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## Signing as Signalling in International Environmental Agreements

Antonina Nazarova \*

Corrado Di Maria \*

Emiliya Lazarova \*

\* University of East Anglia



**SCHOOL OF  
ECONOMICS**

School of Economics  
University of East Anglia  
Norwich Research Park  
Norwich NR4 7TJ  
United Kingdom  
[www.uea.ac.uk/economics](http://www.uea.ac.uk/economics)

# SIGNING AS SIGNALLING IN INTERNATIONAL ENVIRONMENTAL AGREEMENTS

Antonina Nazarova\*      Corrado Di Maria\*      Emiliya Lazarova\*

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## Abstract

In this paper, we revisit the role of the signature by the executive in the context of international environmental agreements. Using a novel panel dataset covering 52 agreements involving 203 countries over the period 1975-2017, we show that, contrary to conventional wisdom, the act of signing a treaty significantly increases the probability of ratification.

**Keywords:** *International Environmental Agreements, Strategic Interaction, Signalling, Signature, Proportional Hazard Models*

**JEL Codes:** *F53, Q58, K33*

## 1 Introduction

Cooperation among sovereign states on the provision of international environmental public goods suffers from long lags, so much so that by the time an agreed decision is reached, the situation may have deteriorated to such an extent that the efforts themselves have become futile. This is particularly the case for large, internationally coordinated policy efforts on environmental issues. The Convention on Long-Range Transboundary Air Pollution, for example, saw negotiations start in 1972, was opened for signature in 1979 and

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\*School of Economics, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, UK.  
Address all correspondence to: [e.lazarova@uea.ac.uk](mailto:e.lazarova@uea.ac.uk)

eventually entered into force in 1983. Similarly, the Kyoto Protocol – negotiated under the aegis of the UN Framework Convention on Climate Change (UNFCCC) – was agreed upon in 1997, entered into force in 2006 and saw its first commitment period start only in 2008.

International environmental treaty-making is a complex process whereby an official text is agreed upon, after extensive negotiations among the representatives of the countries involved. Following the text's formal adoption, the treaty is open for signature and ratification. However, even when the treaty is signed by the legal representatives of a participant state, it still needs to be ratified by the national legislature of each of the treaty participants. Only once a sufficiently large number of participants have ratified it does the treaty enter into force and become binding for all ratifiers.

A significant body of literature has focused on the determinants of the duration of the ratification period, emphasizing the role that economic, political, and institutional factors play in the ratification decision. Several contributions show that the level of economic development and the degree of integration in the global economy both matter for the speedy ratification of international environmental agreements (IEAs). Wagner (2016), for example, finds that higher GDP per capita is associated with faster ratification, while the role of trade openness has been shown to have similar impacts by Neumayer (2002), among others. Institutions matter as well, however. Cazals and Sauquet (2015) show that a higher degree of democratization correlates positively with shorter ratification lags. The speed of ratification is also shown to depend positively on the prevalence of corruption (Fredriksson et al., 2004). The strength of the commitments made within the agreement also plays a role; Battaglini and Harstad (2020) discuss the prevalence of 'weak' treaties, for example. The empirical literature, however, has so far largely abstracted from the role played by the signing of the treaty, assuming it to be a mere formality (e.g. Shaw, 2017).

In this paper, we draw inspiration from recent theoretical contributions on the role of signature as a signalling device (e.g. Hugh-Jones et al., 2018; Nazarova et al., 2023) and revisit the empirical evidence on the role of treaty signing in determining the timing of the ratification decision. Using a sample of 52 IEAs involving 203 countries between 1975 and 2017, we show that, contrary to conventional wisdom, signing a treaty significantly increases the likelihood that the treaty is ratified by the domestic legislature. We also find that this effect is stronger for lower-income countries than for their more affluent counterparts.

In the rest of the paper, we first introduce the conceptual framework that underpins our empirical work (section 2). In section 3, we discuss the empirical strategy and data. Our results are presented in section 4 and section 5 concludes.

## 2 Conceptual framework

In what follows, we empirically test the idea that, rather than being a mere formality, the decision to sign an international treaty may be used strategically by the executive as a signalling device vis-à-vis their international counterparts and their domestic audiences. Hugh-Jones et al. (2018) discuss a model where national executives, having access to the private information they accrue through their participation in the negotiation process, use their signing decisions to signal their respective domestic veto players their collective view on the importance of the treaty. They show that the larger the number of countries that sign the treaty early on in the ratification process ('first-signers'), the more likely individual states are to ratify a treaty. Nazarova et al. (2023) look at the signature decision from a different perspective and show, in the context of a two-stage game between the executive and the domestic legislature, that the executive's decision to sign or not a treaty needs to balance the benefits they derive from successful ratification against the potential loss of political capital that arises from the failed ratification of a signed treaty.

In this paper, we follow the latter line of reasoning and assume that the signature provides the executive with the means to signal to their domestic veto players that the issue under consideration is important enough to risk political capital on, which may persuade them to ratify the treaty. In our empirical investigation, we focus on the domestic factors that determine the executive's cost-benefit trade-off and assess how they affect the ratification decision. In line with the discussion in Nazarova et al. (2023), we assume that the executive's payoff comprises two parts, one that captures the net benefits potentially accruing to the country from the treaty, and one that acknowledges the gains (losses) of political capital arising from the executive's efforts to ratify the treaty.

As for the first aspect, we assume the economic dimension to be crucial. In particular, we expect both the current level of economic development and the country's openness to trade to be positively associated with the potential environmental benefits, and therefore with faster ratification. Indeed, richer countries tend to exhibit stronger preferences for environmental protection, whereas less developed ones might (need to) prioritize economic development at the cost of some environmental deterioration. On the other hand, the ratification of an IEA is often associated with increased access to trade opportunities with partner countries; in this sense, a more open country might have more to gain from ratifying an agreement.

Moving on to the second aspect, following French (2011), we assume that political capital is accumulated by politicians using specific actions to create 'impressions among citizens', that allow them to be credited with the approval of voters and supporters and contribute

to the candidate's potential political influence and contribute to winning elections. From this perspective, signing a treaty that is later ratified may accrue political capital for the executive, whereas a negative outcome of the ratification process is likely to be seen as an embarrassment for the Government. Therefore, we expect that signing a treaty may reduce the time to ratification. We would also expect this effect to be strongest when the ratification process takes place while the Government that negotiated the agreement is still in power. According to Putnam (1988), for example, while negotiating an international treaty, the negotiator is involved in a bargaining process with both international and domestic agents. While the negotiator needs to navigate the requirements of different countries to achieve a feasible agreement, they usually also receive mandates from the domestic legislature. Signing a treaty they have negotiated, might be a particularly strong signal to the ratifiers that their conditions have been met.

Finally, it is important to account for the role of politics and the electoral cycle in the process of ratification. Obviously, political cycles matter most in democratic countries, where electoral chances might be linked to environmental performance. Similarly, the salience of any IEA is likely to be at its peak in the run-up to an election, although it is not clear which way this effect would go. On the one hand, the incumbent might ratify a treaty to burnish their environmental credentials; on the other hand, the ratification of a particularly unpalatable IEA might be pushed into the new electoral cycle to maximize the chances of re-election.

### **3 Empirical model and data**

The main goal of our analysis is to determine whether, following Hugh-Jones et al. (2018) and Nazarova et al. (2023), the executive's decision to sign an International Environmental Agreement may be interpreted as a signal sent by the executive to the legislature to ratify a valuable treaty. Empirically, we aim to gauge whether observing a signature by one country may be linked to an increase in the likelihood of the treaty being ratified. The natural choice in this context, is to cast our empirical analysis within a duration analysis framework and try to test whether the hazard rate depends positively on the signature decision.

Given the discussion in the previous section, however, the decision to sign is, at least theoretically, inextricably linked to the executive's expectations about the actions of the legislature in charge of ratification. The obvious concern is, therefore, that the decision to sign might depend on the expected ratification creating problems with endogeneity and

biases in the estimation. While the substantial lags between signing and ratification – the time lag between the two decisions in our data is close to three years – make it unlikely, *prima facie*, that the executive would be able to condition their decision to sign a treaty on a plausible expectation that the legislature would ratify the treaty several years down the line. Based on this argument, the presence of endogeneity might not represent a serious challenge to our empirical analysis in practice. Nevertheless, for completeness, we start our empirical analysis below by estimating a multilevel multiprocess model á la Bartus (2017). The results of this analysis convincingly rule out the endogeneity concerns mentioned above.

The core of our empirical analysis below then relies on the estimation of Cox proportional hazard (PH) models (Cox, 1972). This approach allows us to assess simultaneously the effect of several factors on (the hazard rate of) treaty ratification and works for both quantitative and categorical independent variables. Our observations are at the treaty-country level and the time to ratification is measured in days, which enables us to use information about the exact dates of signature and ratification and allows for greater granularity than annual observations.

We model the ratification process as a ‘time-to-failure’ process, where countries are observed from the date of treaty adoption until they ratify – there is a ‘failure’ in the traditional parlance of duration models – or they are censored if they do not ratify and reach the end of our time horizon (December 31 2017, in our data). Letting  $t$  be the survival time and  $j$  the unit of observation, we model the hazard rate  $h(t|\mathbf{X}_j)$ , i.e. the rate at which ratification occurs at time  $t$  given that it has not yet happened until then, given  $\mathbf{X}_j$  according to:

$$h(t|\mathbf{X}_j) = h_{0a}(t) \exp(\mathbf{X}_j\beta), \quad (1)$$

where  $h_{0a}(t)$  is the baseline hazard rate, which we assume to differ across the different treaties,  $a \in \{1, 2, \dots, A\}$ ,<sup>1</sup> and  $\mathbf{X}_j$  is a matrix of independent variables. Besides indicators for signature status, the other control variables include the countries’ per-capita GDP and their degree of trade openness, as well as the level of democracy and the time until the following election.

The basis for our empirical analysis is an original dataset which includes information on 203 countries faced with the decision to ratify any of the 52 IEAs adopted during the period 1975-2017. We include all the treaties for which the information about the time of signature is available to us. Our dataset is constructed using public information from open-access texts of IEAs and open-access datasets. For each ‘treaty-country’ observation, the

<sup>1</sup>This is a rather intuitive assumption, given the substantial heterogeneity that exists across treaties that deal with different environmental issues, at different scales, and with different participants.

dataset contains information about: the year of treaty adoption, the year of signing, and the year of ratification, together with key control variables discussed below. Each ‘treaty-country’ pair observation is unique, as each country can sign and ratify/accede to a treaty only once, while the same country may sign/ratify/accede to multiple treaties over time.

Based on the information contained in our dataset, we construct the ‘time to signature’ and the ‘time to ratification’ variables as the time (in days) between the date of adoption and the date of signing/ratification, respectively.

Our key variable of interest is the variable ‘Signed’, which is a dummy variable that takes on the value 1 if the observed country has signed the treaty, and 0 otherwise. To allow for the possibility that the strength of the signature signal differs depending on whether the signatory is the same executive that negotiated the agreement or not, we also define two auxiliary dummy variables, called ‘Signed by negotiator’ and ‘Signed by non-negotiator’. The variables rely on the dates of adoption and signing; if the dates fall within the same electoral cycle, we assume that the signatory is also the negotiator, otherwise, we assume this not to be the case. To construct these variables, we rely on data from the Database of Political Institutions of the Inter-American Development Bank (Cruz et al., 2021). The electoral cycle is taken to last from the first year following an election until the start of the year of the next one. Using the same source, we also construct the ‘Time to next election’, the ‘Years in office’ and the ‘Electoral competitiveness’ variables. The first one simply computes the time in years between the adoption of the treaty and the beginning of the year when the next election is held; the second variable informs us of the length of the tenure of the executive at the time of ratification, which we interpret as a measure of the trust in the executive and the strength of the signal; the last variable is an index of the competitiveness of the last elections held in a country prior to ratification. The index ranges from 1 (no legislature) to 7 (the largest party got less than 75% of the seats in parliament) and is used here as a proxy of the importance of political capital within each country.

The remaining independent variables in our regressions are assembled from a variety of sources. We derive ‘Per-capita GDP’ and ‘Trade openness’ from the World Bank Open Data repository (World Bank, 2023). The former is computed as GDP in 2010 US\$ divided by midyear population, and the latter is calculated as the ratio of the sum of exports and imports to GDP. The ‘Time to next election’ is computed using the information provided in Cruz et al. (2021) and is the difference between the year in which the next election takes place and the current one. Finally, the ‘Democracy’ variable is the POLITY2 indicator contained in the Polity5 database (Center for Systemic Peace, 2020). The variable is a composite index that measures the level of democracy of countries and ranges from -10 (strongly autocratic) to 10 (strongly democratic).

Table 1 contains the descriptive statistics for all the variables in our dataset. In 60% of the cases, the countries in our dataset signed an IEA after its adoption, taking on average 10 months to do so. The average time to ratification was 2,401 days – just over six and a half years.

Table 1: Descriptive statistics

	Mean	Std.Dev.	Observations
Time to ratification	2,014.93	1,892.54	2,035
Time to signature	312.57	199.52	1,100
Signed	0.74	0.44	2,035
Signed by negotiator	0.58	0.49	2,035
Signed by non-negotiator	0.15	0.36	2,035
Per-capita GDP	14.96	18.88	2,035
Trade openness	75.10	44.45	2,035
Democracy	5.19	5.97	2,035
Time to next election	1.95	1.47	2,035
Years in office	5.69	6.09	2,035
Electoral competitiveness	6.34	1.41	2,035
Open membership	0.74	0.44	2,035

## 4 Results and discussion.

As discussed in the previous section, we start our empirical analysis by presenting the results of a multilevel, multiprocess model that allows for the possible endogeneity of the signature decision in the context of the process of ratifying an IEA. To this end, we apply the methodology proposed by Bartus (2017), which controls the potential endogeneity of the signature decision by jointly estimating a parametric duration model, where the observed failure is the ratification decision, alongside a probit equation designed to explain the probability of observing a signed treaty. Table 2 reports the results of this procedure.

The first column of Table 2 presents the baseline duration model, which does not attempt to account for endogeneity. In column (II), the results of the system estimation discussed above are presented. The two sets of coefficients are almost identical. Based on this out-



Table 2: Multilevel analysis (time to ratification) – full sample

	Time to ratification	
	(I)	(II)
Signed	0.353*** (0.069)	0.351*** (0.069)
Per-capita GDP	0.003** (0.002)	0.003** (0.002)
Trade openness	0.002*** (0.001)	0.002*** (0.001)
Democracy	0.013*** (0.005)	0.013*** (0.005)
Time to next election	-0.003 (0.017)	-0.003 (0.017)
Constant	-12.492*** (0.289)	-12.491*** (0.289)
Signed (Probit)		
Per-capita GDP	–	0.027*** (0.003)
Trade openness	–	-0.005*** (0.001)
Democracy	–	0.041*** (0.009)
Time to next election	–	0.022 (0.024)
Year in office	–	0.016** (0.007)
Electoral competitiveness	–	0.041 (0.032)
Constant	–	0.267 (0.231)
Observations	2,035	2,035

Notes: (I) Weibull duration model; (II) System estimation of a Weibull duration model and a Probit model, following Bartus (2017).

Significance levels denoted by \*\*\* for  $p < 0.01$ , \*\* for  $p < 0.05$  and \* for  $p < 0.1$ .

come, we conclude that whatever potential endogeneity concerns might have existed, we believe they are clearly resolved by our discussion above and these empirical results. In what follows, therefore, we turn to the estimation of the Cox PH model introduced in Section 2 above.

As our baseline, we estimate a Cox PH model to explain the time to ratification. This model includes the variable ‘Signed’ to capture the impact of treaty signature following adoption, as well as the control variables described above. The first column of Table 3 contains the coefficient estimates and the second presents the corresponding hazard ratios.<sup>2</sup> The second set of results in Table 3 report on a similar model run on the same set of control variables, with the inclusion of two different variables for signature. ‘Signed by negotiator’ indicates whether the treaty has been signed by the same executive who took part in the treaty negotiations. Conversely, ‘Signed by non-negotiator’ informs us that an election took place between the treaty adoption and the act of signing.

Table 3: Cox proportional hazard model (time to ratification) – full sample

	Full Sample			
	Coefficient	Hazard ratio	Coefficient	Hazard ratio
Signed	0.410*** (0.072)	1.507*** (0.108)	– –	– –
Signed by negotiator	– –	– –	0.464*** (0.074)	1.590*** (0.117)
Signed by non-negotiator	– –	– –	0.327*** (0.097)	1.389*** (0.135)
Per-capita GDP	0.008*** (0.002)	1.008*** (0.002)	0.008*** (0.002)	1.008*** (0.002)
Trade openness	0.000 (0.001)	1.000 (0.001)	0.000 (0.001)	1.000 (0.001)
Democracy	0.016*** (0.005)	1.016*** (0.005)	0.015*** (0.005)	1.015*** (0.006)
Time to next election	-0.011 (0.017)	0.989 (0.017)	-0.026 (0.019)	0.975 (0.019)
Observations	2,035	2,035	2,035	2,035
Equality test <sup>†</sup>	–	–	2.600	–
<i>p</i> -value	–	–	(0.107)	–

Notes: Cox Proportional Hazard estimations with stratification of the baseline hazard by treaty.

<sup>†</sup> The test is for the null hypothesis of equality between the coefficient of ‘Signed by negotiator’ and ‘Signed by non-negotiator’.

Significance levels denoted by \*\*\* for  $p < 0.01$ , \*\* for  $p < 0.05$  and \* for  $p < 0.1$ .

<sup>2</sup>The hazard ratios measure the increase in the hazard rate due to a change in an independent variable, all else equal.

The results of Table 3 confirm that economic and institutional factors matter for the ratification decision. Indeed, they support our view that the likelihood that a treaty is ratified increases with the level of affluence and with the degree of democracy. The hazard ratios, however, inform us that the response of the hazard rate to changes in these variables is quite sluggish. An increase in GDP per capita by 1,000 US\$ leads to less than a 1% increase in the hazard rate; similarly, an increase in the democracy index by one leads to an increase in the hazard rate of only around 1.6%. Neither trade openness nor the time to the next election seems to statistically affect the ratification decision, all else equal.

The truly striking result here, however, is the one emerging from the first row of Table 3. Indeed, the coefficient on the ‘Signed’ dummy is large and highly significant, and signing a treaty leads to an increase of about 51% in the hazard rate relative to the situation where the treaty is not signed. This is a strong and surprising result which runs counter to the approach taken by the vast majority of economists who see the signature of a treaty as a mere formality. Rather, this result supports our view that the decision to sign a treaty acts in fact as a strong signal for the national legislature on the importance of ratifying the treaty.

To delve deeper into this result, we split the signature dummy in two to account for the timing of the signing decision. The second part of Table 3 reports the results of this exercise. As conjectured above, the hazard ratio is higher for the treaties that are signed by the negotiator rather than by a later executive, suggesting that the signal sent by the negotiating executive may be perceived as stronger by the Legislature. Statistically, however, we very narrowly cannot reject the null hypothesis that the coefficients on the two dummies are equal (the  $p$ -value of the test is 0.1067). After all, it seems that the act of signing – rather than who signs the treaty – makes the most difference in this context.

Table 4 replicates the baseline analysis using the single signature dummy splitting the sample along two dimensions. The first two columns present the Hazard Ratios for the sample of lower and higher-income countries, respectively, whereas columns three and four replicate the analysis using the subset of open- and restricted-membership treaties, respectively.<sup>3</sup>

The first two columns of Table 4 reveal that the impact of signing on the speed of ratification is higher for lower-income countries. This is in line with the discussion in Cazals and Sauquet (2015), who argue that participating in international environmental agreements

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<sup>3</sup>Here we follow the World Bank classification of countries by income level in 2021 and include both low- and lower-middle-income countries in the first group. Higher-income countries are then defined as countries drawn from the upper-middle-income and high-income groups. The World Bank methodology uses gross national income (GNI) per capita data in U.S. dollars, converted from local currency using the World Bank Atlas method, which is applied to smooth exchange rate fluctuations.

is often perceived in higher-income countries as an unnecessary constraint imposed on domestic economic agents, similar to the adoption of a new tax.

Finally, our analysis shows that the hazard ratios for ‘Signed’ are virtually the same across treaty types. Indeed, the only significant difference between the results for open and restricted membership treaties is that the level of democratization is significant only in the sample of open membership treaties, hinting at the fact that global treaties may be more politically salient and therefore more likely to be ratified in democratic societies.

Table 4: Cox proportional hazard model – different sub-samples

	Income level		Treaty membership	
	Lower income	Higher income	Open	Restricted
Signed	1.508*** (0.134)	1.427*** (0.197)	1.507*** (0.119)	1.658*** (0.294)
Per-capita GDP	1.004 (0.015)	1.012*** (0.002)	1.007*** (0.002)	1.011*** (0.004)
Trade openness	1.000 (0.001)	0.999 (0.001)	1.000 (0.001)	1.001 (0.001)
Democracy	1.015** (0.006)	1.023** (0.011)	1.022*** (0.005)	0.975* (0.013)
Time to next election	0.999 (0.022)	0.987 (0.028)	0.990 (0.019)	0.982 (0.037)
Observations	1,082	953	1,497	538

Notes: Cox Proportional Hazard estimations with stratification of the baseline hazard by treaty.

Significance levels denoted by \*\*\* for  $p < 0.01$ , \*\* for  $p < 0.05$  and \* for  $p < 0.1$ .

## 5 Conclusions

In this paper, we study the impact of treaty signing on the decision to ratify international environmental agreements. We use a novel dataset comprising 52 IEAs and 203 countries over more than 40 years (1975-2017) and show that the decision to sign a treaty significantly increases the probability that the treaty be ratified by the domestic legislature. Our baseline results suggest that the hazard rate increases by over 50% when a treaty has been signed, compared to cases in which the executive fails to sign the agreement. In line with our theoretical priors, we also show that signing by the negotiating executive carries more

weight than signing by a non-negotiating one. Our results are shown to be robust across developed and developing countries and different types of treaty membership.

Contrary to the conventional wisdom often put forward in the economics literature that signing a treaty ought to be considered as cheap-talk, our results strongly support the alternative view that the signature acts as a powerful signal sent by the executive to the legislature on the benefits of ratification (Hugh-Jones et al., 2018; Nazarova et al., 2023). Our findings are likely to be useful to policymakers across the world, as they clearly show the effectiveness of signing as a nudging tool in support of ratification.

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