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Multilateral Environmental Agreements up to 2050: Are They Sustainable Enough?

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Abstract

Today, reducing CO_2 emissions is a global target which nearly all countries in the world prioritize. Some countries have ratified up to 30 multilateral environmental agreements regarding the atmosphere up to 2006. This number has been surging 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 up to 2050. My results indicate that the number of atmosphere-related multilateral environmental agreements generates good will among global cooperation efforts towards reducing CO_2 emissions and therefore provides a good basis for effective programs to stop climate change.

JEL Code: C13, E17, F53, Q51, Q56.
Keywords: Climate change, CO_2 emissions, environmental agreements, forecasting, spline model.

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1 Introduction

A post-Kyoto Protocol seems to be a preferential solution to climate change which would address 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 aimed at stopping climate change. In spite of this, there was a sense of hope that a post-Kyoto Protocol would be signed at the next meeting in Cancún (Mexico) 2010. This hope has been buoyed by the fact that the current US government displays more moral sense and a much higher awareness of climate change than a decade ago. According to Barack 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 is the only one of the industrialized countries in the world still to ratify the Kyoto Protocol (cf. Mitchell, 2007), the fact mentioned above encourages people all over the world to hope for an early global agreement to climate change, i.e., a working post-Kyoto Protocol. A sense of bitter disappointment has been apparent in the press after the 15th UN Climate Change Conference in Copenhagen, as it became clear that no new agreement would be signed. Due to this, one needs to pose the question whether such a post-Kyoto Protocol is able to address the huge challenges of global warming and whether the worldwide belief invested in this course of action is appropriate and advisable. My data show that multilateral environmental agreements (MEAs) regarding our atmosphere - like the Kyoto Protocol - are measurably 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 up to 2050.

The following section describes and evaluates the data to be applied within an introductive and descriptive analysis. Section 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 4. Section 5 wraps up the projection results of CO_2 emissions up to 2050 with and without the impacts of multilateral environmental agreements; and section 6 concludes.

2 Data description and descriptive statistics

Five different sources provide the data base for the four variables I make use of in this paper: 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. CO_2 emissions (in kt CO_2) were conveniently downloadable 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

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

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 1).

Table 1: Dataset

Variable	Obs.	Mean	Std. Dev.	Min	Max
Year	7520	1983	13.6	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	112,985	455,239	-80	6,977,011
GDP per capita	7520	5,243	8,441	62	72,674
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 1 and 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 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, typical for countries that have been recently considered as developed. Israel also shows an upward sloping graph, but at a certain GDP per capita value (near 19,500 dollars) CO_2 emissions start to fall. Similarly for Germany, with a peak at around 15,000 dollars. Great Britain's peak is at even less than 15,000 dollars, but the graph is very volatile. The United States' per capita CO_2 emissions decrease after around 19,500 dollars GDP per capita, like Israel. In figure 2 all countries are plotted in one graph to underline the stimulus threshold of around 19,500 dollars per capita and the clear Environmental Kuznets Curve relation between per capita values of CO_2 emissions and GDP. Later in section 3 these relationships will be reflected in the regression results, and with that justify applying GDP per capita to explain the countries' CO_2 emissions by means of the respective equations in that section. For example, countries with the highest GDP per capita values (between 17,084 and 72,674 dollars) are the only ones that exhibit lowering impacts on per capita CO_2 emissions.

For the projection approaches in section 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

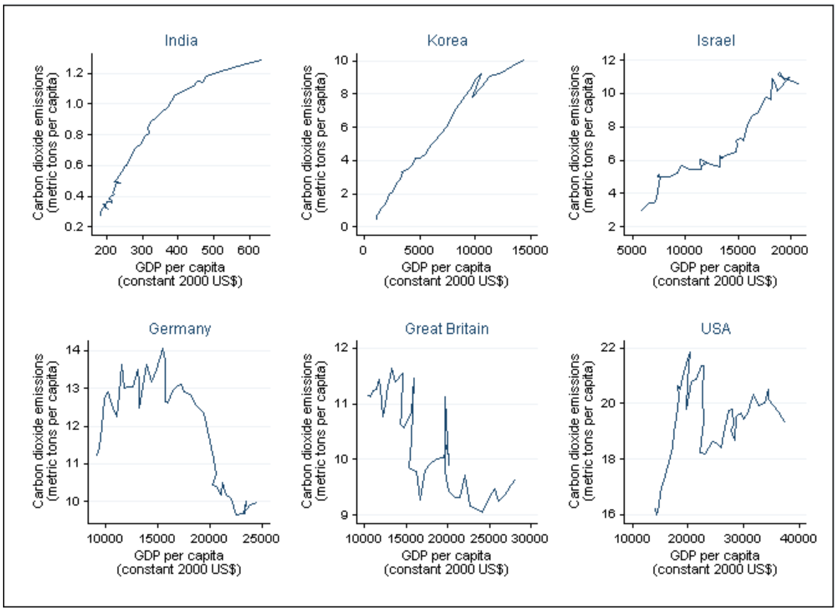

Figure 1: Representative countries in different stadiums of the Environmental Kuznets Curve

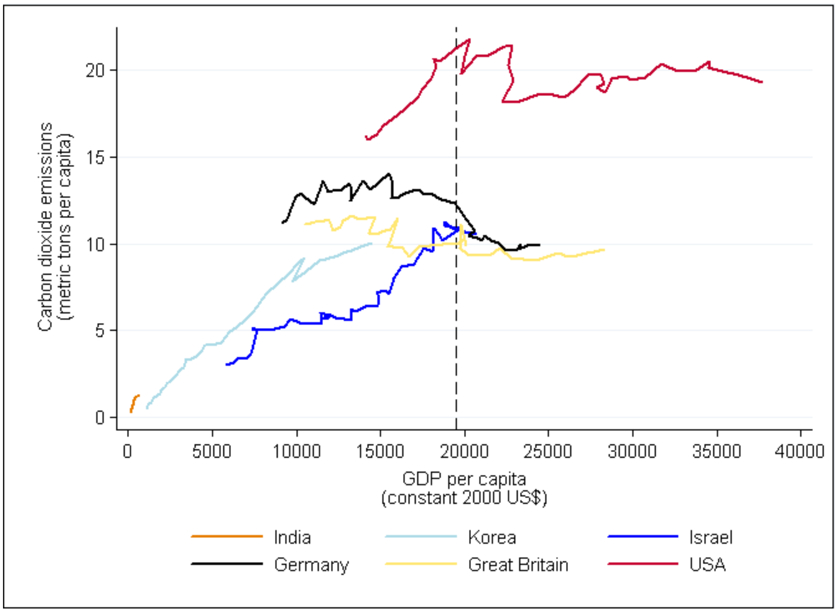

Figure 2: Level specific relationship of per capita CO_2 emissions and per capita GDP

are to be found in table 3 of section 4. Unfortunately I cannot apply more recent data from the IPCC Special Report on Emission Scenarios (SRES), because there GDP values are denoted at market exchange 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 be seen (see figure A1). Moreover, by the use of IS92 data the main purpose of this paper is not constrained by any lack of current figures, because I do not want to reveal another up-to-date CO_2 emissions forecast in the fashion of many other researchers before me. What I want to do, is to consider CO_2 emissions forecasts in relation to forecasts that account for the impacts of multilateral environmental agreements on CO_2 emissions. With the IPCC IS92 data I can filter out very vividly the beneficial impact of the number of atmosphere MEAs by comparing my results with those of Schmalensee, Stoker, and Judson (1998) which are also based on growth rates from IPCC IS92.

Though I described the outcome of the 15th UN Climate Change Conference in Copenhagen as disappointing in my introduction, the participants were however able to reach a compromise – The Copenhagen Accord (see UNFCCC, 2009) – which represents the intention to keep rises in global temperature to less than $+2°C$. This rise in temperature 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 up to 2050. My projection results in section 5 confront the $+2°C$ goal of The Copenhagen Accord with global achievements due to multilateral environmental agreements classified with atmosphere. But before I start with the statistical impacts of atmosphere MEAs on CO_2 emissions, I want to introduce the most important Pros and Cons of MEAs, summarized in a SWOT analysis in figure 3.

A big advantage of MEAs is their multilateral and voluntary character. To preserve the sovereignty of all countries inside a MEA voluntariness is indispensable. As environmental concerns do not stop at a country's border, joint actions of a multilateral form 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 attract 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 may indeed bring about global consensus. But to what extent this consensus means to deal with the consequences if a country deviates from the agreement, or provide guidance to resource management specific behavioral changes is often vague. Another ineffectiveness of MEAs may result from their voluntary character and thus from free-rider advantages of not signing or ratifying a MEA (e.g., the Kyoto Protocol, which is not ratified by the USA). Numerous authors have 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,

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

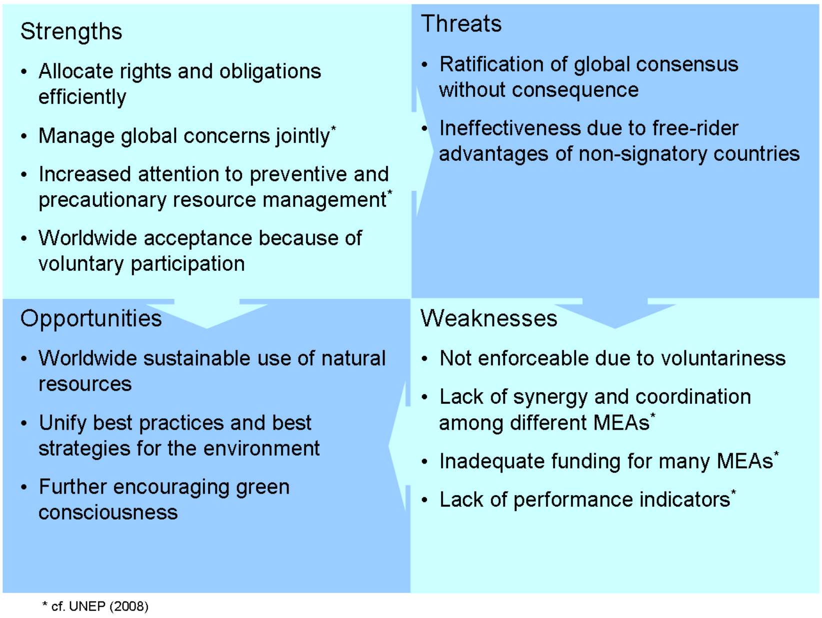

Figure 3: SWOT analysis of multilateral environmental agreements

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 unsatisfactory environmental goals generate high incentives not to sign or to deviate from a MEA. This especially is the case for a potential post-Kyoto Protocol. This means that only small steps can be taken with single MEAs. Up to the present time 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 further problem. On the one hand, coordination is important and it would be beneficial to subsume different environmental issues in one MEA. On the other hand, it implies huge coordination efforts with an enormous demand for expertise in all the different environmental issue-areas which 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 further the development and standardization of best practices and best strategies in environmental protection issues. Last but not least, the voluntary and multilateral character of MEAs encourages green consciousness for present and future generations all over the world. This is of course also true for MEAs in general, as well as for MEAs classified with atmosphere, which I will be focused on in this study.

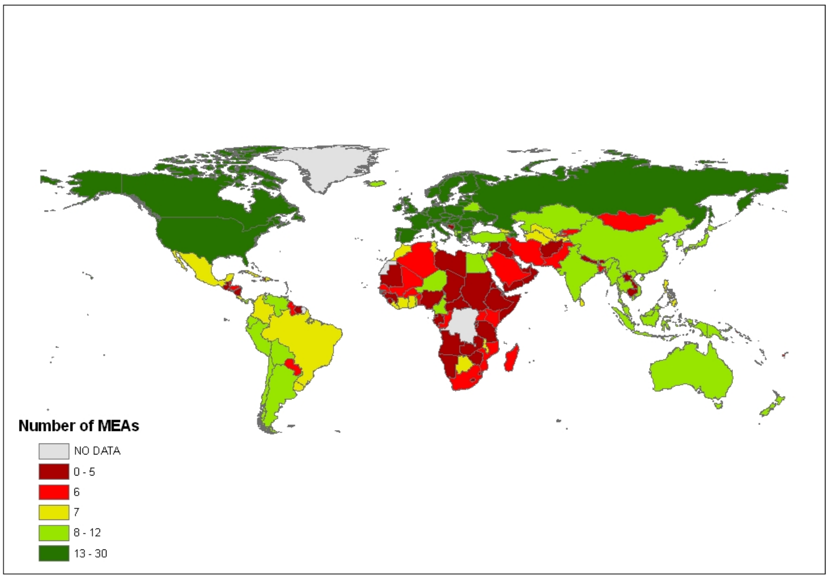

Figure 4: The number of atmosphere MEAs in 2006

The map in figure 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 indicates why hope in more positive developments in the reduction of CO_2 emissions in the future might not be misplaced. The high number of atmosphere MEAs state that these countries do not block global cooperations to reduce CO_2 emissions to the extent which the negotiation difficulties of the Kyoto Protocol would suggest, e.g., as shown by the fact that the USA did not yet ratify that Protocol (cf. Mitchell, 2007).

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 1 and 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. Similar 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:

$$ln\,(c_{it}) \quad = \quad \alpha_i + \beta_t + \eta_s F\,[ln(y_{it}] + \epsilon_{it}, \qquad (1)$$

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 parameter θ_s to equation (1). This lag ensures that potential endogeneity or collinearity – through a contemporaneous impulse from c_{it} on x_{it} or y_{it} on x_{it} (see Egger, Jessberger and Larch, 2011a and 2011b) – can be excluded. I also experimented with more than one lag, but results did not change significantly:[3]

$$ln\,(c_{it}) \quad = \quad \alpha_i + \beta_t + \eta_s F\,[ln(y_{it})] + \theta_s F\,[x_{it-1}] + \epsilon_{it} \qquad (2)$$

Results of equation (1) and (2) are to be found in table 2. Due to the log-log specification of per capita CO_2 emissions and per capita GDP estimations, results of $F\,[ln(y_{it})]$ can be directly interpreted as elasticities. The inverted U-shape of the Environmental Kuznets Curve can be quite clearly seen. 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 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 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 as examples of the two decreasing trends described above. 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 when observing the decreasing CO_2 per capita values with increasing GDP per capita of these countries in figure 1 and figure 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 2 is that with the 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. It may however represent the relatively higher effect in reducing CO_2 emissions by countries with relatively lower GDP per capita

[3]Furthermore, estimation results can avert suspicion in endogeneity as coefficients for $F\,[ln(y_{it})]$ do not change much (see table 2) if controlling additionally for the number MEAs classified with atmosphere. This means that with equation (2) I am able to filter the effect of the number of atmosphere MEAs out of the country-fixed effect.

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 supported by the objectives of the Clean Development Mechanism (CDM) where the reduction of CO_2 emissions in developed countries can also be fulfilled by developing countries. Hereby abatement cost saving opportunities can be achieved and the corresponding reduction effort can be used in part to meet the Kyoto Protocol reduction targets of the developed countries.[4]

Table 2: Estimation results of GDP per capita and the number of atmosphere MEAs

		Equation (1)	Equation (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 - 1,452	1.1769***	1.0406***	-0.1610***
(6)	1,452 - 2,250	1.2892***	1.0559**	-0.1439***
(7)	2,250 - 4,231	-0.6268	-0.5618	-0.0887*
(8)	4,231 - 8,751	0.5938***	0.5313***	-0.0438***
(9)	8,751 - 17,084	0.1846*	0.2995***	-0.0323***
(10)	17,084 - 72,674	-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.

4 Projection approach

Forecast models are invented primarily to forecast values one-step ahead, however as they lose forecasting power very rapidly when 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 (see Pepper, Xing, Chen, and Moss, 1992), analogous to Schmalensee, Stoker, and Judson (1998), summarized in table 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*

[4]cf. The Marrakesh Accords, 2001.

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 up to 1990, and because from 1990 up to 2006 countries' activities related to multilateral environmental agreements increased enormously, the availability of data of the last two decades provides new findings and solves their claim to some extent. 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: 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:

$$\beta_t^l = \gamma^l + \delta^l t + \kappa^l (t - 1980) \cdot 1[t \geq 1980] \quad (3)$$

$$x_{it}^l = \gamma_i^l + \delta_i^l t + \kappa_i^l (t - 1980) \cdot 1[t \geq 1980] \quad (4)$$

From a statistical point of view, 1980 symbolizes the start of a growing impact of the number of atmosphere MEAs on the regression results. In figure 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 at covering 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. Unlike the linear approach all years of the dataset are taken into account:

$$\beta_t^{nl} = \gamma^{nl} + \delta^{nl} t + \kappa^{nl} ln(t - 1950) \quad (5)$$

$$x_{it}^{nl} = \gamma_i^{nl} + \delta_i^{nl} t + \kappa_i^{nl} ln(t - 1950) \quad (6)$$

For the linear and nonlinear projection approach of the year-fixed effects (equations (3) and (5)) I need to exclude the years after 2001. In figure 5 the sharp decline in the year-fixed effects in 2001, representing the impacts of 10/11, is clear to see. If I had used the years from 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 actual upward sloping trend of the whole sample and thus leads to incorrect and undersized projections. This is particularly severe for the nonlinear projection approach. As a result of this, without loss of generality I use only the years from 1960 to 2001 for the year-fixed effects projections.

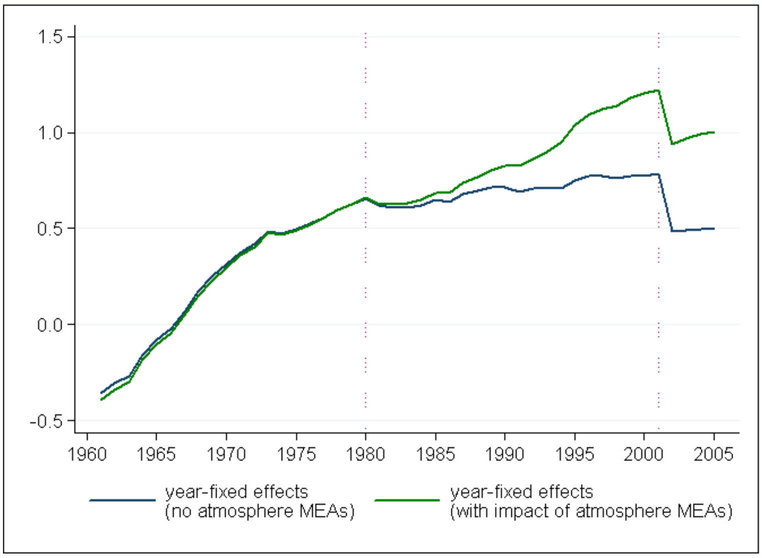

Figure 5: Year-fixed effects between 1960 and 2006

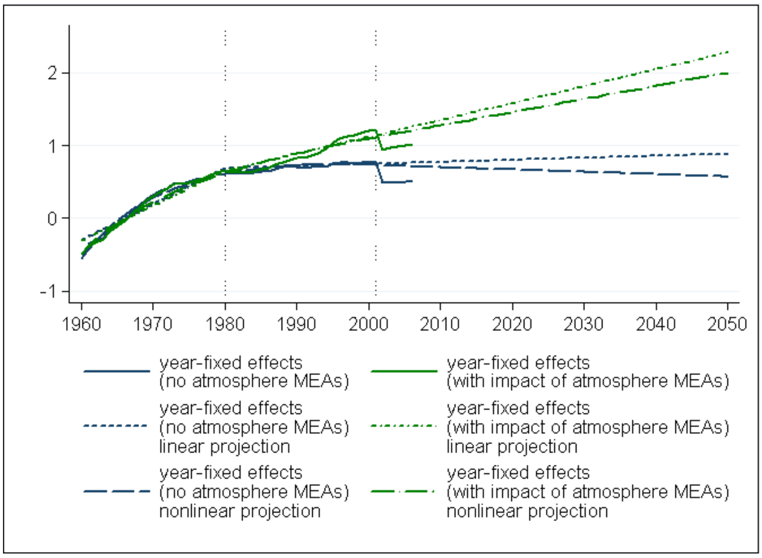

Figure 6: Year-fixed effects projections until 2050

Similar to the year-fixed effects I project the number of atmosphere MEAs linearly as well as nonlinearly applying equations (4) and (6). Projection results open a corridor to a world average number of 25 to 29 atmosphere MEAs in 2050 (see figure 7), i.e., nearly as many atmosphere MEAs as Germany or Luxembourg had 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 will rise from 9 (in 2006) to 25 or 29 (in 2050). This means that on average, the number of atmosphere MEAs in the world only needs to be tripled until 2050. Thus, a fictional world average country has nearly double as many years, than Germany and Luxembourg had, to only triple its number of atmosphere MEAs.

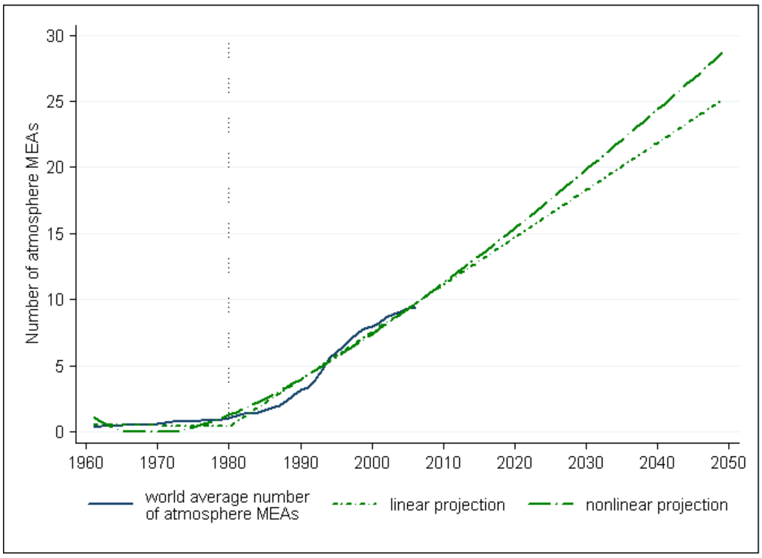

Figure 7: World average number of atmosphere MEAs between 1960 and 2050

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, as well as the number of atmosphere MEAs and the application of spline models, I can now compute the corresponding CO_2 emissions until 2050.

In figure 8 one can 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 projec-

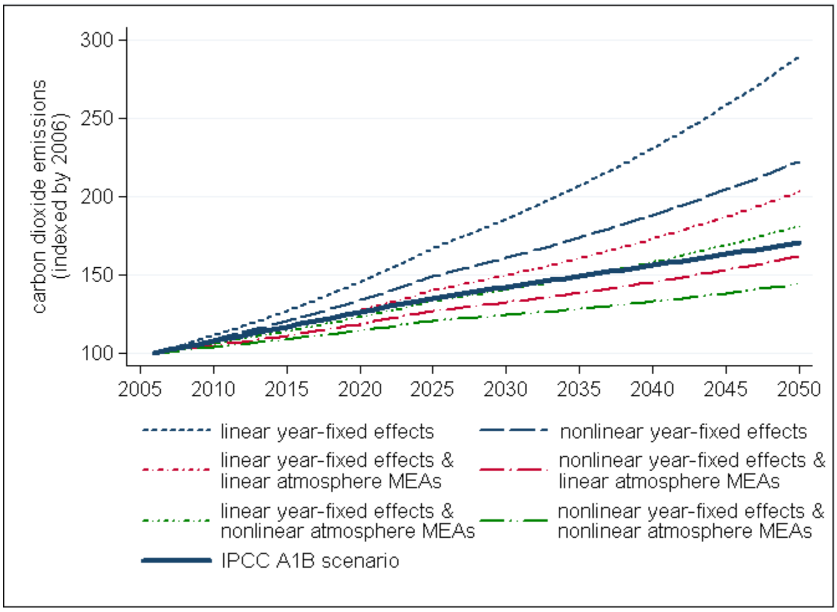

Figure 8: Carbon dioxide emission projections

tions 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. 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 significantly (see red curves vs. blue curves in figure 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

[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 slightly outperform that 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 (1) and (2) this slight lack in accuracy does not harm my relative results.

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 nonlinear projected year-fixed effects) this impact actually equals 78 index points or 35.1% fewer CO_2 emissions in 2050. This means that the moderate accelerating number of MEAs classified with atmosphere (see atmosphere MEAs projections in section 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 which do not take into consideration atmosphere related multilateral 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 put forward a corridor of scenarios in which it would 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.

One could argue that reducing CO_2 emissions to an appropriate level such that the $+2C°$ goal is reachable, would raise the need of atmosphere Meas with severe emission reduction targets, meaning notably more stringent CO_2 emission standards than atmosphere MEAs displayed in the years before the Kyoto Protocol. This is exactly what I thought the data would show. But forecasting the history of atmosphere MEAs, i.e. transferring their historic and low impact on CO_2 emissions reductions into the years up to 2050, they sufficiently and significantly reduce emissions below a certain threshold which is needed to fulfil the Copenhagen Accord. Looking at the hard and long procedures before another atmosphere MEA is ratified, as seen in the surrounding circumstances of a planned post-Kyoto Protocol, it is obvious to have doubts about future MEAs to be signed and ratified in a similarly high number as during the last four decades. But climate protection and especially reducing CO_2 emissions is not an old topic area like fishing conventions. For example the first multilateral environmental agreement has been signed in 1877 *"concerning fishing in the Rhine and its influxes as well as in Lake Constance"* by Alsace-Lorraine, Baden and Switzerland (see. Mitchell, 2007). As a result of this, first of all public resistance had to be erupted in the 1970s (see the slight increase of atmosphere MEAs in the 1970s in figure 7) and public acceptance for environmental protection rules has not been easier to establish than today. As the first strong resistances have been given up until today, a quicker development of atmosphere related MEAs should be appropriate to assume. But even assuming a moderate increase in atmosphere MEAs up to 2050, which is animated by the moderate historic developments, important steps in CO_2 emission reductions can be achieved and the $+2°C$ goal of the Copenhagen Accord seems to be reachable due to the impacts of atmosphere related multilateral environmental agreements.

6 Conclusion

Multilateral environmental agreements in general, as well as multilateral environmental agreements classified with atmosphere in particular, are a plausible means by which to bring the world, or at least more than two countries, to the negotiation table. Until now atmosphere MEAs 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 per capita CO_2 emissions, and they can cause a global sustainable development which keeps temperature rise below $+2°$C until 2050.

This leads to the conclusion that current and future atmosphere MEAs are sufficient in stopping climate change. My results offer a sustainable option for global warming efforts. Green thinking of many countries' politicians and a growing eco-friendly consciousness may lead to the implementation of further necessary measures (like CO_2 certificate trading or carbon tax policies) in order to limit CO_2 emissions even more effectively. However, atmosphere MEAs seem to make a major contribution to reasonable CO_2 emissions reductions until 2050.

Appendix

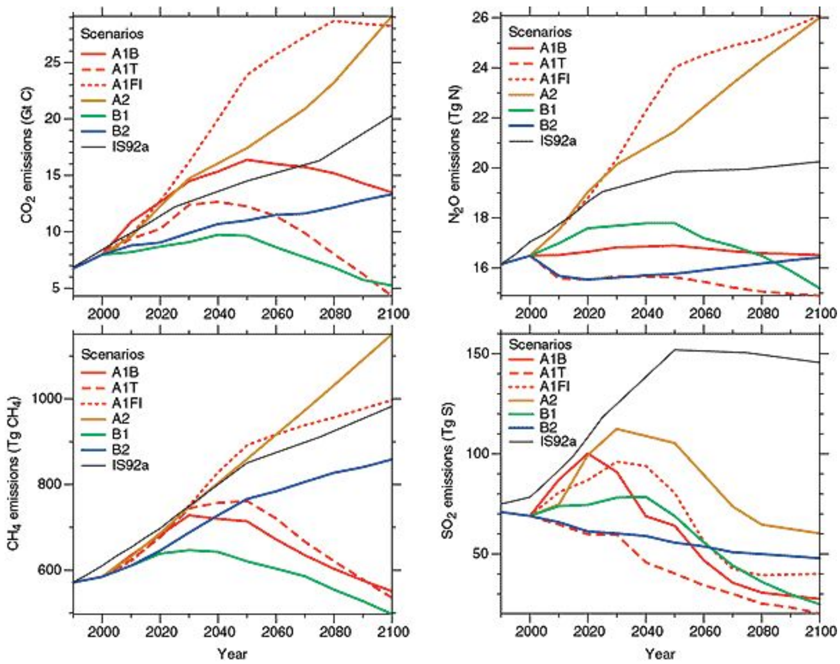

Figure A1: IPCC SRES scenarios

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) are clear to see.

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