**A Appendix: A formal model of signing**

There are *N* states. Each country has a legislature *L* and an executive *E*. The states must decide whether to implement a policy to deal with an environmental or other issue. There is an unobserved state variable *S* ∈{0,1}which equals 1 with probability *s*, and 0otherwise. If *S* = 1,then the policy is appropriate. If *S* = 0, then the policy is not appropriate, either because the underlying issue is not serious, or because the policy will not deal with it effectively. If the policy is implemented in country *i* ∈{1,...,N}, then actor *J* ∈{*E, L*}receives *S-cJi*; otherwise s/he receives 0. Thus *cJi* is the relative cost of the policy, with the benefit of the policy normalized to 1 or 0. Different actors may weigh the costs and benefits of legislative action differently; however, we assume *cJi* ∈ (0,1), so that all actors will prefer to legislate if and only if the probability of the policy being appropriate is above some threshold.

*Information*

Each executive receives a private signal *Si* ∈{0, 1}where *Si* *= S* with probability *πi* *>* 1/2. Executives differ in their level of expertise *πi*. Legislatures receive no signal. All the parameters *cJi, πi* are common knowledge.

For actor *J* in country *i*, let

|  |  |
| --- | --- |
|  (1) |  |

This is the logged, risk-adjusted “cost-benefit ratio” as J sees things before his prior beliefs, *s*, are updated. Note that *KJi* *>* 0if and only if *s-cJi* *<* 0, which means that the actor is an *ex ante* “sceptic” who would not pass legislation in the absence of positive evidence that the policy is appropriate.

Let *αi* be executive *i*’s logged odds of an accurate signal, or “expertise” for short:

|  |  |
| --- | --- |
|  | (2) |

Since *πi* *>* 1/2, *αi* is positive. Suppose any actor has belief *μ* that the policy is appropriate. Then he will wish to pass legislation if

|  |  |
| --- | --- |
|  | (3) |

A little algebra transforms this into

|  |  |
| --- | --- |
|  | (4) |

By Bayes’ rule, for any signal *Si*,

|  |  |
| --- | --- |
|  | (5) |

and transforming to odds and taking logs:

|  |  |
| --- | --- |
|  | (6) |

Similarly *Prob*(*S* = 1*|Si* = 0) *= -αJi+*log*.* Hence an executive will wish to implement the policy, conditional on his own positive signal, if *αi* *≥ KEi*; and conditional on his own negative signal, if *-αi* *≥ KEi*.[[1]](#footnote-1) This additive logic extends to multiple signals: conditional on any number of observed or inferred signals, player *J* in country *i* will wish to implement the policy if

|  |  |
| --- | --- |
|  | (7) |

*Adoption of domestic legislation*

To show the signaling advantages of the treaty route over domestic legislation, we first model the introduction of domestic legislation to implement the policy. Recall that the standard advantages of international treaties (e.g. coordinated policy-making across nations) have been assumed away. Nevertheless, comparing domestic legislation to treaty signature shows a new potential advantage: treaty signature allows domestic vetoes to infer many executives’ signals on the policy.

We assume that without the publicity afforded by the negotiation process, no state observes the legislative process in any other state. Therefore, individual legislation is modelled as follows: the executive chooses whether to propose the policy as a bill in parliament; if the executive proposes, then the legislature accepts or rejects; if the legislature accepts, legislation is passed.

The executive has three pure strategies: ALWAYS propose legislation, NEVER propose, or CONDITION on her signal i.e. propose iff *SE* *=* 1. We rule out the fourth strategy, proposing if and only if her signal is 0, as weakly dominated. We also assume that, even if the legislature always rejects, the executive will only propose if he expects legislation to be beneficial. If the executive proposes, the legislature can either accept or reject. We will rule out some uninteresting equilibria with the Intuitive Criterion: if the executive plays NEVER, then out of equilibrium the legislature believes *SJ* *=* 1if after observing a proposal.

Table 5 shows the conditions for each pair of possible strategies to be in equilibrium. (We drop the *i* subscript temporarily.) If the executive plays CONDITION or NEVER, then the legislature assumes after a proposal that the executive received *SE* *=* 1.[[2]](#footnote-2)

|  |  |  |  |
| --- | --- | --- | --- |
| ***Legislature\*** ***Executive*** | ALWAYS | CONDITION | NEVER |
| *Accept* | *KE* *≤-α* | *-α < KE* *≤ α* | *α < KE* |
|  | *KL* *≤ 0* | *KL* *≤ α* | *KL* *≤ α* |
| *Reject* | *KE* *≤-α* | *-α < KE* *≤ α* | *α < KE* |
|  | *0 < KL* | *α < KL* | *α < KL* |

*Table 5: Single country conditions for different equilibrium strategies*

*Ratification of an international treaty*

Just as in the domestic case executives have three undominated pure strategies: ALWAYS sign; CONDITION, i.e. sign conditional on your own positive signal; and NEVER sign. Suppose that a set of *Q* ofexecutives condition on their signals and only sign if *S****i*** *=* 1for*i* ∈ *Q*. As before we will assume that executives who never sign are treated by executives, out of equilibrium, as conditioning: call the set of such executives *R*. Executives also benefit from the knowledge of their peers; hence executive *i*will sign if and only if

|  |  |
| --- | --- |
|  |  |

Therefore, in an equilibrium where the treaty is tabled, recalling that this requires unanimity, each executive’s best strategy is: [[3]](#footnote-3)

ALWAYS if (9)

CONDITION if (10)

NEVER if . (11)

The legislature in country *i* will then ratify in such an equilibrium if and only if
An equilibrium requires sets *Q* and *R* satisfying the appropriate condition above for each individual in each set. There may be multiple equilibria in which a treaty is tabled. For instance, suppose *N = 3* with *α1* *= α2* *= α3* *= α* and *KE1* *= KE2* *= KE3* *= K*. If *0 < K < α*, then there are three equilibria in which two executives condition on their signal, and the other always signs. This is a typical example of the “swing voter’s curse” (Feddersen and Pesendorfer 1996), where conditional on the other two executives signing, the third executive wishes to sign irrespective of his or her own signal. We examine the effect of the swing voter’s curse below, by simulating equilibria.

To examine the effect of an increase in the number of veto players in country *i*, write the cost of the most skeptical veto player when there are fewer veto players as *KLi*, and the cost when there are more veto players as *K’Li*. Of course *KLi* *≤* *K’Li*; assume the inequality is strict. Consider, in each of the two cases, the effect of an increase in summed expertise (), from a value of *A* to *A’*. There are the following possibilities:

1. *K’Li* < *A*. In this case the most skeptical veto player in country *i* can be convinced even by the lower level of expertise; more expertise has no further effect, irrespective of the number of veto players.
2. *KLi < A < K’Li* < *A’.* In this case, as the number of veto players goes up, the effect of higher expertise is *increased*. With fewer veto players, country *i* is always persuaded irrespective of the level of expertise. With more veto players, only a stronger signal of expertise will persuade the most skeptical veto player.
3. *A < KLi < K’Li* < *A’.* Here again there is no marginal effect of an increase in veto players, since either way country *i* is only persuadable by the higher level of summed expertise.
4. *A < KLi*  < *A’ < K’Li*.Now the marginal effect of an increase in veto players is to reduce the effect of the increase in expertise. With fewer veto players, country *i* only ratifies in response to a strong signal. With more veto players it never ratifies.
5. *KLi < A* < *A’ < K’Li*.
6. *A’ < KLi.* In both these cases there is again no marginal effect, since country *i* is either persuaded at both levels of expertise or at neither.

# B Appendix: Simulations of equilibria

In our model, some executives condition on their own signal of policy appropriateness, while others do not and effectively free-ride on the knowledge of their peers. Legislatures are only persuaded by those executives who are conditioning. However, in our empirics we only observe which states sign a treaty, and not whether they were conditioning (or more broadly, how much information is conveyed by their signature).

To check whether this makes a difference, we simulated equilibria for different numbers of states and random draws of α and κ terms. We discarded cases where there was no pure strategy equilibrium. We also discarded cases where the only pure strategy equilibrium had one or more states never signing, since these equilibria are not observable in our dataset. We ran simulations until we had 100 valid draws, for 3, 5, 8 and 15 states. We then correlated the total sum of α terms of all signers, with the total sum of α terms of signers who were conditioning. Results are shown below. The correlation was strong and significant for all numbers of states, though the correlation is smaller as *n* increases. Thus, the total knowledge of signing states appears to be a good proxy for the real causal variable in our theory, the total knowledge of signers who are conditioning.

α values were drawn independently for each country from the uniform distribution on [0, 3]. κ values were drawn independently from the standard log normal distribution. Code is available on request.

|  |  |  |
| --- | --- | --- |
| Number of countries | Correlation (95% conf. int.) | p-value |
| 3 | .79 (0.70, 0.85) | < 0.001 |
| 5 | .75 (0.64, 0.82) | < 0.001 |
| 8 | .49 (0.32, 0.62) | < 0.001 |
| 15 | .27 (0.08, 0.45) | 0.005 |

# C Appendix 3: Further empirical tests



#### Figure 1. Posterior distribution of parameter estimate for coefficient values obtained by bootstrap resampling for Model 1 from Table 4.

Note: The figure reports estimate of coefficient values, not hazard ratios.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Model A1** | **Model A2** | **Model A3** | **Model A4** |
|  | exp(coeff)(*p*) | exp(coeff)(*p*) | exp(coeff) (*p*) | exp(coeff)(*p*) |
| **Pooled expertise** |  |  |  |  |
| **patent\_i\_sign** | **1.341** |  |  | **0.998** |
|  | **(0.000\*\*\*)** |  |  | **(0.943)** |
| **experience\_i\_sign** |  | **1.152** |  |  |
|  |  | **(0.000\*\*\*)** |  |  |
| **marine\_i\_sign** |  |  | **1.093** |  |
|  |  |  | **(0.000\*\*\*)** |  |
| **Controls** |  |  |  |  |
| first\_sign | 8.119 | 10.889 | 10.445 | 5.788 |
|  | (0.000\*\*\*) | (0.000\*\*\*) | (0.000\*\*\*) | (0.000\*\*\*) |
| wealth\_i\_sign |  |  |  | 1.360 |
|  |  |  |  | (0.000\*\*\*) |
| power\_i\_sign |  |  |  | 1.025 |
|  |  |  |  | (0.500) |
| r\_coast\_land |  |  | 1.093 |  |
|  |  |  | (0.01\*\*) |  |
| LRT  | 5928 | 6052 | 1485  | 6285  |
| (*p*) | (0)  | (0)  | (0)  | (0)  |
| Wald test  | 4210 | 3773 | 1533  | 5830 |
| (*p*) | (0)  | (0)  | (0)  | (0)  |
| Robust (score) logrank test  | 152.3 | 139.5 | 121 | 158.5 |
| (*p*) | (0)  | (0)  | (0)  | (0)  |
| No. Observations | 266642 | 342668  | 157595 | 266642 |
| No. Events | 3870 | 4306 | 1150 | 3870 |
| No. States | 190 | 190 | 185 | 190 |
| Period | 1961-2000 | 1952-2000 | 1959-2000 | 1961-2000 |

#### Table 6: Cox proportional hazards models for treaty ratification.

Notes: Each cell entry [exp(coef)] is the exponential of the coefficient which is the hazard ratio (HR). The likelihood ratio test assumes independence of observations within a cluster (country), the Wald and robust score tests do not. Exp(coef) is the exponential of the coefficient which is the hazard ratio (HR). \*\*\*p|z| = <0.001, \*\*p|z| = <0.01, \*p|z| = <0.05.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Model A5** | **Model A6** | **Model A7** | **Model A8** |
|  | (strata: ISSUES)exp(coeff)(*p*) | (clustertreaties)exp(coeff)(*p*) | exp(coeff) (*p*) | exp(coeff)(*p*) |
| **Pooled expertise** |  |  |  |  |
| **patent\_i\_sign** | **1.363** | **1.369** | **1.354** | **1.634** |
|  | **(0.000\*\*\*)** | **(0.000\*\*\*)** | **(0.000\*\*\*)** | **(0.000\*\*\*)** |
| **Controls** |  |  |  |  |
| first\_sign | 4.195 | 4.659 | 5.205 |  |
|  | (0.000\*\*\*) | (0.000\*\*\*) | (0.000\*\*\*) |  |
| IO\_membership | 1.006 | 1.005 | 1.005 | 1.012 |
|  | (0.036\*) | (0.051) | (0.120) | (0.000\*\*\*) |
| threshold | 1.006 | 1.005 | 1.004 | 1.006 |
|  | (0.000\*\*\*) | (0.123) | (0.013\*) | (0.000\*\*\*) |
| lagpercregion | 1.020 | 1.019 | 1.019 | 1.023 |
|  | (0.000\*\*\*) | (0.000\*\*\*) | (0.000\*\*\*) | (0.000\*\*\*) |
| open | 0.966 | 0.963 | 0.939 | 0.967 |
|  | (0.460) | (0.241) | (0.102) | (0.373) |
| rgdpl | 1.101 | 1.158 | 1.376 | 1.067 |
|  | (0.432) | (0.093) | (0.047\*) | (0.544) |
| rgdplsq | 0.960 | 0.922 | 0.815 | 0.989 |
|  | (0.698) | (0.316) | (0.222) | (0.899) |
| lnso2pc | 1.095 | 1.095 | 1.068 | 1.099 |
|  | (0.000\*\*\*) | (0.000\*\*\*) | (0.014\*) | (0.000\*\*\*) |
| meanpc | 1.120 | 1.116 |  | 1.133 |
|  | (0.000\*\*\*)  | (0.000\*\*\*)  |  | (0.000\*\*\*) |
| polity2 |  |  | 1.021 |  |
|  |  |  | (0.002\*\*) |  |
| gdpl | 0.956 | 0.959 | 0.960 | 0.954 |
|  | (0.028\*) | (0.027\*) | (0.023\*)  | (0.009\*\*) |
| LRT  | 5071 | 6002 | 6006 | 4813 |
| (*p*) | (0) | (0) | (0) | (0) |
| Wald test  | 3213 | 994.3 | 4297 | 2948 |
| (*p*) | (0) | (0) | (0) | (0) |
| Robust (score) logrank test  | 140.3 | 55.74 | 131.9 | 141.1  |
| (*p*) | 0 | 0 | 0 | 0 |
| No. Observations | 205384 | 205384 | 199698 | 205384 |
| No. Events | 3002 | 3002 | 3036 | 3002 |
| No. States | 157 |  | 149 | 157 |
| No. Treaties |  | 112 |  |  |
| Period | 1972-2000 | 1972-2000 | 1965-2000  | 1972-2000 |

#### Table 7: Cox proportional hazards models for treaty ratification.

Note: Each cell entry [exp(coef)] is the exponential of the coefficient which is the hazard ratio (HR). The likelihood ratio test assumes independence of observations within a cluster (country), the Wald and robust score tests do not. Exp(coef) is the exponential of the coefficient which is the hazard ratio (HR). \*\*\*p|z| = <0.001, \*\*p|z| = <0.01, \*p|z| = <0.05.

1. Signing on a negative signal can only occur if costs are negative. Reputational effects could be modelled in this way. [↑](#footnote-ref-1)
2. If the executive plays CONDITION then this belief is uniquely specified by Weak Perfect Bayesian equilibrium. If the executive plays NEVER, then this belief can be justified by the Intuitive Criterion: the out-of-equilibrium proposal would give a highest expected benefit to an executive who had received a positive signal, so this is what the legislature believes. [↑](#footnote-ref-2)
3. If the treaty is tabled, along the equilibrium path the set *R* is empty and all members of *Q* sign, so they all received positive signals. In the main text we ignore *R*, since if it is non-empty no treaty can be signed. [↑](#footnote-ref-3)