{it-1}^{c}, x_{it}, v_i\right)$

	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}^{NBMEA}	0.1594***					
$y_{it-1}^{BIODIVERSITY}$		0.0058				
$y_{it-1}^{NBMEA \neq BIODIVERSITY}$		0.0122***				
$y_{it-1}^{ATMOSPHERE}$			0.3833***			
$y_{it-1}^{NBMEA \neq ATMOSPHERE}$			0.0115***			
y_{it-1}^{LAND}				0.0264		
$y_{it-1}^{NBMEA \neq LAND}$				0.0020***		
$y_{it-1}^{CHEMICALS}$					0.0671***	
$y_{it-1}^{NBMEA \neq CHEMICALS}$					0.0073***	
y_{it-1}^{SEAS}						0.0899***
$y_{it-1}^{NBMEA \neq SEAS}$						0.0099***
Economic determinants:						
$LGDP_{it}$	0.8490***	0.5164***	0.4507***	0.1775***	0.6899***	0.5556***
$LPOP_{it}$	0.0901	0.0616	0.1053**	0.2521**	-0.0397	0.1139
TRADE $LIBERAL_{it}$	0.6701***	0.4062***	0.5504***	0.1756*	0.5507***	0.3960***
INVEST $LIBERAL_{it}$	0.0032***	-0.0011	0.0008	0.0019**	0.0006	-0.0061***
LDC_{it}	0.8518*	0.7493**	0.0600	-0.0495	0.0169	-0.0410
Political determinants:						
PFI_{it}	0.0620***	0.0173	0.0325*	-0.0013	-0.0409***	0.0833***
Environmental determinants:						
PLANT $SPECIES_{it}$	-0.0011***	-0.0004**	-0.0003	-0.0002	0.0002	-0.0014***
$AGRRAW_{it}$	-0.0180***	-0.0088**	-0.0079	0.0017	-0.0041	-0.0185***
CO_2 $EMISSIONS_{it}$	-0.0117	-0.0163	0.0495**	-0.0082*	-0.0298**	0.0044

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 110 countries and 5,170 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).

For a closer look to the interactions between the five MEA clusters we ran serval regressions and exchanged the additional lagged dependent variable, i.e., additional to the lagged number of MEAs of the observed cluster, by the number of MEAs of another (or all other) MEA cluster(s). With this approach we try to filter out the bilateral impacts of different clusters of multilateral environmental agreements. For convenience we include in tables 2.3 to 2.7 the regression results of the lagged number of all other MEAs but the observed one as the additional lagged dependent variable you already know from table 2.2.

Cluster: Biodiversity

In table 2.3 the phenomenon of an insignificant impact of the lagged number of MEAs of the observed cluster, here *biodiversity*, is readily identifiable. An interesting fact is that even though the lagged number of *biodiversity* MEAs does not influence the current number of *biodiversity* MEAs the number of MEAs of all other clusters does. The most considerable impact of a lagged dependent variable on the number of MEAs classified with *biodiversity* comes from the *land* and the *chemicals and hazardous wastes* cluster, of which the impact of *chemicals and hazardous wastes* MEAs is actually highly significant (see $y_{it-1}^{CHEMICALS}$ in column 4 in table 2.3). As the other coefficients of column 4 are nearly equal to the ones of column 1 (except for PFI) the feedback of the lagged number of MEAs related to *chemicals and hazardous wastes* seems to be the main driver of the results in the setting with all MEAs but the observed one (see table 2.3, column 1 and 4). In both cases the number of bilateral investment treaties (INVEST LIBERAL) does not play any role for a country's decision to ratify *biodiversity* MEAs. The major impacts of economic determinants come from LGDP, TRADE LIBERAL, and LDC. Please remember that only in the *biodiversity* cluster LDC has a significant impact (cf. table 2.2) on ratifying *biodiversity* MEAs. Here, in table 2.3, this result is even robust to all different settings (cf. LDC in table 2.3 in columns 1 to 5). Robust impacts also become apparent for PLANT

SPECIES and AGRRAW. Independent of controlling for another MEA cluster, these two environmental determinants affect a country's decision to ratify another *biodiversity* MEA adversely. As stated above these negative effects are very plausible.

Cluster: Atmosphere

Interactions of lagged *atmosphere* MEAs and lagged MEAs of other clusters are quite different to those of the *biodiversity* cluster analyzed afore. In table 2.4 in each column the impact of the own lagged dependent variable is much higher than the one of another cluster. MEAs classified with *biodiversity* or *land* are even insignificant. When these feedback variables become insignificant also the impact of LPOP vanishes. Instead of LPOP here INVEST LIBERAL becomes affective (see LPOP and INVEST LIBERAL in columns 2 and 3 in table 2.4). Only LGDP and TRADE LIBERAL of the economic determinants are positive and highly significant in all regressions. PFI is positive and significant in all settings but the one with *biodiversity* MEAs as additional lagged dependent variable. Also CO_2 EMISSIONS are positive and significant in all cases but in the one with MEAs related to *seas*. As already stated above, it seems that countries are aware of their CO_2 emissions and the related global consequences. Thus the level of their CO_2 emissions boosts their probability to ratify MEAs related to *atmosphere*. The highest bilateral impact on ratifying an additional *atmosphere* MEA has the cluster *chemicals and hazardous wastes* followed by the *seas* cluster. An interpretation of the positive effects of $y_{it-1}^{ATMOSPHERE}$, $y_{it-1}^{CHEMICALS}$ or y_{it-1}^{SEAS} in conjunction with the positive effects of TRADE LIBERAL and LGDP on a country's decision to ratify an additional *atmosphere* MEA can be that MEAs of these three clusters are the main focus of developed countries and hence influence each other bilaterally. Reducing hazardous waste, installing fishing quotas, and fighting global warming seem to be linked together and to work somehow supportingly to arrange a common environmental goal with the aid of a multilateral environmental agreement.

Table 2.3: Parameter estimates with $E\left(y_{it}^{c}|y_{it-1}^{c}, x_{it}, v_i\right)$; $c =$*biodiversity*

	Bio-diversity (Number of MEAs)	Bio-diversity (Number of MEAs)	Bio-diversity (Number of MEAs)	Bio-diversity (Number of MEAs)	Bio-diversity (Number of MEAs)
Lagged dependent variables:					
$y_{it-1}^{BIODIVERSITY}$	0.0058	0.0138	0.0139	0.0100	0.0129
$y_{it-1}^{NBMEA \neq BIODIVERSITY}$	0.0122***				
$y_{it-1}^{ATMOSPHERE}$		0.0125**			
y_{it-1}^{LAND}			0.0355*		
$y_{it-1}^{CHEMICALS}$				0.0316***	
y_{it-1}^{SEAS}					0.0185***
Economic determinants:					
LGDP_{it}	0.5164***	0.7391***	0.6095***	0.5637***	0.5471***
LPOP_{it}	0.0616	0.0414	0.0727	0.0630	0.0544
$\text{TRADE LIBERAL}_{it}$	0.4062***	0.5231***	0.5211***	0.3952***	0.4459***
$\text{INVEST LIBERAL}_{it}$	-0.0011	0.0029**	0.0048***	0.0008	0.0030**
LDC_{it}	0.7493**	0.9797**	0.9099**	0.8675**	0.7793**
Political determinants:					
PFI_{it}	0.0173	0.0325***	0.0297**	0.0363***	0.0125
Environmental determinants:					
$\text{PLANT SPECIES}_{it}$	-0.0004**	-0.0004**	-0.0004**	-0.0006***	-0.0002
AGRRAW_{it}	-0.0088**	-0.0110***	-0.0118***	-0.0099***	-0.0081**
$\text{CO}_2\ \text{EMISSIONS}_{it}$	-0.0163	-0.0178	-0.0150	-0.0163	-0.0147

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 110 countries and 5,170 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).

Table 2.4: Parameter estimates with $E\left(y_{it}^{c}|y_{it-1}^{c}, x_{it}, v_i\right)$; $c = atmosphere$

	Atmosphere (Number of MEAs)	Atmosphere (Number of MEAs)	Atmosphere (Number of MEAs)	Atmosphere (Number of MEAs)	Atmosphere (Number of MEAs)
Lagged dependent variables:					
$y_{it-1}^{ATMOSPHERE}$	0.3833***	0.4944***	0.5077***	0.4248***	0.3714***
$y_{it-1}^{NBMEA \neq ATMOSPHERE}$	0.0115***				
$y_{it-1}^{BIODIVERSITY}$		0.0180			
y_{it-1}^{LAND}			0.0168		
$y_{it-1}^{CHEMICALS}$				0.0295***	
y_{it-1}^{SEAS}					0.0266***
Economic determinants:					
LGDP_{it}	0.4507***	0.5343***	0.4232***	0.4218***	0.4475***
LPOP_{it}	0.1053**	0.0783	0.0808	0.1252**	0.0934*
$\text{TRADE LIBERAL}_{it}$	0.5504***	0.5491***	0.4710***	0.5045***	0.5582***
$\text{INVEST LIBERAL}_{itit}$	0.0008	0.0044**	0.0061***	0.0021	0.0011
LDC	0.0600	0.2053	0.1996	0.1238	0.0766
Political determinants:					
PFI_{it}	0.0325*	0.0371	0.0523**	0.0616***	0.0310*
Environmental determinants:					
$\text{PLANT SPECIES}_{it}$	-0.0003	-0.0004	-0.0007**	-0.0006*	-0.0002
AGRRAW_{it}	-0.0079	-0.0089	-0.0112	-0.0084	-0.0075
CO_2 EMISSIONS_{it}	0.0495**	0.0589**	0.0582**	0.0613**	0.0399

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 110 countries and 5,170 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).

Table 2.5: Parameter estimates with $E\left(y_{it}^{c}|y_{it-1}^{c}, x_{it}, v_i\right)$; $c = land$

	Land (Number of MEAs)	Land (Number of MEAs)	Land (Number of MEAs)	Land (Number of MEAs)	Land (Number of MEAs)
Lagged dependent variables:					
y_{it-1}^{LAND}	0.0264	0.0269	0.0263	0.0288	0.0327
$y_{it-1}^{NBMEA \neq LAND}$	0.0020***				
$y_{it-1}^{BIODIVERSITY}$		0.0068***			
$y_{it-1}^{ATMOSPHERE}$			0.0092***		
$y_{it-1}^{CHEMICALS}$				0.0046**	
y_{it-1}^{SEAS}					0.0016*
Economic determinants:					
$LGDP_{it}$	0.1775***	0.2155***	0.223***	0.1988***	0.2282***
$LPOP_{it}$	0.2521**	0.2321**	0.2457***	0.2546**	0.2256**
TRADE $LIBERAL_{it}$	0.1756*	0.1868*	0.1761*	0.1778*	0.1971*
INVEST $LIBERAL_{it}$	0.0019**	0.0027***	0.0012	0.0023**	0.0030***
LDC_{it}	-0.0495	-0.0119	0.0430	-0.0094	0.0023
Political determinants:					
PFI_{it}	-0.0013	0.0003	0.0014	0.0033	0.0013
Environmental determinants:					
PLANT $SPECIES_{it}$	-0.0002	-0.0003	-0.0003	-0.0003*	-0.0003
$AGRRAW_{it}$	0.0017	0.0006	0.0006	0.0008	0.0012
CO_2 $EMISSIONS_{it}$	-0.0082*	-0.0088*	-0.0088**	-0.0088**	-0.0106**

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 110 countries and 5,170 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).

Cluster: Land

Similar to the results of the *biodiversity* cluster in table 2.3 the coefficient of the lagged dependent variable of the number of MEAs related to *land* is insignificant in all settings (see

y_{it-1}^{LAND} in table 2.5). Here bilateral impacts of every other MEA cluster are positive and significant but very small. The highest one show *atmosphere* related MEAs. This means, ratifying an environmental agreement classified with *land* is more or less a stand alone action, but cooperating multilaterally with other countries with respect to, for example, atmospheric environmental concerns encourages a country to additionally agree on a *land* related MEA. Likewise interesting is that the size of a country's population has a positive impact on such an agreement. Other influences do not vary much. LGDP, LPOP, TRADE LIBERAL, INVEST LIBERAL and CO_2 EMISSIONS show up nearly in all regressions with highly significant impacts. Surprisingly AGRRAW (agricultural raw materials in % of merchandize exports) is insignificant in all regressions. Hence, a country appears not to bear in mind to protect its area against, for example, desertification by ratifying a MEA related to *land* even though its exports are highly dependent to agricultural raw materials, or more general, highly dependent to fertile an wet soils. Here the costs of environmental protection via a MEA seem to exceed the related saved revenues in exports of agricultural raw materials.

Cluster: Chemicals and hazardous wastes

Three already mentioned aspects recur in table 2.6. First, in every regression the lagged dependent variable's impact of *chemicals and hazardous wastes* related MEAs is much greater than the influence of another cluster's lagged number of MEAs. Second, the highest bilateral connection between the *chemicals and hazardous wastes* cluster and one other cluster is reflected in *atmosphere* related MEAs, followed by MEAs classified with *seas* (see $y_{it-1}^{ATMOSPHERE}$ and y_{it-1}^{SEAS} in columns 3 and 5 in table 2.6). Third, the clusters *biodiversity* and *land* do not have a significant influence on a country's probability to ratify another *chemicals and hazardous wastes* related MEA. Again the central economic determinants' impacts come from LGDP and TRADE LIBERAL. New and stable in nearly all regressions in table 2.6 is the negative influence of PFI. As stated above, it may be the case that the more democratic a country is organized the less likely it will ratify another MEA related to *chemicals and hazardous wastes*. Likewise, the coefficient of CO_2 EMISSIONS is negative and significant in all regressions. Thus, due to the negative impact of PFI and CO_2 EMISSIONS, the awareness of countries (and in particular of more democratic ones) with respect to CO_2 emissions and the corresponding positive impact on ratifying *atmosphere* MEAs (see table 2.4) is not true for the *chemicals and hazardous wastes* cluster.

Cluster: Seas

In table 2.7 you will find a very constant influence of the lagged dependent number of MEAs related to *seas* on the ratification decision of an additional *seas* MEA. This influence is independent in the supplementary beneficial and significant impacts of MEAs classified with *biodiversity* or *chemicals and hazardous wastes* (see $y_{it-1}^{BIODIVERSITY}$ and $y_{it-1}^{CHEMICALS}$ in columns 2 and 5 in table 2.7). These results indicate that even though MEAs related to *seas* have a bilateral positive and significant impact on *atmosphere* MEAs (see y_{it-1}^{SEAS} in column 5 in table 2.4) this is not the case the other way around (see $y_{it-1}^{ATMOSPHERE}$ in column 3 in table 2.7). Again the number of *land* related MEAs has no explanatory power to a country's decision to ratify *seas* MEAs. As PFI influences the ratification decision of MEAs classified with *seas* positively and significantly, Congleton's (1992) and Neumayer's (2002) results of a positive systematical impact of political institutions on environmental regulations is true for this cluster. The number of threatened plant species (PLANT SPECIES) and agricultural raw materials in % of merchandize exports (AGRRAW) display a robust and constant influence on the number of *seas* MEAs. Both have a negative and significant impact and reflect the above mentioned cost avoidance of countries that are actually in need of environmental protection by *seas* MEAs, for example, due to their high number of threatened submarine plant species.

Table 2.6: Parameter estimates with $E\left(y_{it}^{c}|y_{it-1}^{c}, x_{it}, v_i\right)$; $c =$ *chemicals*

	Chemicals (Number of MEAs)	Chemicals (Number of MEAs)	Chemicals (Number of MEAs)	Chemicals (Number of MEAs)	Chemicals (Number of MEAs)
Lagged dependent variables:					
$y_{it-1}^{CHEMICALS}$	0.0671***	0.0739***	0.0723***	0.0774***	0.0648***
$y_{it-1}^{NBMEA\neq CHEMICALS}$	0.0073***				
$y_{it-1}^{BIODIVERSITY}$		0.0060			
$y_{it-1}^{ATMOSPHERE}$			0.0254***		
y_{it-1}^{LAND}				0.0059	
y_{it-1}^{SEAS}					0.0115***
Economic determinants:					
LGDP_{it}	0.6899***	0.7467***	0.7137***	0.7229***	0.7032***
LPOP_{it}	-0.0397	-0.0287	-0.0275	-0.0292	-0.0382
$\text{TRADE LIBERAL}_{it}$	0.5507***	0.5827***	0.5443***	0.5705***	0.5735***
$\text{INVEST LIBERAL}_{it}$	0.0006	0.0048***	0.0002	0.0050***	0.0023**
LDC_{it}	0.0169	0.0841	0.0987	0.0756	0.0586
Political determinants:					
PFI_{it}	-0.0409***	-0.0245*	-0.0278**	-0.0175	-0.035***
Environmental determinants:					
$\text{PLANT SPECIES}_{it}$	0.0002	0.0001	0.0001	0.0000	0.0002
AGRRAW_{it}	-0.0041	-0.0050	-0.0053	-0.0053	-0.0042
CO_2 EMISSIONS_{it}	-0.0298**	-0.0261*	-0.0261*	-0.0270**	-0.0297**

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 110 countries and 5,170 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).

Table 2.7: Parameter estimates with $E\left(y^c_{it}|y^c_{it-1}, x_{it}, v_i\right)$; $c = seas$

	Seas (Number of MEAs)	Seas (Number of MEAs)	Seas (Number of MEAs)	Seas (Number of MEAs)	Seas (Number of MEAs)
Lagged dependent variables:					
y^{SEAS}_{it-1}	0.0899***	0.0903***	0.0947***	0.0924***	0.0914***
$y^{NBMEA \neq SEAS}_{it-1}$	0.0099***				
$y^{BIODIVERSITY}_{it-1}$		0.0303***			
$y^{ATMOSPHERE}_{it-1}$			0.0072		
y^{LAND}_{it-1}				0.0121	
$y^{CHEMICALS}_{it-1}$					0.0161**
Economic determinants:					
LGDP_{it}	0.5556***	0.5790***	0.6448***	0.6439***	0.5779***
LPOP_{it}	0.1139	0.1283	0.1261	0.1367	0.1245
$\text{TRADE LIBERAL}_{it}$	0.3960***	0.4274***	0.4634***	0.4896***	0.4099***
$\text{INVEST LIBERAL}_{it}$	-0.0061***	-0.0033*	-0.0023*	-0.0019	-0.0047***
LDC_{it}	-0.0410	-0.0464	0.0501	0.0491	0.0074
Political determinants:					
PFI_{it}	0.0833***	0.0791***	0.0842***	0.0841***	0.0840***
Environmental determinants:					
$\text{PLANT SPECIES}_{it}$	-0.0014***	-0.0014***	-0.0012***	-0.0012***	-0.0014***
AGRRAW_{it}	-0.0185***	-0.0189***	-0.0177***	-0.0181***	-0.0182***
CO_2 EMISSIONS_{it}	0.0044	0.0061	0.0088	0.0036	0.0057

Notes: t-statistics in parentheses. *, **, *** indicates that parameters are significant at 10%, 5%, and 1%, respectively. There are 110 countries and 5,170 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).

2.6 Conclusion

Dividing MEAs into five different clusters gives the opportunity for new insights in the size, effective direction, and significance level of regressors and proves that the number of MEAs without classification into different clusters can provide a reliable first impression of the impacts of determinants on ratifying MEAs like we did in chapter 1. The advantage of using the UNEP (2001) definition of MEA clusters is, on the one hand, that specific influences of environmental determinants can be filtered out, meaning there is a quantifiable and significant impact of CO_2 emissions, agricultural raw materials (in % of merchandize exports), and the number of threatened plant species on the ratification decision of MEAs. On the other hand, mutual positive influences between the MEA clusters can be figured out. In this manner MEAs are bilaterally provoking MEAs in other environmental issues. Interestingly the lagged dependent variable, i.e., the history of a country's number of MEAs of the considered cluster, does not always have explanatory power to the current number of MEAs. This is the case for the clusters *biodiversity* and *land*. But here we find bilateral significant influences of the number of MEAs of all other clusters than the regarded one.

All things considered, the positive impacts of LGDP and TRADE LIBERAL dominate all settings and do not differ much between the number of MEAs without classification (see table 2.2) and among the MEA clusters (see tables 2.3 to 2.7). Due to this, we can intensify our interpretation of a positive impulse of globalization on the ratification of MEAs via the rising interconnectedness of all countries worldwide. Additionally we can show that there are further influences of a global interconnectedness on multilateral environmental agreements via the mechanism that different MEA clusters stimulate each other. Thus, a global green contagion is apparent with and within multilateral environmental agreements.

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Chapter 3

Multilateral Environmental Agreements in 2050: Are They Sustainable Enough?

Abstract

Today, reducing CO_2 emissions is a global target which nearly all counties in the world prioritize. Some countries have been ratified up to 30 multilateral environmental agreements regarding the atmosphere until 2006. This number is surging especially since 1989 after the ratification of the Montreal Protocol. Following the findings of the inverted U-shaped Environmental Kuznets Curve and applying a spline model I can show the beneficial impact of the rising number of multilateral environmental agreements on the forecasts of CO_2 emissions until 2050. My results indicate that the number of atmosphere related multilateral environmental agreements indeed generates an environmental friendly spirit among global cooperation of reducing CO_2 emissions and therefore serves well as a basis for effective programs to stop climate change.

3.1 Introduction

A post Kyoto Protocol seems to be a preferential solution to climate change and therefore to the global disagreements and concerns regarding global warming. But as seen in Copenhagen at the end of 2009 the world's government leaders were not able to restart global cooperation aiming to stop climate change. Due to this, the world is full of hope a post Kyoto Protocol will be signed at the next meeting in Cancún (Mexico) 2010. This hope is stimulated by the fact that the current US government displays a moral sense and a much higher awareness to climate change than a decade ago. According to Barac Obama's, statement which has been quoted in the press all over the world, *"we have come a long way, but we have much further to go"*[1]. Even though the USA, as the remaining only one of the industrialized countries in the world, did not yet ratify the Kyoto Protocol (cf. Mitchell, 2007), the fact mentioned above encourage people all over the world to hope for an early global agreement to climate change, i.e., a working post Kyoto Protocol. A

[1] among others see msnbc.com news services, updated 12/19/2009 7:42:09 AM ET, `http://www.msnbc.msn.com/id/34475636/`

bitter disappointment has been apparent in the press after the 15th UN Climate Change Conference in Copenhagen as it became clear that this time no new agreement could be signed. Due to this, one need to pose the question whether such a post Kyoto Protocol is able to afford the huge challenges of global warming and whether this worldwide hope is appropriate and advisable. My data show that multilateral environmental agreements (MEAs) regarding our atmosphere - like the Kyoto Protocol - are measurable beneficial for the purpose of stopping climate change. Moreover, I can show that the rapidly rising number of atmosphere related MEAs, with its underlying CO_2 emission reduction efforts, will play an important role in the countries' CO_2 emission behavior until 2050.

The following section describes and evaluates the applied data within an introductive and descriptive analysis. Section 3.3 outlines the spline model and the corresponding results I use for the projections of the year-fixed effects and the number of atmosphere MEAs in section 3.4. Section 3.5 wraps up the projection results of CO_2 emissions until 2050 with and without impacts of multilateral environmental agreements; and section 3.6 concludes.

3.2 Data description and descriptive statistics

Five different sources span the data corpus of the four variables I make use of in this chapter: Real gross domestic product (GDP) in constant 2000 US$ from Maddison's (2003) historical time-series is extrapolated for missing years by using growth indices at real U.S. dollars from the World Bank's World Development Indicators 2008. Population data is also drawn up from these two sources. Comfortably CO_2 emissions (in kT CO_2) were downloadable at a single blow from World Bank's World Development Indicators 2008. The underlying number of multilateral environmental agreements is made up of the Center for International Earth Science Information Network (CIESIN), Data-base from Socioeconomic Data and Applications Center (SEDAC) (see CIESIN, 2006) and of a dataset by courtesy of Ron Mitchell (see Mitchell, 2007). To filter out the atmosphere related MEAs I make use of the UNEP clusterfication of MEAs (cf. UNEP, 2001). All four variables range from 1960 to 2006 and capture 160 countries (see table 3.1).

Table 3.1: Dataset

Variable	Obs.	Mean	Std. Dev.	Min	Max
Year	7520	1983	13.5660	1960	2006
GDP (bn)	7520	143.3	637.2	0.036	11,410
Population (m)	7520	30.6	107.2	0.016	1,311
CO_2 emissions (kt)	7520	112985	455239	-80	6977011
GDP per capita	7520	5243	8441	62	72674
CO_2 per capita	7520	3.7	5.9	-0.019	94.1
Number of atmosphere MEAs	7520	3	5	0	30

I apply per capita values of GDP and CO_2 emissions for the econometric model. Figures 3.1 and 3.2 display the relationship of these variables, visualizing the findings of the inverted U-shaped Environmental Kuznets Curve – i.e., at first ascending and then decreasing CO_2 emissions with increasing GDP per capita – using the example of six representative countries. In figure 3.1 India represents a developing country with low GDP per capita and thus rising per capita CO_2 emissions with increasing GDP per capita. South Korea, a former developing country, displays a still rising but upward sloping graph which is typical for countries that have been shortly considered as developed. Israel also shows an upward sloping graph, but at a certain GDP per capita value (near 19500 dollars) CO_2 emissions start to fall. Same for Germany, with a peak at around 15000 dollars. Great Britain's peak is even at less than 15000 dollars, but the graph is very volatile. And the United States' per capita CO_2 emissions decrease after around 19500 dollars GDP per capita, like Israel. In figure 3.2 all countries are plotted in one graph to underline the stimulus threshold of around 19500 dollars per capita and the clear Environmental Kuznets Curve relation between per capita values of CO_2 emissions and GDP.

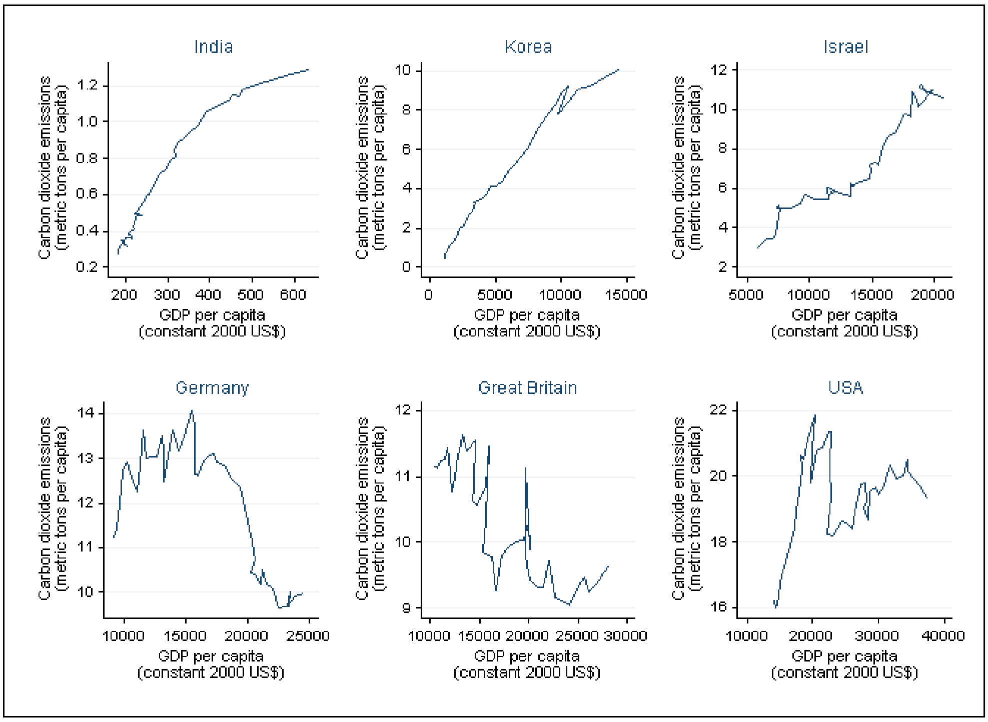

Figure 3.1: Representative countries in different stadiums of the Environmental Kuznets Curve

For the projection approaches in section 3.4 I apply world average annual growth rates for GDP and population from the IPCC emission scenarios IS92 dataset version 1.1 (see Pepper, Xing, Chen, and Moss, 1992). These numbers are to find in table 3.3 in section 3.4. Unfortunately I cannot apply more recent data from the IPCC Special Report on Emission Scenarios (SRES), because there GDP values are accounted as market exchange

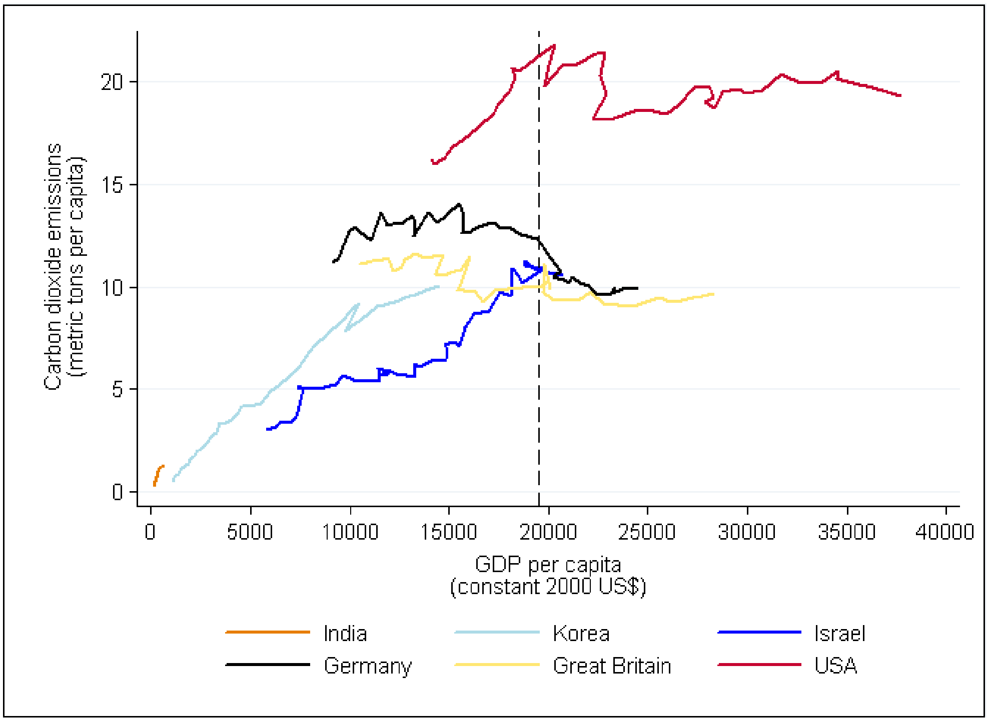

Figure 3.2: Level specific relationship of per capita CO_2 emissions and per capita GDP

rates (mex) instead of constant US$ [2]. But in figure 17 of the IPCC Third Assessment Report (TAR), Climate Change 2001, Working Group I, The Scientific Basis, the very similar trend of CO_2 emissions of the A1B scenario based on data from the IPCC Special Report on Emission Scenarios (SRES) and the ones of IS92 are clearly to see (see figure 3.A.1). Moreover, applying IS92 data my main purpose of this chapter does not suffer any lack of information, as I do not want to reveal another CO_2 emissions forecast like many other researchers before me. What I want to do, is to set CO_2 emissions forecasts in relation to forecasts that account for impacts of multilateral environmental agreements on CO_2 emissions. And with the IPCC IS92 data I can filter out very plastically the beneficial impact of the number of atmosphere MEAs by comparing my results with the ones of Schmalensee, Stoker, and Judson (1998) which are also based on growth rates from IPCC IS92.

[2]cf. IPCC Data Distribution Centre at `http://www.ipcc-data.org/`

As disappointing as I described the outcome of the 15th UN Climate Change Conference in Copenhagen in my introduction, yet it was not. The participants were able to reach a compromise – The Copenhagen Accord (see UNFCCC, 2009) – representing the intention to keep global temperature rises to less than +2°C. This temperature rise until 2050 can be complied with the IPCC A1B scenario (see IPCC SRES, 2000; IPCC TAR, 2001; Pepper, Xing, Chen, and Moss, 1992) which represents a balanced energy mix across all sources, a mid-range increase in CO_2 emissions until 2050, and decreasing CO_2 emissions after 2050. In my opinion, this is a very realistic and plausible scenario for the future - at least for the years until 2050. My projection results in section 3.5 bring the +2°C goal of The Copenhagen Accord face to face to global achievements with multilateral environmental agreements classified with atmosphere. But before I start with statistical impacts of atmosphere MEAs on CO_2 emissions I want to give an introduction to the most important Pros and Cons of MEAs, summarized in a SWOT analysis in figure 3.3.

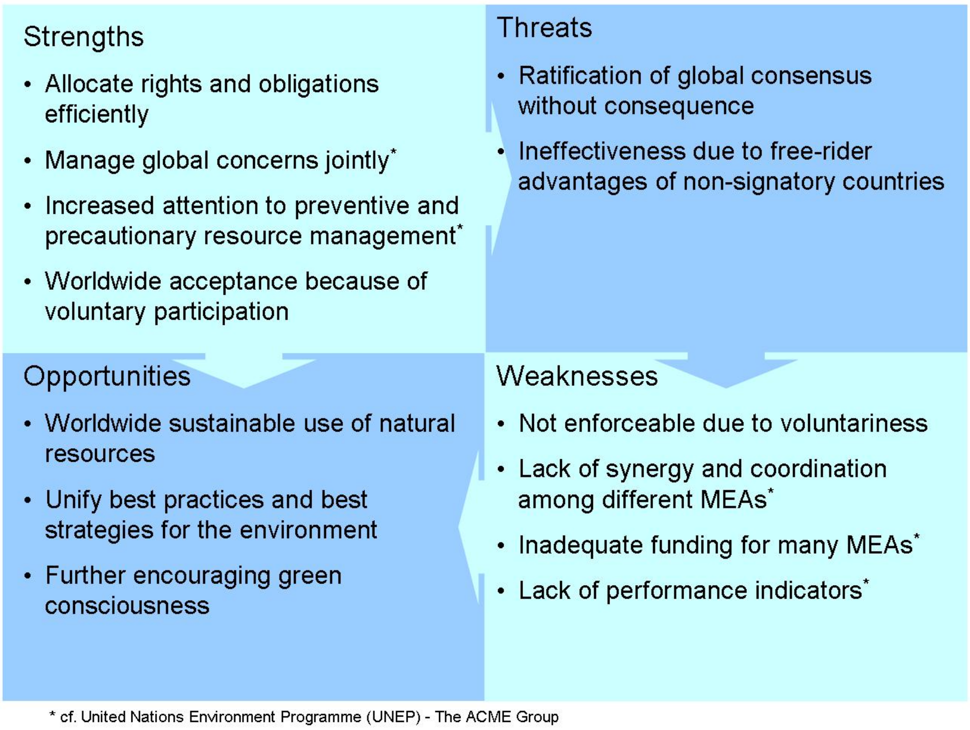

Figure 3.3: SWOT analysis of multilateral environmental agreements

A big advantage of MEAs is their multilateral and voluntary character. To save sovereignty of all countries inside a MEA voluntariness is indispensable. And as environmental concerns do not stop at a country's border joint actions in a multilateral manner are a good way to handle environmental protection. By means of the discussion and negotiation process in the run-up to a MEA this form of global cooperation seems to be a very efficient instrument to allocate the participants' rights and obligations as well as to increase worldwide attention to global environmental affairs with the associated preventive and precautionary resource management. On the one hand these strengths offer opportunities, but on the other hand they contain threats which can result in weaknesses. For example the negotiation process during the pre-agreement period indeed may bring about global consensus. But to what extend this consensus means to comprise consequences arising out of deviating from the agreement or guidances to resource management specific behavioral changes, is often vague. Another ineffectiveness of MEAs may result from the voluntary character and thus from free-rider advantages of not signing or ratifying a MEA (cf. the Kyoto Protocol, which is not ratified by the USA). Numerous authors analyzed these strategic aspects by use of game theoretic approaches (among many others see Barrett and Stavins, 2003; Barrett, 2001; Barrett, 1994; Bloch and Gomes, 2006; Buchholz, Haupt, and Peters, 2005; Caparrós, Hammoudi, and Tazdaït, 2004; Carraro, 1998; Carraro, Eyckmans, and Finus, 2006; Carraro, Marchiori, and Sgobbi, 2005; Chander and Tulkens, 1992; Finus and Rundshagen, 1998; Finus, van Ierland, and Dellink, 2006; Hoel, 1992; Hoel and Schneider, 1997). In my opinion, a material weakness of MEAs is that due to their voluntariness sharp cuts in resource usage or high abatement costs cannot be written down in such agreements. Costly or displeasingly environmental goals generate high incentives not to sign or to deviate from a MEA. This is especially the case for a potential post-Kyoto Protocol. This means that only small steps can be carried through with single MEAs. Till this day the effect of a single MEA is difficult to measure as there is no adequate performance index that captures the different mechanisms of MEAs. But in the medium or long run the sum of a range of MEAs may become equal to an important big step in environmental protection. Coordination among different MEAs is often a problem. On the one hand coordination is important and it would be beneficial to subsume different environmental issues in one MEA. But on the other hand it implies huge coordination efforts with an enormous demand for expertise in all different environmental issue-areas the agreement shall cover. In conjunction with inadequate funding this is often not achievable. But the lack of synergy among different MEAs does not stand in contrast to the opportunities of worldwide sustainable use of natural resources that can be achieved with further efforts in single environmental disciplines. MEAs also support the development and standardization of best practices and best strategies in environmental protection issues. And last but not least the voluntary and multilateral character of MEAs for sure has the opportunity to encourage green consciousness for present and future generations all over the world. Of course this is true for MEAs in general as well as for MEAs classified with atmosphere, on which I am focused in this chapter.

The map in figure 3.4 shows the worldwide distribution of the number of atmosphere MEAs ratified until 2006. The number of atmosphere MEAs is separated into five quantiles: 0-20, 20-40, 40-60, 60-80, and 80-100 quantiles. Hereby countries can be easily classed as countries with the median number of atmosphere MEAs (yellow), countries with a low or the lowest number of atmosphere MEAs (red and dark red), and countries with a high or the highest number of atmosphere MEAs (green and dark green). For example Germany and Luxembourg are dark green colored as they show the highest number of MEAs related to atmosphere in 2006. The United States, Latvia, Cyprus, and Azerbaijan are also dark green colored as they produce just enough MEAs to be in the top group. Interestingly the typical black sheep in terms of emitting CO_2 – the United States, Russia, and China – are colored green or dark green. This fact seems to indicate a first valid reason why hope in more friendly developments of CO_2 emission reductions in the future could be appropriate. The high numbers of atmosphere MEAs state that these countries do not block global

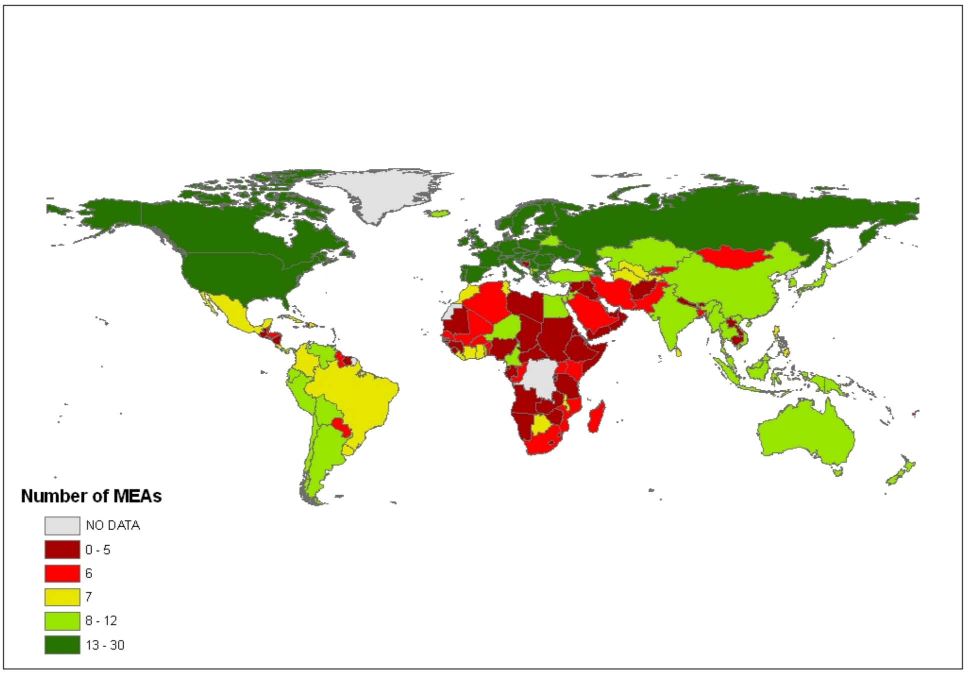

Figure 3.4: The number of atmosphere MEAs in 2006

cooperations in CO_2 emission reductions to the extent negotiation difficulties of the Kyoto Protocol would suggest, e.g., as the USA did not yet ratify that Protocol (cf. Mitchell, 2007).

3.3 Econometric model

According to the Environmental Kuznets Curve the level of GDP per capita matters in terms of a country's CO_2 emission behavior. And according to the graphs in figure 3.1 and 3.2 countries show similar behavior inside a specific GDP per capita range. Hence countries should be sampled into different segments to filter out their segment specific impact on per capita CO_2 emissions. Analogous to Schmalensee, Stoker, and Judson (1998) I apply a spline model with 10 segments. They show that the explanatory power of 10 or 12 segments is not significantly different from using 20 or 24 segments but much more convenient to use. This segmentation is labeled by function F in the following regression equation:

$$ln\,(c_{it}) \;=\; \alpha_i + \beta_t + \eta_s F\left[ln(y_{it}\right] + \epsilon_{it}, \tag{3.1}$$

where c_{it} denotes per capita CO_2 emissions country i, $i = 1, ..., N$ has emitted in year t, $t = 1, ..., T$. α_i and β_t represent the country-fixed and year-fixed effects, respectively. y_{it} are country specific and yearly values of GDP per capita, and η_s specifies the segment specific parameter that is to be estimated. The error term is denoted by ϵ_{it}. In order to be able to compare results of this model with results of a model which additionally captures the impact of MEAs related to atmosphere, I add x_{it-1}, representing the country specific and yearly count of atmosphere MEAs lagged by one period, and the associated segment specific paramter θ_s to equation (3.1). This lag makes sure that potential endogeneity – through an contemporaneous impulse from y_{it} on x_{it} (see chapter 1 and 2) – can be excluded. I also experimented with more than one lag, but results did not change significantly[3]:

$$ln\,(c_{it}) \;=\; \alpha_i + \beta_t + \eta_s F\left[ln(y_{it})\right] + \theta_s F\left[x_{it-1}\right] + \epsilon_{it} \tag{3.2}$$

Results of equation (3.1) and (3.2) are to find in table 3.2. Due to the log-log specification of per capita CO_2 emissions and per capita GDP estimations results of $F\left[ln(y_{it})\right]$ can be directly interpreted as elasticities. The inverted U-shape of the Environmental Kuznets Curve is quite clearly to see. Here it appears first as a backslash followed by the classical inverted U-shape: In the first four segments the effect of GDP per capita is falling from a

[3]Furthermore, estimation results can avert suspicion in endogeneity as coefficients for $F\left[ln(y_{it})\right]$ do not change much (see table 3.2) if controlling additionally for the number MEAs classified with atmosphere. This means with equation (3.2) I am able to filter the effect of the number of atmosphere MEAs out of the country-fixed effect.

high value. Then it rises again up to the middle segments and – skipping the insignificant impact of the 7^{th} segment – from segment 8 onwards the effect is decreasing again. In the 10^{th} segment it is even well below zero and significant. This is true for both equations. According to GDP per capita values India is listed in segments 1 to 4 and Korea in segments 5 to 9 over the whole period between 1960 and 2006. Thus, they can serve pretty well as examples of the two decreasing trends I described above. And as countries like the United States, Germany, France, and Great Britain are part of the 10^{th} segment, the negative and significant effect of this segment becomes plausible having a look at the decreasing CO_2 per capita values with increasing GDP per capita of these countries in figure 3.1 and figure 3.2. MEAs related to atmosphere display a significant impact on the CO_2 emissions per capita in all segments, and as a sign of effectiveness their direction is always negative. Another insight which can be derived from table 3.2 is that with rising segment number the impact of the number of atmosphere MEAs decreases. Unfortunately this does not explain where the declining impact of multilateral environmental agreements at rising GDP per capita stems from. But it may represent the relatively higher effect in reducing CO_2 emissions by countries with relatively lower GDP per capita values, as these countries have a relatively higher marginal product in CO_2 emission reduction (or lower marginal abatement costs) than richer countries that already invest much in CO_2 emission reduction. This fact is backed by the objectives of the Clean Development Mechanism (CDM) with which CO_2 emission reductions of developed countries can be fulfilled in developing countries. Hereby abatement cost saving opportunities can be achieved and the corresponding reduction effort can be used partly to meet the Kyoto Protocol reduction targets of the developed country[4].

[4] cf. The Marrakesh Accords, 2001

Table 3.2: Estimation results of GDP per capita and the number of atmosphere MEAs

		Equation (3.1)	Equation (3.2)	
Segments	GDP range (2000 US$)	GDP per capita	GDP per capita	Number of atmosphere MEAs
(1)	62 - 215	2.3307***	2.4257***	-0.6461***
(2)	215 - 343	0.7762***	0.7669***	0.0139
(3)	343 - 574	-0.0516	-0.0513	-0.2806***
(4)	574 - 928	-0.0420	-0.0496*	-0.1457***
(5)	928 - 1452	1.1769***	1.0406***	-0.1610***
(6)	1452 - 2250	1.2892***	1.0559**	-0.1439***
(7)	2250 - 4231	-0.6268	-0.5618	-0.0887*
(8)	4231 - 8751	0.5938***	0.5313***	-0.0438***
(9)	8751 - 17084	0.1846*	0.2995***	-0.0323***
(10)	17084 - 72674	-0.5199***	-0.4142***	-0.0143

Notes: *, **, *** indicates that parameters are significant at 5%, 1%, and 0.1%, respectively. There are 160 countries and 7,520 observations, or more specifically, 752 observations per segment. Parameters are estimated over the period 1960-2006.

3.4 Projection approach

As forecast models are invented primarily to forecast values one-step ahead and as they loose forecasting power very rapidly by trying to forecast 12 steps ahead or more, I use IPCC projections for population and GDP for the years between 2006 and 2050 from IPCC IS92 (cf. Pepper, Xing, Chen, and Moss (1992)), analogous to Schmalensee, Stoker, and Judson (1998), summarized in table 3.3. Schmalensee, Stoker, and Judson (1998) stated in their paper that a *"serious question is whether [...] per-capita income is likely to be the same in the future as in the recent past, since future decisions in all nations will be* *made with different technologies and environmental information than past decisions" (p. 20, footnote 21).* Because they employed measured data until 1990 and because after 1990 until 2006 countries' activities related to multilateral environmental agreements accelerated enormously, the very fact of data availability of the latest two decades gives new findings and solves their claim to some extend. With my approach of filtering out the impact of the number of atmosphere MEAs I am able to give additional insights into future CO_2 emission reduction efforts in the world by means of environmental agreements.

Table 3.3: IPCC A1B scenario projections of GDP and population

Average annual growth rates	GDP	Population
2006-2025	2.86	1.35
2025-2050	2.10	0.70

To complete the projection approach or rather to extrapolate the remaining two parameters – the year-fixed effects and the number of atmosphere MEAs – I make use of a linear and a nonlinear method like Schmalensee, Stoker, and Judson (1998). With these two methods I try to capture a plausible corridor of the parameters.

The linear approach is a linear spline model with two growth rates for the periods before and after 1980 (superscript l indicating *linear*). t contains the years, $1[t \geq 1980]$ represents a dummy which is zero for the years before 1980, and γ, δ, and κ are to be estimated:

$$\beta_t^l = \gamma^l + \delta^l t + \kappa^l (t - 1980) \cdot 1[t \geq 1980] \qquad (3.3)$$

$$x_{it}^l = \gamma_i^l + \delta_i^l t + \kappa_i^l (t - 1980) \cdot 1[t \geq 1980] \qquad (3.4)$$

From a statistical viewpoint, 1980 symbolizes the start of a growing impact of the number of atmosphere MEAs on the regression results. In figure 3.5 both graphs of the year-fixed effects run parallel before 1980. But afterwards the regression that accounts for the number of atmosphere MEAs has a higher gradient. Thus, I try to capture this point of separation with a different trend for the years after 1980.

The nonlinear method (with superscript *nl*) aims to cover the upward sloping trend of the year-fixed effects over the whole course of time. Here a logarithmic function comes very close to the real trend. In distinction to the linear approach all years of the dataset are taken into account:

$$\beta_t^{nl} = \gamma^{nl} + \delta^{nl} t + \kappa^{nl} ln(t - 1950) \tag{3.5}$$

$$x_{it}^{nl} = \gamma_i^{nl} + \delta_i^{nl} t + \kappa_i^{nl} ln(t - 1950) \tag{3.6}$$

For the linear and nonlinear projection approach of the year-fixed effects (equations (3.3) and (3.5)) I need to exclude the years after 2001. In figure 3.5 the sharp decline in the year-fixed effects in 2001, representing the impacts of 10/11, is clearly to see. If I had used the years 2002 to 2006 for the projection, I would have projected only further declining year-fixed effects after 2006 and for all following years. As this drop is still predominant in the last year of my sample, it outweighs the actually upward sloping trend of the whole sample and thus leads to incorrect and undersized projections. This is particularly serious for the nonlinear projection approach. Due to this, without loss of generality I use only the years 1960 to 2001 for the year-fixed effects projections.

Similar to the year-fixed effects I project the number of atmosphere MEAs linearly as well as nonlinearly applying equations (3.4) and (3.6). Projection results open a corridor of a

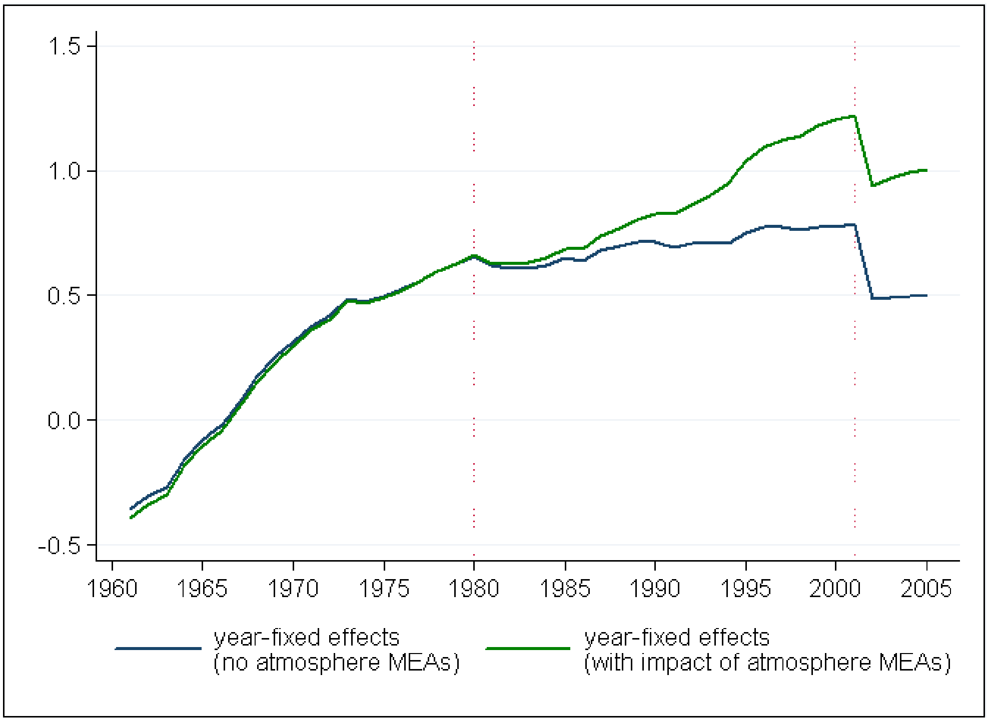

Figure 3.5: Year-fixed effects between 1960 and 2006

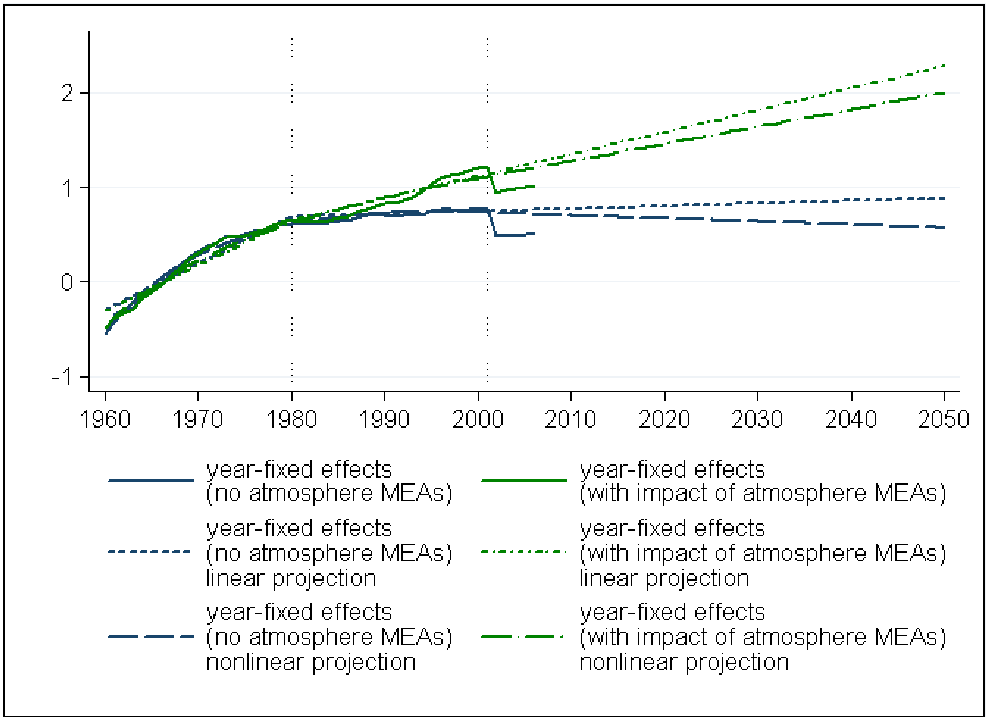

Figure 3.6: Year-fixed effects projections until 2050

world average number of 25 to 29 atmosphere MEAs in 2050 (see figure 3.7), i.e., nearly as many atmosphere MEAs as Germany or Luxembourg already have in 2006. In my opinion, this is a plausible future scenario of a realistic average number of atmosphere MEAs in the world. Between 1980 and 2006, e.g., Germany and Luxembourg raised their number of atmosphere MEAs from 4 and 5 to 30. In other words, they increased sixfold their number of atmosphere MEAs within 26 years. Thus, it should be plausible to assume the world average number of MEAs to raise from 9 (in 2006) to 25 or 29 (in 2050). This means, on average the number of atmosphere MEAs in the world only needs to be tripled until 2050, and there are nearly double as many years to fulfill the triplication than Germany and Luxembourg had.

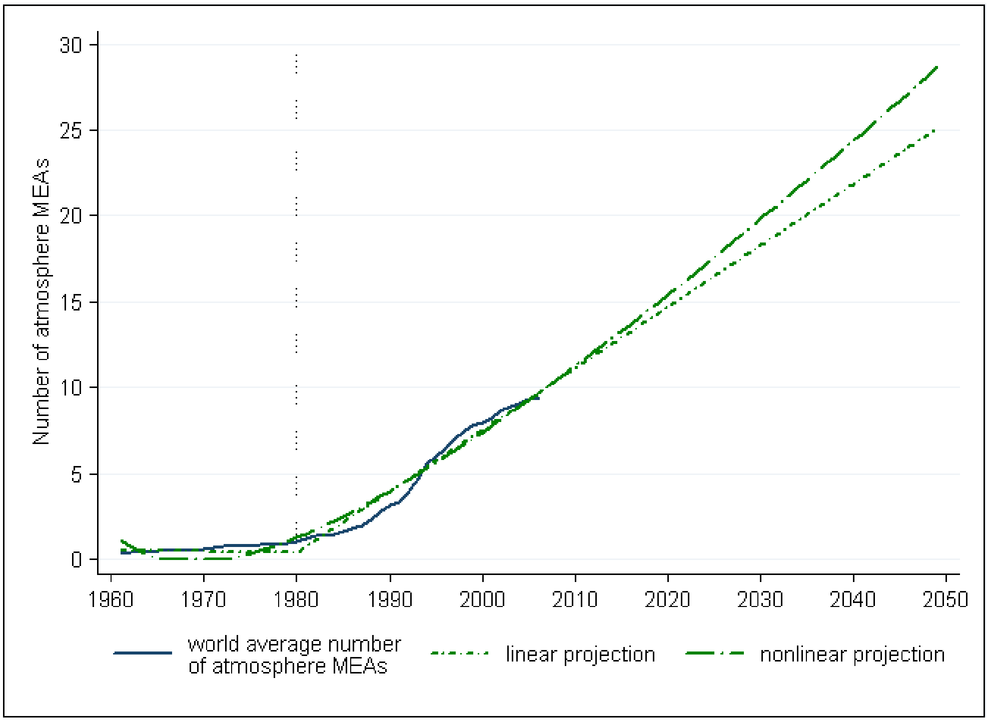

Figure 3.7: World average number of atmosphere MEAs between 1960 and 2050

3.5 Results

Employing the projections of GDP and Population, which are based on IPCC A1B scenario growth rates, and the linearly and nonlinearly projected year-fixed effects and number of atmosphere MEAs, applying spline models, I can now compute the corresponding CO_2 emissions until 2050.

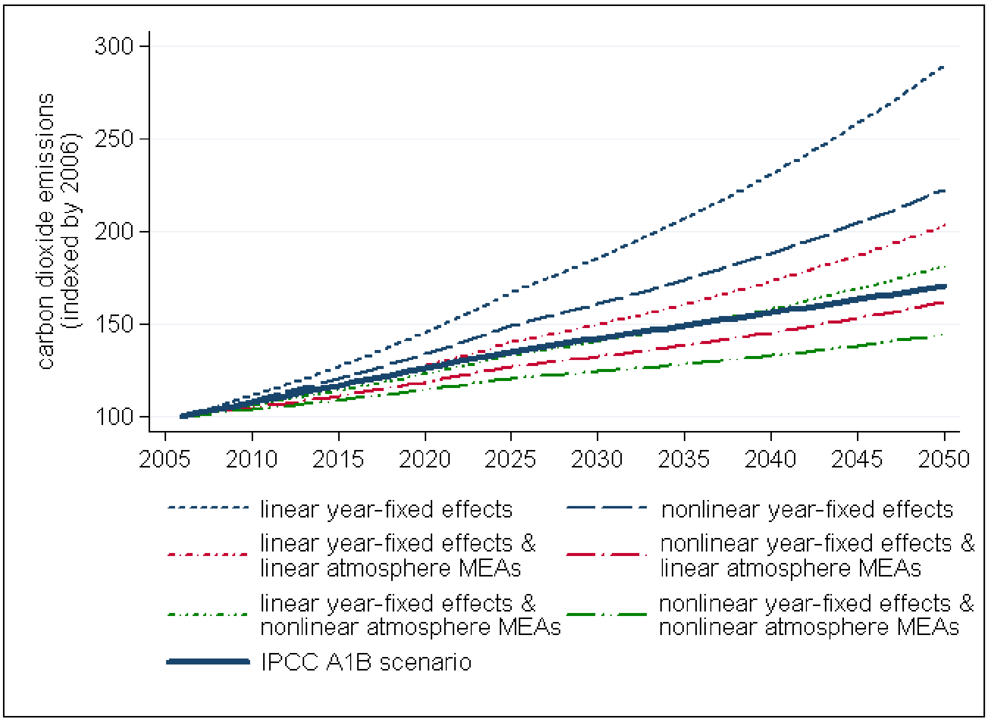

Figure 3.8: Carbon dioxide emission projections

In figure 3.8 you find one benchmark curve of the IPCC A1B scenario, two curves representing the 10-segment spline model results with linear and nonlinear projection approaches of the year-fixed effects, and four curves based on different combinations of linear and nonlinear projections of the year-fixed effects and the number of atmosphere MEAs. For an easier identification of the curves I use short dashes for CO_2 emissions results based on linear projections of year-fixed effects and long dashes for results with nonlinear projected year-fixed effects. One dot separating the dashes indicates additionally linear projected atmosphere MEAs. And two dots separating the dashes symbolize results of an underlying nonlinear projection approach of the number of atmosphere MEAs. The two curves that do not consider the number of atmosphere MEAs (short dashes and long dashes without dots) are very similar to the results of Schmalensee, Stoker, and Judson (1998). Here CO_2 emissions double or nearly triple, compared to emissions in 2006, reaching an index value of 222 and 289, respectively[5]. But taking into account the growing number of multilateral environmental agreements related to atmosphere, CO_2 emissions projection results can be reduced quite a lot (cf. red curves vs. blue curves in figure 3.8). By introducing linearly projected atmosphere MEAs corresponding CO_2 emissions projections can be reduced by 86 index points, i.e., 29.8% in 2050 (short-dash curve vs. short-dash-dot curve) or by 60 index points and 27.0% (long-dash curve vs. long-dash-dot curve), respectively. With the latter setting CO_2 emissions projections can actually undercut the IPCC A1B scenario projections. And assuming both nonlinear projected year-fixed effects and atmosphere MEAs, results can fall short even further. More precisely, here CO_2 emissions projections are 26 index points or 15.3% lower than the IPCC A1B scenario projections in 2050. In relation to the curve that does not account for atmosphere MEAs (but also contains non-linear projected year-fixed effects) this impact actually equals 78 index points or 35.1% less CO_2 emissions in 2050. This means, the moderate accelerating number of MEAs classified with atmosphere (cf. atmosphere MEAs projections in section 3.4) intensifies its impact on CO_2 emissions over time to the extent that emissions can be reduced by up to 35.1% or even 37.4% in 2050 relative to projections not considering atmosphere related multilateral

[5] In fruitful discussions with Maximilian Auffhammer during his stay at the Ifo Institute for Economic Research at the Univerity of Munich I learned about another model setting which probably predicts the total level of CO_2 emissions more precisely. In a forthcoming paper Aufhammer and Steinhauser (2010) show that their new model setting of a slightly changed composition of a reduced form model can outperform a littel the one of Schmalensee, Stoker, and Judson (1998) on the basis of U.S. CO_2 emissions data at the state level. But in a performance test between their best model and the ones of Holtz-Eakin and Selden (1995), Yang and Schneider (1998), and Schmalensee, Stoker, and Judson (1998) the *"Schmalensee et al. (1998) predictions lie closest to the best model among the three" (Auffhammer and Steinhauser, 2010, p.17)*. In addition, as I compute the differences of CO_2 emissions projections between equations (3.1) and (3.2) this slight lack in accuracy does not harm my relative effects.

environmental agreements. These values represent comparisons that can be drawn from the two scenarios based on nonlinear projected year-fixed effects and the two scenarios assuming linear projected year-fixed effects, respectively. Interestingly all four settings that account for the impact of a growing number of atmosphere MEAs are located around the IPCC A1B scenario. Thus, they open a corridor in which it seems to be possible to fulfill the +2°C goal of the Copenhagen Accord with the aid of small but continuous steps achieved with atmosphere related multilateral environmental agreements.

3.6 Conclusion

Multilateral environmental agreements in general and multilateral environmental agreements classified with atmosphere in particular are a good tool to bring the world or at least more than two countries to a round table to discuss about climate change and other atmosphere related topics, and to decide the participants' affords optimizing it. Till this day they represent the one and only way to come to a global agreement about global warming. This effort can be attributed to the United Nations Framework Convention on Climate Change (UNFCCC) or more specifically to the Kyoto Protocol. Analyzing the quantitative effects of atmosphere MEAs on the fight against climate change, i.e. reducing CO_2 emissions, yields to a optimistic view. There is a significant and negative effect of atmosphere MEAs on CO_2 emissions, and they can bring about enough sustainable development to succeed a temperature rise less than +2°C until 2050.

This leads me to the conclusion that current and future atmosphere MEAs on its own are sufficient in stopping climate change. My results can grant them a sustainable impulse in global warming efforts. Green thinking of many countries' politicians and a growing eco-friendly consciousness may embody the foundation of further necessary measures (like

CO_2 certificate trading or carbon tax policies) in order to limit CO_2 emissions even more effectively. But atmosphere MEAs seem to cope it or at least seem to make a major contribution to reasonable CO_2 emissions reductions until 2050.

"How do you feel about [multilateral environmental agreements]?
Tell me, pray.
You are a dear, good-hearted man,
But I believe you've little good of it to say."
(J. W. von Goethe, Faust, 1808, p. 226)

Appendix - Chapter 3

3.A.1 CO_2 emissions of the IPCC A1B scenario

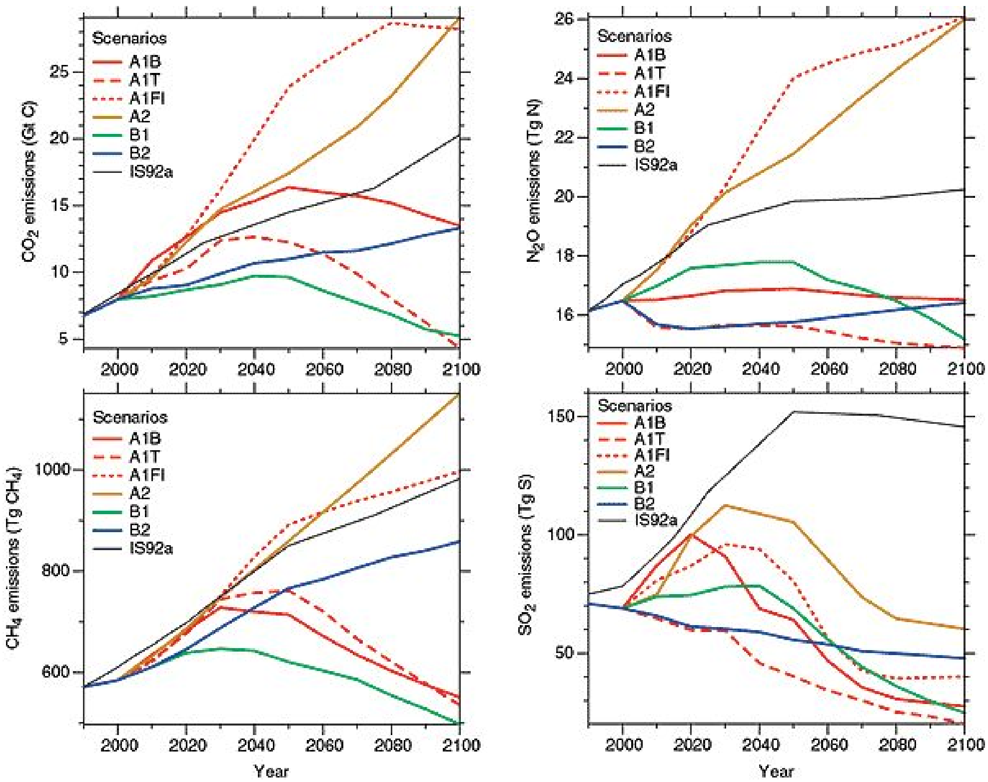

Figure 3.A.1: IPCC SRES scenarios

This is figure 17 of the IPCC Third Assessment Report (TAR), Climate Change 2001, Working Group I, The Scientific Basis (see IPCC TAR, 2001; downloadable at `http://www.grida.no/publications/other/ipcc_tar/`). In the upper left box the very similar trend of CO_2 emissions of the A1B scenario, based on data from the IPCC Special Report on Emission Scenarios (SRES) (see IPCC SRES, 2000), and the emissions of the IS92 (see Pepper, W. J., X. Xing, R. S. Chen, and R. H. Moss, 1992) is clearly to see.

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Ich versichere hiermit eidesstattlich, dass ich die vorliegende Arbeit selbstständig und ohne fremde Hilfe verfasst habe. Die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sowie mir gegebene Anregungen sind als solche kenntlich gemacht. Die Arbeit wurde bisher keiner anderen Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht.

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