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Strategic behavior in IEAs: When and why countries joined the Kyoto Protocol*

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Abstract: We empirically analyze the formation of international environmental agreements within a political economy framework. We develop a theoretical model of state dependent net benefits of ratification predicting (i) strategic behavior with respect to the timing of ratification and (ii) that ratification per se is not necessarily a stronger signal of support compared to signature. Analyzing the signature and ratification process via generalized binary and ordered response models, we find significant evidence for our theoretical predictions. In addition, we show that a wide selection of determinants including economic and political factors influences the decision whether to sign and when to ratify.

Keywords: Climate Change, Generalized Response Models, International Environmental Agreements, Kyoto Protocol

JEL-Classification: Q54, F53, C25

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1 Introduction

International environmental agreements (IEAs) are an important part of the toolbox of policy makers to combat global environmental problems, as suggested by the pure number of existing treaties.[1] As there is no supranational authority that can enforce transnational treaties, IEAs hinge on the voluntary participation of member countries. In the context of climate change, however, the difficulties in agreeing on a uniform policy for the post Kyoto era become more and more evident, as the COP15 meeting in Copenhagen in December 2009 proofed markedly. The passed consensus of the meeting, the so called *Copenhagen Accord*, failed to meet the expectations of experts, politicians and the broad public alike: neither does it include specific greenhouse gas emission (reduction) targets for the period after 2012 nor is it supported by a majority of the world's sovereign nations.

In order to increase the probability of successful international cooperation in the future, it would be serviceable to better understand the determinants of existing IEAs to enter into force. As the Kyoto Protocol (KP) is so far the only existing international treaty including specific targets for greenhouse gas emissions for at least some developed countries, we empirically analyze its enacting process within a political economy framework. The key novelty in this paper is that we assume that each country's net benefits of ratification depend on a broad selection of economic and political factors and, in particular, on whether the treaty eventually enters into force. We develop a theoretical model of state dependent ratification benefits and test it via a generalized ordered response model. In combination with specific rules of the KP, our theoretical model predicts strategic behavior of potential member countries, which we verify empirically. We also analyze the signature stage of the KP by means of a generalized binary response model, as our theoretical model implies that ratification is not necessarily a stronger signal for support than signature.

The existing literature analyzing IEAs in general and the KP in particular focused on the decision of countries whether or when to ratify an agreement. Often, the KP is part of a data set comprising several IEAs in order to study ratification within binary choice or duration models.[2] Other treaties, these papers examined, include the Helsinki Protocol (Murdoch et al. 2003), the Vienna and/or Montreal Protocol (Congleton 1992, Beron et al. 2003), or the Framework Convention on Climate Change (von Stein 2008). With respect to the KP, Fredriksson et al. (2007) analyze countries' determinants for ratification by 2002. They use a hazard rate model to analyze whether corruption facilitates environmental lobbying. In a similar approach, von Stein (2008) analyzes the effect of different political factors on the ratification of the KP. Neumayer (2002a,b) are – to the best of our knowledge – the

[1] For more information, visit the ENTRI project database at: http://sedac.ciesin.columbia.edu/entri.
[2] See Bernauer et al. (2008) and Roberts et al. (2004) for a recent literature overview.

only papers also analyzing the signing stage of the KP, in which the author focused on two specific questions: whether more democratic countries exhibit a higher probability of signing and whether trade openness facilitates signing.

In the present paper, we contribute to the existing literature in several ways. First, we study strategic behavior with respect to ratifying the KP. In this respect our paper shares some similarities with Beron et al. (2003) who find no evidence for strategic behavior in the ratification of the Montreal Protocol using trade relationships. Concentrating on state dependent net benefits of ratification, our theoretical model allows us to distinguish four different categories of countries: (i) countries unconditionally supporting the KP, (ii) countries which prefer the KP to enter into force but are even better off if this is achieved without ratifying themselves, (iii) countries which prefer the KP not to enter into force, but given it does, are better off to ratify and (iv) countries that are unconditionally harmed by the KP. A country's category has implications for the timing of ratification. Countries of category (i) have no incentive to postpone ratification and should thus do so right away. Category (ii) countries should postpone ratification, as they are better off if the KP enters into force without them ratifying. However, as they prefer the KP to enter into force, they should ratify if its enacting is endangered by their reluctance to ratify. Countries of category (iii) will only ratify when the KP already entered into force or it is apparent that it will do so, and countries of category (iv) never ratify. We show that, due to the specific design of the KP, the ratification period splits into three subperiods. In the first period only category (i) countries are expected to ratify. In the second period which starts by Russia's announcement to ratify the KP and, after the withdrawal of the U.S., can be interpreted as a coordination of the remaining Annex I countries to bring the KP into force, category (ii) countries ratified. Russia's actual ratification of the KP, which also triggered the KP to enter into force marks the beginning of the third period, in which category (iii) countries are expected to ratify.

Second, with hindsight, it turned out that whether to ratify was not a crucial issue in case of the KP. So far, 191 countries ratified the KP, with the US being the only prominent exception, but only 84 countries signed it during the signature period between 1998 and 1999. While the KP was open for signature for only one year, the ratification stage comprised almost 10 years. Thus, signing and ratification may have different meanings. Moreover, our theoretical model suggests that ratification per se is not necessarily a stronger signal for support than signature.[3] In particular, this holds for category (iii) countries, which should never sign the treaty but are expected to ratify it when it is clear that it will enter into force. We, therefore, consider the signing stage as being under-researched so far with Congleton

[3] Signing a treaty is often considered as cheap talk, as it does not imply any binding legislation on national level.

(1992) and Neumayer (2002a,b) as the only exceptions we are aware of.

Third, for explaining signing and ratification, we do not ex ante focus on specific aspects like interest groups (Fredriksson et al. 2007), democracy (Congleton 1992, Neumayer 2002a, Midlarsky 1998), trade (Neumayer 2002b), or political entanglement (Bernauer et al. 2008). Instead, we apply a comprehensive economic analysis using a broad set of variables including measures for damage costs of climate change, measures for energy usage, amount of emissions, and political factors that may influence or are already known to influence international cooperation.

Our empirical analysis of the KP supports our theoretical model of strategic behavior based on state dependent net benefits of ratification: we find evidence that (i) the split of the ratification period into the three subperiods is appropriate, and (ii) the net benefits of ratification are lower the later is the subperiod of ratification. We also show that a wide range of determinants influences the decision whether to sign and when to ratify. However, we identify different determinants for signing and ratification. While signature is mainly driven by damage and compliance cost measures, political factors are important for the timing of ratification.

The remainder of the paper is organized as follows. Section 2 gives a brief introduction to the KP. In Section 3 we develop our theoretical model for the two stages under consideration. We elaborate on the data used, the econometric strategy and the estimation results in Section 4 and discuss our findings in Section 5. Finally, Section 6 concludes.

2 The Kyoto Protocol in a Nutshell

In the Kyoto Protocol (KP), initially adopted on 11 December 1997, 39 industrialized countries and the European Community, so called Annex B countries,[4] commit to reduce the emissions of four greenhouse gases by 5.2% on average over the period between 2008 to 2012 compared to 1990 levels. It was open for signature between 16 March 1998 and 15 March 1999. Over this period the KP received 84 signatures. Of the 39 countries with reduction commitments, only 3 countries Belarus, Hungary and Iceland did not sign the protocol (Belarus just joined the list of countries with reduction commitments in November 2006). In addition to signature, countries had to ratify the protocol in order to accede to it. Countries which did not sign the protocol during the signature period were able to join it by ratification at any time later on. For entering into force the KP had to satisfy two conditions: It

[4] In fact, the list of Annex B countries detailed in the KP with limitations on greenhouse gas emissions is identical to the list of Annex I countries specified in the United Nations Framework Convention on Climate Change (UNFCCC) except for Turkey which is an Annex I but not an Annex B country. In the following, we abstract from this subtle difference and will exclusively use the term Annex I.

had to be ratified by (i) at least 55 countries, which (ii) represented at least 55% of 1990 global greenhouse gas emissions of Annex I countries.

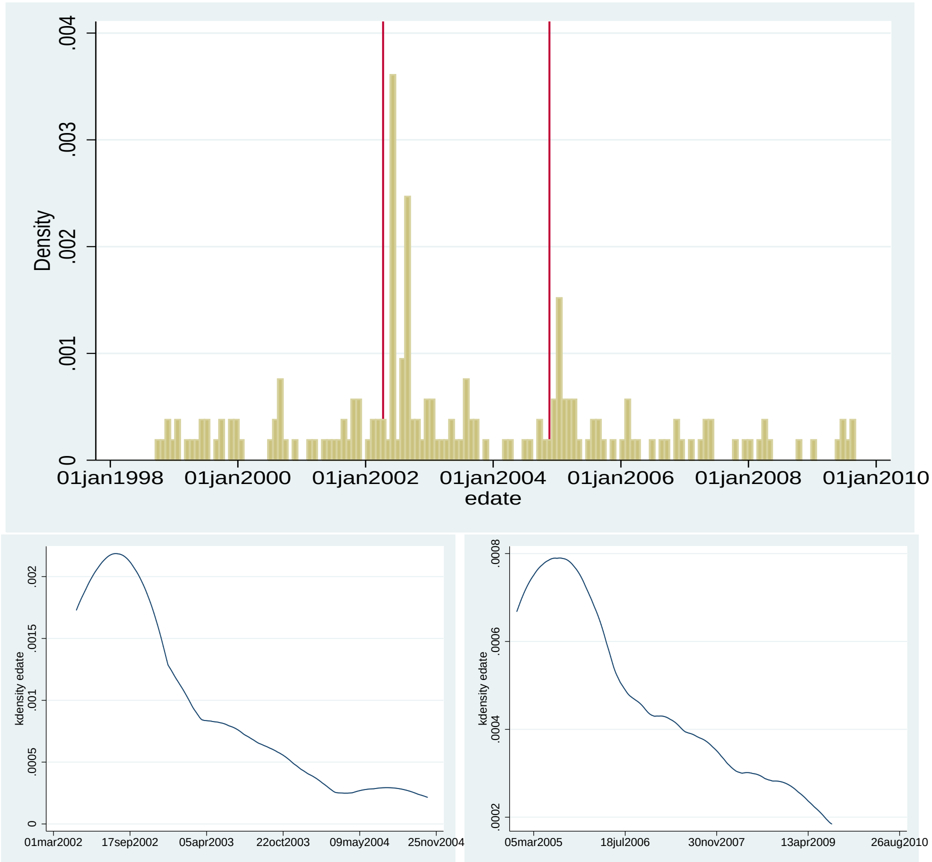
The first condition was satisfied on 23 May 2002 when Iceland ratified the KP. In March 2001 the U.S., despite signing the KP, announced not to ratify. As the U.S. were responsible for 36.4% of the 1990 emission levels of Annex I countries, their withdrawal from the ratification process made Russia – accounting for 17.4% of the 1990 emission levels of Annex I countries – the pivotal player for reaching the second condition. Although Russia declared to ratify the KP already in 2002 after the EU-Russia summit, it was not until 4 November 2004 that Russia's ratification entered into force – and with it the KP on 16 February 2005, having now taken both hurdles.[5] Until now, 191 countries and the EU have ratified the KP.[6] The USA is the only Annex I country which did not ratify the protocol. It is also the only country which signed the protocol and did not ratify it afterwards.

So far, empirical studies of the KP concentrated on the ratification process as the event of accession to the treaty.[7] This seems plausible, as a treaty is only acknowledged under national legislation after ratification. As a consequence, ratification should be a stronger signal of commitment than signature. We argue, however, that this need not be the case for the KP. As we will show in the following sections, both stages seem to provide important signals for a country's support of the Kyoto Protocol. As outlined above, the KP was open for signature only from March 1998 to March 1999 and it only entered into force after at least 55 countries with at least 55% of 1990 global greenhouse gas emissions of Annex I countries ratified it. Thus, signing countries had to act fast at a time at which it was not clear whether the KP will ever enter into force. In fact, only 84 countries signed the treaty while 191 countries have ratified the KP until now.

Moreover, with respect to the ratification process timing may be important. We argue however, that it is not only total elapsed calendar time that matters (Fredriksson et al. 2007), but also whether ratification took place *before* or *after* certain key events. Figure 1 shows a histogram of the ratification process. We identify two key events (marked by vertical lines), Russia's announcement of supporting the KP in the concluding statement of the EU–Russia summit on 29 May 2002 and its actual ratification in November 2004, which triggered increased ratification activity (see kernel density estimates).[8] This indicates that a considerable number of countries ratified either after Russia's announcement of support

[5] For a detailed discussion of Russia's ratification process see, for example, Buchner and Dall'Olio (2005).
[6] San Marino and Somalia, which ratified in 2010, are not included in our data sample.
[7] While some studies estimated determinants for ratification up to some threshold date in a probit model (Neumayer 2002a,b), other studies explicitly analyze the duration of the ratification process with a hazard model (Fredriksson et al. 2007).
[8] Other potential key events like the withdrawal of the U.S. in March 2001 are insignificant with respect to increased ratification activity. The same holds for the signing stage.

Figure 1: Number of countries ratifying the KP over time. Histogram of the KP ratification process (top), kernel density estimates for phase 2 (bottom left) and phase 3 (bottom right).



or after it was clear that the KP will enter into force. As we shall argue in the next section, this observation is consistent with the hypothesis that countries ratify at different times depending on their net benefits from the KP entering into force.

As a consequence, we analyze both the signature and ratification process. In fact, we seek the determinants for signature during 16 March 1998 and 15 March 1999. For the ratification process we distinguish three important phases: The first phase ends with the announcement of Russia's support for the KP on 29 May 2002 and phase three starts with its actual ratification on 4 November 2004. The second phase captures the time between these two key events.

3 Theory

We assume that all countries asses the expected benefits and costs associated with joining the Kyoto Protocol (KP). We assume further that countries make rational choices in their decision whether to sign, and whether and when to ratify the KP, that is countries sign/ratify if the net benefit of signing/ratification is positive.

3.1 State dependent benefits of ratification

The key novelty in our approach is that we assume that expected benefits of the KP depend not only on countries' ratification decisions but also on whether it will eventually enter into force. Thus, we distinguish two states of the world $S = K$ if the KP is enacted and $S = \bar{K}$ if not. Of course, whether the KP will enter into force also depends on country i's decision to ratify ($y_i = 1$) or not ($y_i = 0$). We denote the expected benefits of country i by $B_i(y_i, S)$, which depend on the country's ratification decision y_i and the state of the world S.

Without loss of generality, we assume that ratification has no effect on the expected benefits of all countries i if the KP is not entering into force

$$B_i(1, \bar{K}) = B_i(0, \bar{K}) = B_i(\bar{K}) \; . \tag{1}$$

This allows us to characterize countries according to the signs of the following two differences:

$$\Delta B_i^1 = B_i(1, K) - B_i(\bar{K}) \; , \tag{2a}$$

$$\Delta B_i^2 = B_i(1, K) - B_i(0, K) \; . \tag{2b}$$

$\Delta B_i^1 > 0$ indicates that country i is better off by ratifying the KP if it enters into force compared to the case that the KP will not be enacted at all. If $\Delta B_i^2 > 0$ country i is better off by ratifying the KP, given the KP enters into force.

As there are no legally binding commitments associated with signature, it has often been considered as cheap talk. Nevertheless, countries may fear a loss of international credibility if they sign the KP but fail to ratify it afterwards. This is supported by the fact that signing but not ratifying the KP was only observed for one country, the U.S. Therefore, we assume that only countries sign the KP, which are (at least at the time of signing) also sure to ratify it. Moreover, strategic considerations should play a minor role during the signature stage, as at that time countries did not know whether the KP will ever enter into force and signing did not have any legal consequences. Moreover, this event is independent of their ratification decision. As a consequence, we expect only countries with $\Delta B_i^1 > 0$ to sign the KP.

Due to the two hurdles, it depends on how many and which countries ratify whether the KP enters into force. Countries for which $\Delta B_i^1 > 0$ and $\Delta B_i^2 > 0$ hold simultaneously lend unconditional support to the KP and have no incentive to postpone ratification. We expect these countries to ratify in the first phase. For example, this may include non-Annex I countries with high potential damages from climate change like small island states.

Countries for which $\Delta B_i^1 > 0$ but $\Delta B_i^2 \leq 0$ would like the KP to enter into force, but also have an incentive to postpone ratification, as they are not worse (and probably better) off if enaction is achieved without themselves ratifying. In particular Annex I countries fall into this category, as they have an incentive to free-ride on the abatement efforts of other Annex I countries. We expect these countries to ratify in the second phase. The intuition is that after the withdrawal of the U.S. the possibilities for free-riding decreased drastically. In addition, it was clear that the KP would not be enacted unless Russia ratified. Thus, Russia's announcement of support in the concluding statement of the EU–Russia summit on 29 May 2002 can be interpreted as the consensus of the remaining Annex I countries to bring the KP into force. In fact, we see that most Annex I countries ratified shortly after Russia announced its support.

Countries for which $\Delta B_i^1 \leq 0$ and $\Delta B_i^2 > 0$ prefer the KP not to enter into force at all (or are indifferent), but given the KP is enacted, they are better off ratifying. As a consequence, we expect these countries to ratify in the third phase after the KP entered into force. As an example consider oil exporting non-Annex I countries. They prefer not to have any agreement constraining global greenhouse gas emissions. But, given the KP is enacted, they are better off ratifying in order to reap potential benefits of the KP such as technology transfers via the clean development mechanism. In fact, all OPEC countries did not sign the KP during the signature period[9] and ratified it after entering into force.

Finally, there may be countries for which $\Delta B_i^1 \leq 0$ and $\Delta B_i^2 \leq 0$. As these countries would never benefit from ratification no matter whether the KP is entering into force, we expect these countries not to ratify at all. Table 1 summarizes the predictions of our theory with respect to the timing of ratification.

According to our theory of state dependent benefits, ratification is not necessarily a stronger signal of support than signature. Signatories are expected to ratify the KP in the first or second phase. Contrariwise, countries which ratified in the third phase should not have signed the KP in the first place. Moreover, Annex I countries with emission reductions

[9] Except Indonesia which left OPEC later on.

Table 1: Predicted ratification timing dependent on net benefits ΔB^1 and ΔB^2.

	$\mathbf{\Delta B^1 > 0}$	$\mathbf{\Delta B^1 \leq 0}$
$\mathbf{\Delta B^2 > 0}$	phase 1	phase 3
$\mathbf{\Delta B^2 \leq 0}$	phase 2	never

targets are expected to ratify in the second phase. Table 2 shows that these predictions are well supported by our data.

Table 2: Timing of ratification of signatories and Annex I countries in our sample.

	Ratification phase		
Signatory	1	2	3
0	27	28	51
1	28	44	9

	Ratification phase		
Annex I	1	2	3
0	52	53	55
1	3	29	5

In addition, our theory suggests an ordinal ordering of the three ratification phases. With declining "degree of support" for the KP, which is accompanied by declining expected net benefits from ratifying the KP, countries should exhibit lower probability of signing the KP and should ratify later, if at all. Countries benefiting unconditionally from the KP should ratify in the first phase, countries benefiting from the KP but with incentives to free-ride on other countries abatement efforts are expected to ratify in the second phase and countries for which ratification is only beneficial if they cannot prevent the KP coming into force sign in the third phase.

3.2 Observable variables

We do not directly observe the expected net benefits of a country but only whether it signs and when it ratifies the KP. The hypothesis is that the expected net benefits are a function of a vector of observable influences, which we group into four categories: damage costs of climate change (DC), energy and emissions (EE), economic factors (EF) and political factors (PF).

Damage costs of climate change

An important part of the expected benefits are the mitigated damages from climate change which stem from a successful reduction and stabilization of global greenhouse gas emissions.

Although it is clear that the KP in itself cannot achieve this goal, it is an important cornerstone towards it: In contrast to the 1992 United Nations Framework Convention on Climate Change, the KP is the first international agreement in which (at least some) countries commit to a greenhouse gas emissions target. In case of success, the KP could lead the way to more ambitious reduction targets for greater parts of the world. Thus, countries should be more likely to exhibit positive expected net benefits from the KP entering into force, the higher are their expected damage costs from climate change.

Calculation of damage costs of climate change is a difficult task, due to a variety of uncertainties. First, damage costs crucially hinge on future global greenhouse gas emissions that would occur if no international agreement towards a stabilization of atmospheric greenhouse gas concentrations can be achieved. These so called business-as-usual scenarios strongly depend on the future economic development, and thus vary substantially for different development scenarios (IPCC 2000). Second, there is still substantial uncertainty how atmospheric greenhouse gas concentrations translate into temperature rise. In fact, the best current estimate for the rise of the global mean temperature in thermodynamic equilibrium for a doubling of atmospheric CO_2 concentrations compared to pre-industrial levels ranges from 1.5–4.5°C (IPCC 2007). Moreover, temperature rise is very heterogeneously distributed across the globe. Third, converting temperature rise into damages is an even more difficult task, as this depends on the complex interdependence of ecosystems and the interdependence of ecosystem and socio-economic systems.

So far, predominantly effects of climate change on agriculture (Deschênes and Greenstone 2007b, Schlenker et al. 2005) and human health (Deschênes and Greenstone 2007a, 2009 and Deschênes and Moretti 2009) have been analyzed in the economics literature. We use arable land per person (ARLA), value added of agricultural sector in percentage of GDP (VAAG) and precipitation per square km (PREC) as indicators to measure the influence of agricultural aspects on decision making with respect to the KP. We also include the climate change index (CCI) published by Baettig et al. (2007) that compounds information about additional extreme weather events with respect to temperature and precipitation (e.g., very hot, very dry and very wet years). As drought periods and heat waves have impacts on both agricultural output and human health, the climate change index serves as an indirect measure for potential damage costs of climate change with respect to agriculture and human health. Moreover, it also captures more general impacts on the economic system associated with extreme weather events.

Climate change may also trigger sea level rise which impacts on countries with low altitude and a high share of people living in coastal areas (Tol 2009).[10] We include the share of

[10] The example of the small island state Tuvalu that already applied for asylum in different countries because

population living in coastal region (CPOP) in our empirical analysis to capture effects of potential sea level rise on political decision making.

Energy, emissions and economic factors

An important part of the costs of adopting the KP is the limitation of greenhouse gas emissions. Although only Annex I countries are subject to emission targets and, thus, face direct compliance costs, anticipation of compliance costs of subsequent climate change mitigation treaties by non-Annex I countries may influence their expected net benefits and, consequently, their decision whether to sign or ratify the KP.[11] In general, compliance costs may depend on energy production and consumption (Deschênes and Greenstone 2007a), greenhouse gas emissions and economic development. Moreover, compliance costs crucially depend on assumptions about induced technological change, energy prices and in how far marginal abatement costs can be equalized between countries, for example, by an emission trading scheme.

As measures for energy consumption and production we incorporate GDP per unit of energy use (GDPE) and the share of electricity production by natural gas, coal and oil (ELPR). Emissions are captured by CO_2 intensity (COIN) and CO_2 emissions per capita (COPC). In order to capture general economic patterns, we include GDP per capita (GDPC) and annual GDP growth (GDPG)[12] in our empirical analysis (Neumayer 2002a,b, Fredriksson et al. 2007).

Political Factors

Apart from damage and mitigation costs of climate change, there are other factors influencing the expected net benefits of acceding to the KP. First, Neumayer (2002a) finds that, everything else equal, democracies are more likely to ratify the KP (and three other IEAs) than non-democracies. Congleton (1992) argues that authoritarian rulers have a shorter time horizon (due to higher fear of being thrown out of office) and appropriate higher shares of the economy's income than the median voter in a democracy. The first effect leads to less strict environmental regulations, at least for environmental problems of a long-term nature such as climate change. The second effect on environmental regulation is ambiguous. A larger income share may lead to less strict environmental regulations if these regulations result in lower national income. But, a higher income may lead to a higher demand for

of threatening sea level rise proofed that markedly.

[11] In fact, we already observe discussions between the US and China on the role of emerging economies in the reduction efforts of greenhouse gases.

[12] We took the 5 year average between 1994 and 1998 in order to eliminate business cycles effects.

environmental quality if environmental quality is a normal or luxury good. As an indicator for the level of democracy we employ the Freedom House Index on Political Rights (POLI). The hypothesis is that higher levels of political rights correlate with higher expected net benefits of IEAs. The index ranges from 1 to 7 with 1 being highest political rights. As a consequence, expected net benefits should decrease with the level of the Freedom House Index.

Second, all countries are sovereign in their decisions whether to accede to the KP, as there exists no supranational authority which can enforce accession. Nevertheless, there exists a network of international linkages between countries. These linkages may be economical, such as trade relationships, or political, for example, through international agencies or military power. Independent of their nature, these linkages may lead to contingent behavior among countries. More precisely, countries may experience benefits or avoid disadvantages if they behave with respect to the KP as other countries do to which they are strongly interconnected. Beron et al. (2003) analyze the ratification of the Montreal Protocol in an interdependent probit model, where linkages among countries are determined by international trade flows. They find little evidence that countries are influenced by the decisions of their trade partners. Bernauer et al. (2008) study contingent behavior in a sample of 180 countries and approximately 340 IEAs over the period from 1950 to 2000. They conclude that international factors have a stronger effect on cooperative behavior than domestic factors. We use WTO membership (WTO) and trade in percentage of GDP (TRAD) as indicators for economic entanglement, and the National Material Capabilities Indicator (CINC) of the Correlates of War Project as a proxy for "power", defined as the capacity of a state both to exercise and to resist influence (Singer et al. 1972, Singer 1988).

Finally, we conjecture that countries that signed the KP expressed a strong commitment to the KP and underpinned this commitment by early ratification. As a consequence, we also test for signature (SIGN) in the ratification stage.

4 Empirics

After introducing the data, we outline the empirical strategy used to analyze the Kyoto Protocol. Finally, we report the results of the econometric analysis.

4.1 Data

Data for our empirical analysis stem from different sources. Table 3 shows the summary statistics and the data sources for each of the variables used in the empirical exercise. Our dataset consists of a cross-section of countries for the year 1998,[13] the time at which the KP was open for signature. WDI is an acronym for the World Development Indicators published by the World Bank and UNFCCC denotes data from the website of the United Nations Framework Convention on Climate Change.[14] PW is the PennWorld database provided by the Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania (Heston et al. 2009). COW indicates that the variable is available on the Correlates of War Project website.[15] UNEP refers to the GEO database provided by the United Nations Environment Programme[16] and, finally, FH denotes the variable has been downloaded from the website of the Freedom House organization.[17] Samples for the signing and the ratification stage regressions are identical except for Russia and the US that are not included in the ratification stage.[18]

Using a cross-country data set of the present form always implies some challenges with respect to the empirical strategy. In particular, there are three issues we would like to mention. First, every variable used in an econometric model may be available for a different set of countries leading to different sample sizes when using different specifications. Second, variables on country level may be highly correlated and, thus, cause a collinearity problem in the empirical analysis. Third, there is a potential for an unobserved heterogeneity bias. We address the first issue by comparing results for different sample sizes and different sets of covariates. To avoid collinearity, we only choose variables that show a moderate level of correlation.[19] However, it is not possible to construct a panel structure in order to correct for unobserved heterogeneity, as both decisions (signature and ratification) are only taken once.

4.2 Countries' benefits of the KP: a latent variable approach

Our assumption of rational choice implies that each country chooses, conditional on its characteristics, the combination of signing the KP, or not, and ratifying it in a certain period, which maximizes its expected net benefits. We identified two key events which split the ratification period into three subperiods: if a country ever ratifies the KP, it may do so prior to the announcement of Russia's ratification, after the announcement but before Russia's actual ratification, or after Russia ratified the KP.

[13] Exceptions are: GDPG (1994–1998), CPOP (1995), CCI (based on 1961–1990 data) and PREC (Average annual precipitation in mm per m^2 between 1961 and 1990).
[14] http://unfccc.int
[15] http://www.correlatesofwar.org/
[16] http://geodata.grid.unep.ch/
[17] http://www.freedomhouse.org
[18] The US did not ratify the Kyoto Protocol and Russia is the pivotal player determining the thresholds for the ratification subperiods.
[19] In the present sample, the highest correlation is at -.701 for GDPC and VAAG.

Table 3: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N	Source
SIGN	0.437	0.497	0	1	190	UNFCCC
RAT	1.968	0.787	1	3	188	
Annex I	0.205	0.405	0	1	190	
POLI	3.448	2.228	1	7	183	FH
GDPE	4.341	2.162	0.535	10.48	126	WDI
COPC	4.47	6.946	0.014	59.392	179	
COIN	2.066	0.940	0.153	4.873	132	
ARLA	0.254	0.285	0	2.354	181	
GDPG	4.01	5.277	-10.007	39.937	181	
VAAG	18.508	15.719	0.133	78.643	165	
ELPR	59.98	34.434	0.022	100	133	
GDPC	7843.558	8113.454	288.71	44841.933	180	PW
TRAD	84.964	44.821	15.865	319.085	180	
CPOP	0.576	0.426	0	1.515[a]	180	UNEP
PREC	1241.011	852.818	51.2	3566.7	185	
WTO	0.717	0.452	0	1	180	COW
CINC	0.005	0.017	0	0.148	180	
CCI	5.894	2.69	0	9.48	188	Baettig et al. (2007)

[a] The reason for the max being larger than one is that overall population stems from a different source.

Then, a country is supposed to sign the KP if the underlying latent variable $y_s^\star$ (its net benefit of signing) is positive. Although we do not observe $y_s^\star$, we observe whether a country signed or not (i.e., whether y_s=1 or 0). We, therefore, hypothesize:

$$y_s = 1 \ , \quad \text{if and only if} \quad y_s^\star > 0 \ . \tag{3}$$

The underlying structural model can then be written as:

$$y_{si}^\star = \alpha + \beta X_i + \epsilon_i \ . \tag{4}$$

where y_{si} denotes the signing decision of country i, X consists of measures for damage costs of climate change (DC), economic factors (EF), energy and emission related factors (EE) and political variables (PF). Furthermore, α, β, and ϵ are the parameter(s) (vectors) to be estimated and the disturbance term.

Building on our theoretical considerations in Section 3, we assume the net benefit of signing to be positive if $\Delta B_1 > 0$, i.e. the country generally supports the KP.

Furthermore, a country's decision when to ratify the KP depends on the underlying latent variable $y_r^\star$ (its net benefit of ratifying), which in turn depends on whether the KP is entering into force. Again, we cannot observe $y_r^\star$, but we observe in which period a country ratified the KP, i.e. $y_r = j$ with $j = 1, 2, 3$. According to our theory, the higher are a country's net benefits from ratification $y_r^\star$, the earlier the period in which it ratifies:

$$y_r = \begin{cases} 1 : \text{Period } 1 & \Leftrightarrow \quad \text{Mar 1998 -- May 2002} \ , \\ 2 : \text{Period } 2 & \Leftrightarrow \quad \text{May 2002 -- Nov 2004} \ , \\ 3 : \text{Period } 3 & \Leftrightarrow \quad \text{Nov 2004 -- Mar 2009} \ . \end{cases} \tag{5}$$

In addition,

$$y_r = j \ , \quad \text{if and only if} \quad \tau_{j-1} \leq y_r^\star < \tau_j \ , \tag{6}$$

where τ_k $(k = 0, \ldots, 3)$ denote the threshold values for the latent variable at which a country changes the ratification period.

Then, the underlying structural model for the ratification stage can be written as:

$$y_{ri}^\star = \gamma + \theta SIGN_i + \lambda X_i + \eta_i \ . \tag{7}$$

where y_{ri} and $SIGN$ denote the timing of ratification and whether a country is among the signatories, respectively, and X again consists of DC, EF, EE, and PF. Furthermore, γ, θ, λ, and η are the parameter(s) (vectors) to be estimated and the disturbance term. Given the underlying latent variable approach, we use binary and ordered response models to analyze the signing and the ratification stage.

4.3 The signing decision

The decision whether to sign the KP is a binary choice. As a consequence, we use probit type estimators to analyze the determinants of signing (or not signing) the KP:

$$Pr(y_{si} = 1|X_i) = Pr(\epsilon_i > -\beta X_i) = \Phi(\beta X_i) \ , \tag{8}$$

where again y_{si} indicates whether a country signed the KP. As we will show in the following section, there is evidence that the homoscedasticity assumption of the standard probit model ($\sigma^2 = 1$) has to be relaxed such that the variance can vary as a function of explanatory variables. The resulting heteroscedastic probit model can then be written as:

$$Pr(y_{si} = 1) = \Phi(\beta X_i / \exp[\mu Z_i]) \ , \tag{9}$$

where Z_i denotes a vector of variables included in the variance equation and μ the associated parameter vector (Harvey 1976).

4.3.1 Model selection

In order to elicit the optimal empirical strategy in terms of model fit and predictive power, we estimated two different models using different sets of explanatory variables. We contrast the standard probit (PROB) model with the heteroscedastic probit (HETPROB), which is a generalization of the former. The reason for including a heteroscedastic model is that the variance turns out to be a function of GDP per capita (GDPC).[20] In Table 4 we further distinguish the estimated models: (i) the full set of explanatory variables implying 111 observations, (ii) a reduced set of explanatory variables after applying the stepwise procedure[21] implying also 111 observations, and (iii) a set of explanatory variables maximizing the number of observations (165 countries).

The lower part of Table 4 shows various measures of model fit for the six different specifications under consideration. Comparing both information criteria (BIC and AIC) and the percentage of correctly predicted outcomes (PCP), the standard probit and the heteroscedastic probit model with reduced sets of explanatory variables, as displayed in columns 3 and 4, are the preferred estimators.[22]

4.3.2 Estimation results

Marginal Effects for the determinants of signing the KP are shown in the upper part of Table 4. Although effects are robust across estimation methods and different sets of explanatory variables, we focus on the estimation results of the preferred estimators in columns 3 and 4. Although GDPC does not have a significant effect on signing itself in HETPROB, it turns out that the likelihood-ratio test of heteroscedasticity is significant with a p-value of 0.057.

The effects of ARLA, PREC, and COIN are positive and highly significant with semi-elasticities of roughly .09, .24, and .22. For HETPROB, we also find a positive and significant effect for CCI (.27) and for PROB an effect for the Annex I dummy (.043). Moreover, all models show evidence for a significant positive effect of the measure of political power (CINC) with semi-elasticities of .02. In addition, we find negative and statistically significant effects for VAAG and ELPR with -.17 for VAAG and between -.002 and -.14 for ELPR, respectively. GDPE shows a negative effect for PROB with -.23 but it slightly fails significance at the 10% level for HETPROB.

[20] Including a squared term for GDPC does not change the results.
[21] We applied the stepwise procedure to detect insignificant variables (p-value $>$ .4).
[22] We also estimated both models using different sets of explanatory variables while holding the number of observations constant. Results for these specifications are available upon request.

Although VAAG and ARLA should both reflect damages on agriculture, they exhibit opposite signs. However, looking at the data reveals that high values of VAAG do not imply high values in ARLA and vice versa. In fact, primarily poor countries exhibit high values of VAAG, such as Liberia, Guinea-Bissau, etc. In contrast, Australia and Canada are among the top five countries with respect to ARLA. Thus, the opposite signs may reflect that countries with a high share of agricultural value added in GDP may experience different effects from climate change than countries with a high density of arable land. Moreover, rising temperatures may have different effects on agriculture in the northern and southern hemisphere in terms of adaptation opportunities and agricultural output.

Comparing our results across the specifications displayed in table 4, it is evident that our findings a robust to the choice of estimator, covariates and sample size.

4.4 The ratification decision

In contrast to signing, all parties to the UNFCCC included in our data set, except for the USA, ratified the KP until the end of 2009. Thus, the question is not whether a country ratified but when. As already mentioned, we split the ratification period into three subperiods: (i) before Russia announced ratification, (ii) after Russia's announcement and its actual ratification (which triggered the KP to enter into force), and (iii) after Russia's ratification and the KP becoming effective. According to our theory outlined in Section 3, the underlying latent variable, net benefits from ratification, is decreasing the later the ratification takes place. We model the ratification stage as an ordered response assuming that:

$$\begin{aligned} Pr(y_{ri} = j|SIGN_i, X_i) = Pr(\tau_{j-1} \leq y^{\star}_{ri} < \tau_j|SIGN_i, X_i) = \\ F(\tau_j - \theta SIGN_i - \lambda X_i) - F(\tau_{j-1} - SIGN_i - \lambda X_i)\ , \end{aligned} \tag{10}$$

where y_{ri} indicates the period in which country i ratified and F indicates the cumulative distribution function of the error term η. θ and λ are parameter vectors and τ_1 to τ_{j-1} denote threshold parameters to be estimated assuming that $\tau_0 = -\infty$ and $\tau_3 = \infty$.

As will be shown in the following section, the standard ordered response model is too restrictive in this setting. As a consequence, we apply different alternatives in order to decide on the best estimator. It turns out that a generalized ordered response model (Maddala 1986, Peterson and Harrell 1990) with the logistic cumulative density function as link function F that allows for (some of) the parameter estimates to differ between outcomes j, performs best in terms of model fit:

$$Pr(y_{ri} = j) = F(\tau_j - \theta_j SIGN_i - \lambda_j X_i) - F(\tau_{j-1} - \theta_{j-1} SIGN_i - \lambda_{j-1} X_i). \tag{11}$$

Table 4: Signing Stage Results

	(1) PROB	(2) HETPROB	(3) PROB	(4) HETPROB	(5) PROB	(6) HETPROB
ARLA	0.104	0.102	0.0977	0.0906	0.109	0.105
	(0.027)	(0.003)	(0.040)	(0.030)	(0.001)	(0.000)
VAAG	-0.156	-0.189	-0.165	-0.207		
	(0.006)	(0.003)	(0.005)	(0.004)		
PREC	0.222	0.184	0.246	0.241	0.127	0.147
	(0.002)	(0.006)	(0.000)	(0.000)	(0.045)	(0.035)
CCI	0.167	0.168	0.195	0.272	-0.108	-0.129
	(0.399)	(0.167)	(0.319)	(0.041)	(0.199)	(0.167)
GDPC	0.0758	-0.0169	0.0916	0.0434	0.0528	0.0863
	(0.267)	(0.804)	(0.173)	(0.618)	(0.273)	(0.197)
GDPE	-0.223	-0.129	-0.228	-0.169		
	(0.031)	(0.168)	(0.018)	(0.101)		
COIN	0.252	0.179	0.249	0.215		
	(0.053)	(0.148)	(0.030)	(0.079)		
COPC	-0.0577	-0.0101	-0.0580	-0.0240	-0.0108	-0.0233
	(0.158)	(0.790)	(0.109)	(0.470)	(0.638)	(0.428)
CINC	0.0196	0.0305	0.0164	0.0242	0.0235	0.0221
	(0.045)	(0.002)	(0.053)	(0.014)	(0.000)	(0.000)
TRAD	-0.0818	0.0114	-0.0916	-0.0226	0.00351	-0.000296
	(0.245)	(0.762)	(0.182)	(0.435)	(0.962)	(0.997)
CPOP	0.0451	0.159			0.0343	0.0197
	(0.490)	(0.084)			(0.518)	(0.837)
GDPG	-0.0197	-0.0122			-0.0347	-0.00906
	(0.640)	(0.488)			(0.143)	(0.159)
ELPR	-0.146	-0.00191	-0.136	-0.00187		
	(0.062)	(0.017)	(0.073)	(0.089)		
POLI	-0.0107	-0.0174			-0.0747	-0.0108
	(0.887)	(0.356)			(0.196)	(0.653)
WTO	0.0190	0.0160			0.0815	0.101
	(0.815)	(0.883)			(0.186)	(0.183)
Annex I	0.0438	0.0992	0.0428	0.131	0.0412	0.328
	(0.050)	(0.325)	(0.034)	(0.174)	(0.004)	(0.011)
N	111	111	111	111	165	165
LL0	-76.90		-76.90		-113.7	
LL	-43.69	-40.73	-43.98	-42.13	-78.54	-78.16
BIC	167.4	166.2	149.2	150.2	223.5	227.8
AIC	121.4	117.5	114.0	112.3	183.1	184.3
HL(p)	(0.2173)		(0.2194)		(0.2879)	
PCP	82.88	83.78	82.88	81.98	75.76	77.58

Note: Parameter estimates show semi-elasticities ($d(y)/d(\ln x)$) for the variables in the upper part and marginal effects (discrete changes for dummy variables from 0 to 1) in the lower part (all calculated at the means of the explanatory variables); p-values in parentheses. Standard errors are robust. N, number of observations; LL0, constant-only Log-Lik.; LL, Log-Lik.; BIC, Bayesian Information Criterion; AIC, Akaike's Information Criterion; HL, Hosmer-Lemeshow goodness-of-fit test; PCP, percent correctly predicted outcomes.

4.4.1 Model selection

Two important questions have to be discussed at this stage. First, is the classification of the dependent variable y_r supported by the data? In contrast to the signing stage, we do not model ratification as a binary decision. Instead, by splitting the ratification period into three subperiods, we use a more subtle measure that has to be validated by the data. More precisely, it may be that the key events we identified are not as important as we presume and, thus, our set of explanatory variables is not able to distinguish between outcomes (Anderson 1984).

Second, is the ordering of our dependent variable that is implied by our underlying latent variable backed by the empirical model? On the one hand, if the outcome categories were different, but there was no ordering, unordered models were preferable, as they are less restrictive compared to ordered models. If, on the other hand, there were an underlying ordering, multinomial models were inefficient, as they do not utilize all available information.

To test the validity of the classification of the dependent variable, we use a Wald test (after estimating a multinomial logit)[23] to detect whether our different alternatives can be combined. *Full*, *Stepwise* and *Max. Observation* indicate the set of covariates and resulting sample size with the full set of explanatory variables, a reduced set after applying the stepwise procedure,[24] and a reduced set that implies the maximum number of observations, respectively. For all different specifications the results in Table 5 justify rejecting the Null-hypothesis that all parameter estimates for a given pair of alternatives are zero.

Table 5: Test for Combining Alternatives

Full, $N = 109$				Stepwise, $N = 112$				Max. Observation, $N = 163$			
Alt. tested	chi2	df	P>chi2	Alt. tested	chi2	df	P>chi2	Alt. tested	chi2	df	P>chi2
$2 \leftrightarrow 3$	41.471	17	0.001	$2 \leftrightarrow 3$	31.236	12	0.002	$2 \leftrightarrow 3$	56.276	12	0.000
$2 \leftrightarrow 1$	31.069	17	0.020	$2 \leftrightarrow 1$	24.162	12	0.019	$2 \leftrightarrow 1$	21.094	12	0.049
$3 \leftrightarrow 1$	44.362	17	0.000	$3 \leftrightarrow 1$	34.124	12	0.001	$3 \leftrightarrow 1$	37.530	12	0.000

The second question boils down to the estimator choice. Candidates are either one of the two polar types of standard multinomial and ordered models or a model type lying in between. As we shall show, the generalized ordered logit (Maddala 1986, Ierza 1985), in particular the partial proportional odds model (Peterson and Harrell 1990), serves best in terms of

[23] The tests has been calculated using the mlogtest command (user written by Long and Freese 2005) in Stata. For two alternative outcomes j and k in the ratification model the hypothesis can be written as: $H_0 : \lambda_{j|k} = \theta_{j|k} = 0$.

[24] We sequentially detected the most insignificant variables (p-value > .4) and skipped them from the final estimation.

model fit. Table 6 shows the estimation results for our set-up using different estimation approaches.

In general, mutlinomial models are more flexible than standard ordered response models. This comes, however, at the cost of a efficiency loss, as the number of estimated parameters increases drastically. However, estimating a standard ordered response model may be too restrictive for the following reasons. First, the parallel lines assumption may be violated implying there exists evidence against the restriction of identical estimates for all alternatives. As a Brant test[25] applied after an ordered logit supports this hypothesis for several variables, stratified (Anderson 1984), sequential or generalized ordered models (Maddala 1986) are advisable. Second, there may be heteroscedasticity in our model, which is supported by our previous findings on the signature stage. Thus, a generalization of the traditional ordered logit/probit (Alvarez and Brehm 1995) may be appropriate.

Table 6: Ratification Stage Model Fit

	MLOG	OLOG	SLOG	SEQL	GOLOG
Full					
N	109	109	109	109	109
LL0	-113.6	-113.6	-113.6	-113.6	-113.6
LL	-60.86	-82.46	-81.03	-62.33	-77.63
BIC	290.6	254.0	255.9	293.5	249.1
AIC	193.7	202.9	202.1	196.7	195.3
LR(p)					0.00190
PCP	72.48	69.72	65.14	71.56	67.89
Stepwise					
N	112	112	112	112	112
LL0	-116.3	-116.3	-116.3	-116.3	-116.3
LL	-67.10	-85.65	-83.89	-68.66	-73.03
BIC	256.9	237.4	238.5	260.0	226.3
AIC	186.2	199.3	197.8	189.3	180.1
LR(p)					0.0000138
PCP	75	71.43	67.86	72.32	69.64
Max. Observations					
N	163	163	163	163	163
LL0	-176.2	-176.2	-176.2	-176.2	-176.2
LL	-132.2	-154.1	-158.5	-132.8	-138.9
BIC	396.9	379.5	393.5	398.0	359.3
AIC	316.5	336.2	347.1	317.6	309.8
LR(p)					0.000000243
PCP	63.80	54.60	53.99	61.35	60.12

Note: N, number of observations; LL0, constant-only Log-Lik.; LL, Log-Lik.; BIC, Bayesian Information Criterion; AIC, Akaike's Information Criterion; LR(p), p-value for Lik. ratio test (olog nested in golog); PCP, percent correctly predicted outcomes. The user written commands gologit2 (Williams 2006) have been used to estimate the generalized ordered model.

In order to find the preferable empirical model, we estimate several model specifications and list important measures of fit in Table 6. Columns 1 and 2 show the results for the

[25] User written by Long and Freese 2005.

multinomial logit model (MLOG) and the standard ordered logit (OLOG). Results for the the stratified logit (SLOG) model and the sequential logit (SEQL) are stated in columns 3 and 4. Finally, column 5 shows the result for the preferred generalized ordered logit model (GOLOG).[26]

Comparing both information criteria for the multinomial logit (MLOG) and the ordered logit (OLOG) estimates for all three specifications, there is no clear indication which to prefer. While BIC is in favor of the OLOG, the AIC values support the MLOG results. The percentage of correctly predicted outcomes (PCP) lends further support for the MLOG model. However, both estimates are inferior to the GOLOG results in column 5. The stratified logit model (SLOG), as introduced by Anderson (1984), relaxes the parallel regression assumption and is applicable in case of doubt for an ordering of the dependent variable. Comparing all available measures of fit, however, the stratified logit model does not outperform most of the other model specifications, and in particular, not the preferred generalized ordered logit model in column 5.

Another attractive approach in our setting is the sequential logit model (SEQL), as proposed by Maddala (1986).[27] The appealing feature of sequential models is their ability to explicitly account for the time dimension of the dependent variable. However, comparing AIC and BIC also SEQL is outperformed by the GOLOG. SEQL only outperforms GOLOG in terms of predictive power. However, the difference is always in a reasonable range in order to stick to GOLOG as the difference in AIC and BIC usually is rather substantial.

Finally, column 5 displays results for the preferred generalized ordered logit/partial proportional odds model (GOLOG). In order to calculate and interpret marginal effect we therefore rely on these estimates as they are best in terms of information criteria and at the same time show a reasonable predictive power (PCP = 70%) for the preferred stepwise specification.

4.4.2 Estimation results

Table 7 shows the estimation results for the ratification stage. We present estimates for the preferred estimator, the generalized ordered logit (GOLOG), with the full set of explanatory variables ($N = 109$), after applying the stepwise procedure ($N = 112$) and with the maximum number of observations ($N = 163$). Although information criteria and predictive power reject the latter two specifications (while holding the number of observations fixed),

[26] Although possible in the generalized ordered response model, no observations have an outcome with a predicted probability that is less than 0 in our specification. In addition to the presented models, we also used a heteroscedastic ordered model as suggested by Williams (2009). However, as the Log-likelihood function did not converge, the interpretation of marginal effects is not advisable.

[27] We estimate the sequential model using the user written command seqlogit in Stata by Buis (2007).

we provide the results in order to compare marginal effects for all sample sizes and sets of covariates. In general, the results show only little differences and even less for the significant effects.

The results confirm our theoretical predictions stated in Section 2. Whether a country signed the KP has a significant positive effect on period 1 and a negative effect on period 3 (.16 and -.28). Countries with a higher VAAG did have a significantly higher probability of ratifying in period 1 (.07) and a significantly lower probability in period 3 (-.13). ELPR also shows a clear pattern with a significant positive effect on periods 1 and a negative effect on period 3 (.001 and -.002).

As expected, political factors impact on the timing of ratification. Countries with higher levels of CINC are less likely to ratify in period 1 and more likely to ratify in 2 (-.09 and 0.09). In addition, everything else equal, the degree of political rights have a significant positive effect in period 1 (-.05) and a negative effect on the probability of ratification in period 3 (0.10), while being member of the WTO does not affect the timing of ratification. Trade openness (TRAD) and being a Annex I country has a significant negative impact in period 1 (-.14 and -.18).

Comparing the signing and ratification stage, we observe that indicators for damage costs of climate change and measures for compliance costs seem to have lower predictive capabilities for the decision when to ratify the KP compared to the signing stage. As this may stem from the fact that we included signing (SIGN) as an explanatory variable for the ratification process, we re-estimate the GOLOG model omitting SIGN (Table 8). Although we observe similar results, there are minor differences worth mentioning. Now, VAAG is insignificant in all periods, while COPC has a negative impact in the first (-0.09) and a positive impact in the third period (0.13). In addition, the Annex I dummy is significantly positive in the second period (0.25).

5 Discussion

Our analysis shows that damage cost and compliance cost measures are particularly important for the decision whether to sign the KP. Countries are more likely to sign, the higher is the share of arable land (ARLA), the lower is the value added of agricultural sector in percentage of GDP (VAAG), the higher is precipitation (PREC), the higher is the climate change index (CCI), the higher is the CO_2 intensity (COIN) and the lower is the share of electricity production from fossil fuel sources (ELPR). In addition, the power index (CINC) exert a significantly positive impact.

Table 7: Ratification Stage Estimation Results

	Full			Stepwise			Max. Observations		
Period	1	2	3	1	2	3	1	2	3
ARLA	0.00160	0.000326	-0.00193				-0.0311	-0.00682	0.0380
	(0.971)	(0.971)	(0.971)				(0.208)	(0.415)	(0.185)
VAAG	0.0738	0.0150	-0.0889	0.0720	0.0566	-0.129			
	(0.146)	(0.562)	(0.161)	(0.087)	(0.252)	(0.052)			
PREC	0.0263	0.00536	-0.0317				0.0242	0.00530	-0.0295
	(0.686)	(0.731)	(0.687)				(0.639)	(0.680)	(0.640)
CCI	-0.0389	-0.00793	0.0468				0.0206	0.00450	-0.0251
	(0.840)	(0.844)	(0.839)				(0.799)	(0.814)	(0.801)
GDPC	-0.0127	0.209	-0.196	0.0552	0.0433	-0.0985	0.0470	0.0103	-0.0573
	(0.886)	(0.001)	(0.054)	(0.324)	(0.414)	(0.311)	(0.337)	(0.556)	(0.360)
GDPE	-0.0928	-0.0189	0.112	-0.0595	-0.0467	0.106			
	(0.418)	(0.559)	(0.394)	(0.353)	(0.359)	(0.294)			
COIN	0.107	0.0217	-0.128	0.0662	0.0520	-0.118			
	(0.277)	(0.569)	(0.274)	(0.239)	(0.318)	(0.190)			
COPC	-0.117	-0.0239	0.141	-0.0653	-0.0513	0.117	-0.0518	-0.0113	0.0631
	(0.215)	(0.540)	(0.198)	(0.181)	(0.303)	(0.143)	(0.106)	(0.432)	(0.108)
CINC	-0.0149	-0.00304	0.0180	-0.0854	0.0885	-0.00313	-0.0881	0.0917	-0.00369
	(0.361)	(0.581)	(0.353)	(0.007)	(0.005)	(0.793)	(0.008)	(0.006)	(0.679)
TRAD	-0.0881	-0.0179	0.106	-0.139	0.132	0.00711	-0.0466	-0.0102	0.0568
	(0.191)	(0.522)	(0.161)	(0.031)	(0.103)	(0.923)	(0.446)	(0.544)	(0.441)
SIGN	0.204	0.0399	-0.244	0.160	0.117	-0.277	0.217	0.0246	-0.241
	(0.064)	(0.485)	(0.041)	(0.063)	(0.173)	(0.011)	(0.006)	(0.583)	(0.001)
CPOP	-0.0549	-0.0112	0.0661				-0.111	-0.0242	0.135
	(0.575)	(0.655)	(0.570)				(0.235)	(0.480)	(0.239)
GDPG	-0.000668	-0.000136	0.000804				0.0000699	0.0000153	-0.0000852
	(0.943)	(0.941)	(0.942)				(0.989)	(0.989)	(0.989)
ELPR	0.00156	0.000319	-0.00188	0.00133	0.00104	-0.00237			
	(0.145)	(0.530)	(0.127)	(0.063)	(0.241)	(0.033)			
POLI	-0.0791	-0.0161	0.0952	-0.0546	-0.0429	0.0975	-0.0487	-0.0107	0.0594
	(0.001)	(0.520)	(0.001)	(0.031)	(0.181)	(0.002)	(0.003)	(0.375)	(0.002)
WTO	0.0537	0.0224	-0.0760	0.0529	0.0705	-0.123			
	(0.390)	(0.596)	(0.449)	(0.220)	(0.355)	(0.256)			
Annex I	-0.157	-0.133	0.290	-0.183	0.121	0.0616	-0.268	0.275	-0.00734
	(0.018)	(0.166)	(0.040)	(0.038)	(0.358)	(0.616)	(0.000)	(0.025)	(0.954)
N	109			112			163		
LL0	-113.6			-116.3			-176.2		
LL	-77.63			-73.03			-138.9		
BIC	249.1			226.3			359.3		
AIC	195.3			180.1			309.8		
PCP	67.89			69.64			60.12		

Note: Parameter estimates show semi-elasticities ($d(y)/d(\ln x)$) for the variables in the upper part and marginal effects (discrete changes for dummy variables from 0 to 1) in the lower part (all calculated at the means of the explanatory variables); p-values in parentheses; Estimates have been obtained by running the gologit2 command (user written by Williams (2006)) in Stata 11 with robust standard errors. The autofit command has been applied to determine the variables for which the parallel lines assumption can be imposed. A Wald test implied parallel lines in the preferred specification for all variables except CINC, TRAD and Annex I. Results are robust to different sensitivity checks like, e.g., dropping EU countries or OPEC members.

Table 8: Ratification Stage Estimation Results Excluding SIGN

	Full			Stepwise			Max. Observations		
Period	1	2	3	1	2	3	1	2	3
ARLA	0.0381	-0.00386	-0.0343				-0.0138	-0.00239	0.0162
	(0.421)	(0.727)	(0.455)				(0.661)	(0.693)	(0.659)
VAAG	0.0386	-0.00390	-0.0347	0.0546	0.0228	-0.0774			
	(0.491)	(0.758)	(0.496)	(0.177)	(0.405)	(0.169)			
PREC	0.122	-0.0124	-0.110				0.0536	0.00930	-0.0629
	(0.028)	(0.732)	(0.054)				(0.288)	(0.528)	(0.292)
CCI	-0.118	0.0120	0.106				-0.00390	-0.000676	0.00458
	(0.648)	(0.769)	(0.656)				(0.966)	(0.965)	(0.965)
GDPC	0.0820	-0.00830	-0.0737	0.0876	0.0366	-0.124	0.0663	0.0115	-0.0778
	(0.340)	(0.723)	(0.385)	(0.151)	(0.449)	(0.187)	(0.187)	(0.546)	(0.222)
GDPE	-0.157	0.0158	0.141	-0.0896	-0.0375	0.127			
	(0.196)	(0.746)	(0.195)	(0.263)	(0.379)	(0.218)			
COIN	0.194	-0.0196	-0.174	0.0752	0.0314	-0.107			
	(0.081)	(0.725)	(0.137)	(0.304)	(0.399)	(0.263)			
COPC	-0.146	0.0148	0.131	-0.0906	-0.0379	0.129	-0.0600	-0.0104	0.0704
	(0.213)	(0.720)	(0.276)	(0.065)	(0.389)	(0.077)	(0.094)	(0.483)	(0.105)
CINC	-0.0118	0.00119	0.0106	-0.0690	0.0830	-0.0141	-0.0661	0.0805	-0.0144
	(0.654)	(0.784)	(0.656)	(0.027)	(0.008)	(0.249)	(0.037)	(0.012)	(0.131)
TRAD	-0.120	0.0122	0.108	-0.0598	-0.0250	0.0848	-0.0407	-0.00706	0.0478
	(0.118)	(0.745)	(0.108)	(0.239)	(0.345)	(0.180)	(0.532)	(0.616)	(0.531)
CPOP	-0.0396	0.00401	0.0356				-0.0937	-0.0162	0.110
	(0.718)	(0.816)	(0.714)				(0.328)	(0.547)	(0.334)
GDPG	0.0000470	-0.00000475	-0.0000422				-0.00129	-0.000224	0.00152
	(0.997)	(0.997)	(0.997)				(0.810)	(0.809)	(0.808)
ELPR	0.00163	-0.000165	-0.00147	0.00132	0.000550	-0.00187			
	(0.176)	(0.745)	(0.175)	(0.088)	(0.372)	(0.081)			
POLI	-0.0595	-0.0672	0.127	-0.0728	-0.0305	0.103	-0.0563	-0.00975	0.0660
	(0.019)	(0.035)	(0.000)	(0.002)	(0.313)	(0.000)	(0.001)	(0.434)	(0.001)
WTO	0.0761	0.00614	-0.0822	0.0801	0.0695	-0.150			
	(0.317)	(0.856)	(0.406)	(0.142)	(0.303)	(0.174)			
Annex I	-0.164	-0.0488	0.213	-0.222	0.254	-0.0321	-0.254	0.342	-0.0885
	(0.053)	(0.496)	(0.105)	(0.009)	(0.033)	(0.807)	(0.000)	(0.001)	(0.430)
N	109			112			163		
SE									
LL0	-113.6			-116.3			-176.2		
LL	-79.99			-80.26			-144.6		
BIC	249.1			231.3			365.6		
AIC	198.0			190.5			319.2		
PCP	67.89			68.75			60.12		

Note: Same estimation as in Table 7 but without SIGN as an explanatory variable.

Indicators for damage costs of climate change and measures for compliance costs seem to have lower predictive capabilities for the decision when to ratify the KP. Only the value added of agricultural sector in percentage of GDP (VAAG) and the share of electricity production from fossil fuel sources (ELPR) have a significantly positive impact in the first subperiod and a significantly negative effect in the third.[28] However, political factors turn out to be significant (CINC, TRAD and POLI). Overall, it seems that poor and less influential countries (high share of agricultural sector on GDP, low CO_2 emissions per capita, low power index, low trade share, non-Annex I country) were significantly more likely to ratify in the first subperiod, developed and powerful countries (Annex I country, high power index) were more likely to ratify in the second and less democratic countries with high CO_2 emissions per capita ratified in the third subperiod.

Thus, our analysis qualifies the results of the existing empirical literature investigating the signing and ratification of the KP (see the literature overview in Section 1). While political factors play a significant role for when to ratify the KP, the signing decision is rather driven by damage and compliance costs. Therefore, we strongly argue for testing a wide range of potential influences in the analysis of international environmental agreements instead of focussing on specific factors.

Moreover, our empirical analysis strongly supports our theoretical considerations outlined in Section 3. First, the division of the ratification period into three subperiods according to the two key events of Russia's ratification announcement and its actual ratification (which, in turn, triggered the KP to enter into force), seems appropriate. As shown in Table 5, the three subperiods are significantly different. Second, our search for the most appropriate estimator (see Table 6) gives strong support for the generalized ordered logit model implying that there exists an ordering of the underlying latent variable, the net benefits of ratification, with respect to the three subperiods. In line with our theoretical model, the net benefits of ratification decrease the later the subperiod of ratification. Third, as predicted by our theoretical considerations, countries which signed the KP are significantly more likely to ratify in the first subperiod and are significantly less likely to ratify in the third. Forth, our analysis shows that Annex I countries had a higher probability of signing but, at the same time, had a lower probability of ratifying in the first subperiod.

In summary, we find sound empirical evidence for strategic behavior with respect to ratifying

[28] Comparing signing and ratification results, we find that both ARLA and VAAG exert a negative effect on signing but a positive effect on ratification in the first period, which is puzzling given that signing has a positive effect on ratification in the first period. Looking into the data reveals that several very poor countries like Uganda, Malawi, Gambia, Nauru, Guinea, and Equatorial Guinea all of which have high levels of VAAG, low levels of ELPR, did not sign the KP but ratified in the first period. These countries should be unconditional beneficiaries of the KP, as they will be negatively affected by climate change but will probably not face any binding emission regulations in the foreseeable future. In line with our theory, they ratified in the first period. However, these countries did not sign the KP in the first place.

the KP. On the one hand, ratification is not necessarily a stronger signal for support than signing. In particular, countries ratifying after the KP entered into force are suspected to do so because ratification is only beneficial if the KP cannot be prevented in the first place. As already argued, this is certainly true for OPEC members. On the other hand, Annex I countries, which have a strong incentive to free-ride on the emission reductions of other Annex I countries, were reluctant to ratify the KP right away.[29] The 55% emission hurdle in combination with U.S.' withdrawal from the KP reduced free-riding opportunities substantially which eventually led to a cooperation of the remaining Annex I countries in bringing the KP into power.

With hindsight it seems that the 55% emission hurdle helped to overcome Annex I countries' reluctance to ratify the KP. However, we are cautious to suggest that such hurdles are, in general, helpful to overcome free-riding incentives in the context of international environmental agreements. On the one hand, they may help to coordinate on cooperative actions, as in the case of the KP. On the other hand, the higher is the hurdle, the higher is the negotiation power of individual countries to exert side-payments and transfers for their cooperation, which may actually impede cooperation (see, for example, the COP 15 meeting in Copenhagen).

6 Conclusions

We analyzed the decision of countries whether to sign and whether and when to ratify the KP by testing for a wide range of potential influences, covering not only political factors but also variables reflecting damage costs of climate change, energy and emissions patterns and general economic indicators. We find that damage and compliance cost measures have an significant impact on the decision whether to sign the KP. For the ratification stage, we developed a theory of strategic behavior, which explains countries' timing of ratification with respect to certain key events. We identified Russia's announcement to ratify and its actual ratification as the important key events, which triggered increased ratification activity. Our empirical results support our selection of key events and provides strong evidence for strategic behavior.

It seems that the particular set-up of the KP, namely the 55% hurdle of 1990 Annex I greenhouse emissions, in combination with the withdrawal of the U.S. played an important role to overcome the free-riding incentives from Annex I countries to benefit from other countries emission abatements without ratifying themselves. Although we are cautious to

[29] Also countries with high power index were more likely to sign and, at the same time, less likely to ratify in the first ratification period.

suggest that such hurdles facilitate establishing international environmental agreements, we consider further empirical investigation of similar rules in international agreements as a fruitful avenue for future research.

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