Informational Benefits of International Environmental Agreements

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Abstract

Given that it is difficult to monitor, and even more so to enforce, International Environmental Agreements, it is surprising that they are signed and implemented. This paper offers a theoretical model, which addresses the phenomena. The focus is on informational and coordination problems---a country which is unsure about the benefits of environmental policy may believe that the benefits are higher the greater the number of other countries which lean towards taking action. Whereas each country may individually take no environmental action, in equilibrium several countries may take environmental action if they expect others to. An International Environmental Agreement can thus be self-enforcing. Such effects can appear even if international environmental spillovers are absent, and even if monitoring and enforcement are infeasible. Our approach can explain additional phenomena: why a country that is known to care little about the environment may deeply influence other countries if it takes environmental action, why lags may appear between the signing of an agreement and its implementation, and how requirements for approval by several bodies within a country can increase support for environmental action.

Keywords

Environmental policy, international agreements, signaling, regulation
JEL codes: Q58, D82, L51

1. Introduction

It is difficult to explain the existence of ambitious international environmental agreements. Take climate change as an example. Climate change is a pure world public bad, so that action to prevent it is a public good which can generate free riding. In addition, the benefits of reducing climate change are uncertain and come with a time lag of thirty to fifty years, due to the thermal inertia of the oceans. Both factors make climate change action difficult to sell for politicians.

This paper explicitly considers the uncertainty involved in environmental policies, inquiring into how the action of one country influences the beliefs of another country about the benefits of action. Section 2 reviews the literature. Section 3 sets out the basic ingredients of the model. Section 4 uses a model without international spillovers to illustrate the role of an International Environmental Agreement (IEA) as a signal for national policies. Section 5 adds the international spillovers to the model. Section 6 brings in reputational concerns for politicians whose type is unknown by the voters. Section 7 brings in multiple political agents and analyzes their role in IEA's.

2. Literature

An extensive literature discusses international environmental agreements. It is surveyed in two recent books by Barrett (2003,2007). Most of this literature considers each country as an individual player that has costs of emission reductions and suffers environmental damages. The costs are a function of one's own efforts; the damage is a function of total emissions. Because international agreements are by nature not enforceable, most popular is the non-cooperative model: no international authority can impose efforts on every country and countries cannot even be forced to stick to the agreements they signed. The results of this non-cooperative model are rather pessimistic as this is a typical case of a pure public bad. Barrett (1994) considers a simple one-shot model with many identical countries and a pure public bad. He finds that in the simplest model, the number of signatories is at most three whatever the number of countries. The cooperative model allows for transfers across countries, and offers a partial or global agreement that benefits all parties by designing a system of transfers that makes all parties better off and produces the grand coalition (Chander & Tulkens (1994)). This solution, however, is difficult to enforce. More important for this paper is that none of these models detail the internal political phase..

Two strands in the literature consider both the national political process and the international negotiation process. The first strand is a theoretical analysis of the median voter model. The second strand is an empirical approach. For example, Buchholz et al. (2005) suppose the median voter determines the negotiation position of a country followed by an international bargaining phase between countries. Their central result is that the median voter will select a very low environmental target because this allows him to receive a larger share of the gains of cooperation. The result is pessimistic: despite the

presence of bargaining (cooperation) between countries, the outcome is an even weaker environmental agreement than the Nash non cooperative outcome predicts. This model has several drawbacks: it predicts very weak environmental agreements, it must assume that the bargaining outcome is enforced and it has only one political level in place: a parliament that executes the median voter preferences. Roelfsema (2007) proposes an alternative theoretical model and shows that if the median voter cares sufficiently for the environment, he has an incentive to delegate policy making to a politician that cares more for the environment than himself. By doing so, he mitigates the risks of a 'race to the bottom' in environmental taxes.

The second strand is empirical and tries to explain the participation decisions in environmental agreements in function of the level of democracy. No structural model is specified. Congleton (1992) finds that democracies will more easily sign the Montreal Protocol[1] . But this is not such a strong test as, according to Barrett (2003), the non signatories (such as Eritrea and Iraq) are more like international outlaws. Murdoch et al. (2002) finds an opposite result in the sense that the Helsinki Protocol[2] was likely to be signed by countries that are more democratic. Frederiksson and Gaston (1999) find that democratic governments tend to sign an international agreement sooner. Murdoch and Sandler (1996) also find that voluntary cutbacks of CFC's are higher in countries with more political freedom. Barrett (2003) is skeptical about this empirical work because the participation decision of countries are not independent decisions: some agreements only enter into force if there is a minimum participation.

The evidence on IEAs is mixed and complex, perhaps because it is often difficult to measure the benefits and costs of IEA's. Murdoch and Sandler (1997), studying the atmospheric ozone problem related to the use of CFC's, show that the IEA mainly implements the non-cooperative equilibrium. Barrett (2003) reviews the making of several IEA's and presents a complex story. He draws the attention to four important characteristics of IEA's. First, IEA's take often a long time to be signed. Second, IEA's are first signed by the executive but only enter into force when they are ratified by parliament. Third, most IEA's only enter into force if there is sufficient participation. Fourth, countries do not always observe the IEA they have adhered to. Huang (2002) considers how a country's aversion to losing face by violating an international treaty can lead countries to abide with international environmental treaties.

We will also draw upon the literature on international trade agreements, on the credibility of national policies, and on political agency. Maggi and Rodriguez-Clare (2007) use a model for trade negotiations where politicians rather than country preferences play a central role. International agreements are seen as a way to commit to industrial lobbies. Conconi and Perroni (2003) show how an international agreement can be enforced by a trigger strategy when the one-time gain from cheating on the agreement is sufficiently smaller than the discounted future cost of a "policy war," and how such international cooperation can strengthen the credibility of domestic policy.

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[1] The Montreal protocol limits the emission of pollutants like CFC's that contribute to the atmospheric ozone problem.

[2] The Helsinki protocol limits the sulfur emissions that contribute to acidification problem.

We follow other work in supposing that policy can be more effective the more confident is the public that the state of nature makes the policy a good one. The essential idea that policy may lack credibility appears in works on trade protection (see Staiger and Tabellini (1987), Matsuyama (1990), and Tornell (1991)). The discussion of commitment in public policy relates to work by Strotz (1955-56), Kydland and Prescott (1977), Barro and Gordon (1983), and Persson (1988). They show that current decisions of economic agents depend, in part, on their expectations of future policy. Phelps and Pollak (1968) apply the principle to determine optimal savings decisions. Alesina and Tabellini (1988) and Tabellini and Alesina (1990) extend these insights by showing that voters may favor budget deficits that constrain future public policy. Glazer (1989) applies these principles to demonstrate that collective choices will show a bias towards durable projects.

Related studies examine how expectations of a policy change may change behavior in a way that increases political support for the policy under consideration. Cassing and Hillman (1986) show that a declining industry may suddenly collapse when its small size reduces political support for protective tariffs. Obstfeld (1986) shows that a balance-of-payments crisis can be self-fulfilling when agents expect a speculative attack to set off an inflationary domestic-credit policy. Rodrik (1991) claims that trade liberalization will succeed if it induces the growth of firms that support such liberalization. Glazer and Hassin (1998) examine why government may avoid finding that a policy will fail, because such information would reduce the public's expectations that the program will be continued, and will therefore reduce investment.

3. Assumptions

The state of nature, which determines the potential benefits of an environmental (Green) policy is uncertain. The state of nature can be either High (which makes a Green policy yield high benefits) or Low (which makes a Green policy yield low benefits). The prior probability that nature is in the High state is λ. For many environmental problems there is and was much uncertainty on the causes, the effects, and the valuation of the damages, and also uncertainty about the cost of policy actions. The uncertainty is only resolved gradually. Famous examples are stratospheric ozone formation and climate change. The role of CFC's in damaging the stratosperic ozone layer was discovered by scientists in 1974, but the different protocols restricting the emissions were only agreed in the period 1985 to 1999 with increasingly precise estimates of the effects, benefits and costs of action. For climate change, the scientific evidence and the computation of benefits and costs of action started in the early 1990's, and there is now still a large uncertainty on the ultimate effects, costs and benefits of actions (see Barrett (2003).

A minister in charge of environmental policy can be either a Green (G) type or else a Brown (B) type. Each can take only one action: sign an international agreement and commit to an environmental (Green) policy or not. A Green policy is irreversible, with a sunk cost I. Each minister sees a signal about the state of nature (H or L); the signal is

correct with probability *s*. The signal seen by the ministers may be different: even if the national scientists may have the same views on the physical mechanisms (for climate change via IPCC), there need be no consenus on the costs of climate change, on the costs of policies to reduce emissions, on the redistributive effects of policies, or on political support for proposed policies. We do suppose that estimates of the costs and benefits of a policy are positively correlated across countries.

We consider two countries, *i* and *j*. The discounted additional benefit (before accounting for the sunk cost *I*) for each country of adopting a Green policy is $W_H(\lambda_p)$ or $W_L(\lambda_p)$ [3]. The benefit only depends on the state of the environment that materializes and on the posterior probability λ_p that is used by the agents in that country. The posterior probability is important because it determines the preventive investments (R&D as well as green investments) by the general public. One reason is that the greater the confidence in the policy's advisability, the more confident are firms or other investors (e.g., households buying cars) that the policy will be enforced, and so the more, or the earlier, they will invest. Alternatively, the public may care about environmental quality, and the more serious they think the problem is, the more is each person willing to spend on addressing the problem.

The posterior probability λ_p is formed by the agents based on the prior probability λ and on the behavior of the politicians as they receive a signal on the state of the environment.

Call λ_E the posterior belief about the state of nature held by a minister. The value of λ_E may differ from the value of λ_P because a minister observes his own signal, but the public only observes the actions of the ministers. The expected benefit to a Brown politician of adopting a Green policy is $\lambda_E\left[W_H(\lambda_p)\right]+(1-\lambda_E)\left[W_L(\lambda_p)\right]-I$. If he does not adopt a Green policy, his expected benefit is zero. The expected benefit to a Green politician of adopting a Green policy is $\lambda_E\left[W_H(\lambda_p)\right]+(1-\lambda_E)\left[W_L(\lambda_p)\right]+G-I$, where *G* is a positive parameter; it can reflect, his personal preferences or the influence of (green) special interest group lobbying as in Dixit et al. (1997). The model can equivalently be formulated as one where the Green politician defends the general interest and the Brown minister is bribed by special interest groups and has a specific utility B of not signing an environmental agreement. We come back to this interpretation later.

We will use first models where everyone knows the type of the politician. For these models we use the following timeline for the game:

1. Nature determines the state of nature, either High or Low.

2. The minister in each country observes an imperfect signal of the state of nature. The probability of a correct signal is *s*.

[3] The benefit function integrates risk attitudes.

3. Each minister decides whether to sign an environmental agreement, knowing what the other minister does.

4. The public forms its posterior probability as a function of the observed political actions

5. Each minister decides on environmental policy in his country.

6. The state of the environment is realized as High or Low, and the payoffs are determined.

4. Participation in environmental agreements as a signal of the state of nature

The benefits of environmental action can be uncertain and people only learn gradually about the damages. For a single decision maker this uncertainty raises the question whether he should delay action until more information is (Kolstad 1996). In the literature on international treaties, the impact of learning on the success of an IEA is not necessarily positive. Learning affects the strategic behavior of the different countries and this can lead to less powerful IEA's. The conclusions (Kolstad and Ulph, 2007) in this domain are rather pessimistic: learning does not make IEAs more attractive.

Here we take a different approach to learning and to IEAs. First, we assume that countries learn independently rather than collectively about the environmental problem. More importantly, in our model, a country's behavior and welfare is not only a function of the number of participants in an IEA but also a function of the beliefs of its citizens and the type of political agent. Environmental action (signing an IEA) by one country can be seen as a signal of the importance of the environmental problem, and this extra signal can increase the participation of countries and in this way also the internal credibility of the environmental policy.

We consider three cases: both ministers are Green, both ministers are Brown, and one is Green while the other is Brown. Our model supposes that the different types of ministers, Green and Brown, show different biases. We can make two different assumptions. One is that Brown ministers will never adopt a Green policy (a policy that ameliorates environmental problems), but that a Green minister who is sufficiently confident that the state of nature favors a Green policy will adopt a Green policy. In this case, a Green minister learns nothing from the behavior of a Brown minister, but can learn from a Green minister in the other country about the likely state of nature. The alternative assumption is that a Green minister will always favor a Green policy, but that a Brown minister will favor a Green policy only if he is sufficiently confident that the state of nature favors a Green policy. Here, a Brown minister can learn from a Brown minister, but not from a Green minister, in the other country. Analytically, it does not matter which approach we adopt. We arbitrarily choose to examine the case where a Brown minister may be persuaded to take action by learning what another Brown minister did. Thus, we

assume that *G* is so large, that a Green politician always signs the international environmental agreement. We shall see that in equilibrium, a minister who signs an international environmental agreement will want to implement a Green policy.

Case 1: Both ministers are Green. Then they both sign the IEA. The public's posterior probability that the state of nature is High is equal to the prior probability λ because the public knows that Green ministers favor a Green policy regardless of the state of nature.

Case 2: Both countries have Brown ministers. Here we must distinguish three cases: both saw signal *H*, both saw signal *L*, and one saw signal *H* while the other saw signal *L*.

Case 2.A If both saw signal *H*, the posterior probability that the state of nature is *H* is:

$$\lambda_E^{Hi\hat{}Hj} = \frac{s^2\lambda}{s^2\lambda + (1-s)^2(1-\lambda)},$$

which is greater than λ.

Assumption A1. The value of $\lambda_E^{Hi\hat{}Hj}$ is sufficiently large so that a Brown minister would sign the agreement if he knows that both ministers saw an *H* signal .

Case 2.B If both saw an *L* signal, the posterior probability that the state of nature is High is

$$\lambda_E^{Li\hat{}Lj} = \frac{(1-s)^2\lambda}{(1-s)^2\lambda + s^2(1-\lambda)}.$$

Assumption A2. The value of $\lambda_E^{Li\hat{}Lj}\left[W_H(\lambda_p^{Li\hat{}Lj})\right] + (1-\lambda_E^{Li\hat{}Lj})\left[W_L(\lambda_p^{Li\hat{}Lj})\right]$ is sufficiently small so that if both ministers saw an *L* signal, no Brown minister would sign an environmental agreement or adopt a Green policy). Under this assumption, the general public will infer the same posterior probabilities as the political agent.

Case 2.C Two Brown ministers where one (say *i*) saw signal *L* and one (say *j*) saw signal *H*. The posterior probability that the state of nature is High is

$$\lambda_E^{Hi\hat{}Lj} = \frac{s(1-s)\lambda}{s(1-s)\lambda + s(1-s)(1-\lambda)}.$$

Clearly, $\lambda_E^{Hi\hat{}Lj} > \lambda_E^{Li\hat{}Lj}$: the probability that the state of nature is H is clearly larger when one minister saw an H signal than when none did.

Assumption A3. The value of $\lambda_E^{Hi\hat{}Lj}$ is sufficiently small so that a Brown minister would not commit to an environmental policy if he saw a High signal and the other country saw

a Low signal. (). Under assumptions A1,A2 and A3, the general public, knowing the type and the objective functions, will infer in cases 2.A, 2.B and 2.C the same posterior probabilities as the political agent.

Under these assumptions, welfare may be higher when both ministers are Brown than when both ministers are Green. The point is that if both Brown ministers favor a Green policy, then the public has far more confidence that the state of the environment is High than when Green ministers adopta Green policy. More formally, expected benefits in each country when both ministers are Green are $\lambda W_H(\lambda) + (1-\lambda)W_L(\lambda) - I$ because the Green governments agree to sign an environmental agreement whatever the signal received so that the posterior probability of the public equals the prior probability.

Expected benefits when both ministers are Brown are $\lambda_E^{Hi\hat{}Hj} W_H(\lambda_p^{Hi\hat{}Hj}) + (1-\lambda_E^{Hi\hat{}Hj})W_L(\lambda_p^{Hi\hat{}Hj}) - I$, where the posterior probabilities of the public are equal to those of the political agent. Under our assumptions (A1, A2, A3), an environmental policy is only justified if signals HH are received. This implies that though under Brown ministers an environmental agreement is less likely to be adopted, the increased confidence that a Green policy is adopted only when it will have large benefits makes welfare larger under Brown than under Green ministers

Note also the benefits to Brown ministers of coordinating their actions. Neither one alone may be willing to undertake a Green policy; but if one country expects the other to adopt a Green policy, then each would be willing to adopt it. An International Environmental Agreement can provide such coordination. Moreover, such an IEA would be self-enforcing. Also note that the benefits of an IEA here arise not from direct spillovers from the environmental policy (indeed, the environmental policy may affect environmental policy only within the country which adopts it), but from informational externalities.Case 3: One country has a Green Minister, and the other has a Brown minister

The third case to consider has a Green minister in one country (say country *i*) and a Brown minister in the other (say country *j*). The Green minister, by assumption, always adopts a Green policy. Therefore, his action gives no information about the state of nature. A Brown minister who sees an *H* signal calculates the posterior probability that the state of nature is H as

$$\lambda_E^{Hj} = \frac{s\lambda}{s\lambda + (1-s)(1-\lambda)}.$$

Again, the public may learn from the Brown government if it is beneficial to sign an environmental agreement and this will increase the credibility of policy and the efforts of the public.

One should ask if an IEA is identical to a form of cheap talk. The answer, with one exception, is Yes in our case without international environmental spillovers and without economies of scale in producing abatement. The analysis we gave would apply if, instead

of two countries signing an IEA, the prime minister in each country each announced that he would adopt a Green policy. But, as this example suggests, an IEA has an advantage over other coordination mechanisms---the negotiations can be done in secret. Thus, suppose a prime minister incurs a cost, even a very small one, for announcing a policy that he later reverses, or for revealing that his estimate of the state of nature is wrong. Suppose that a Brown minister in country i is unsure what a Brown minister in country *j* will announce until after country *i* makes its announcement. Then with some positive probability, country *i* will announce a Green policy, whereas country *j*, seeing a different signal, does not adopt a Green policy. Though country *i* could later reverse its policy, a minister who does so may incur a reputational cost. Therefore, ministers in the two countries may prefer to engage in secret negotiations, jointly agreeing to announce a Green policy only if both saw that the state of nature is Green. It can be the very secrecy of negotiations leading to an IEA which can make them effective and appealing.

Sequential policy

In the Nash equilibrium we described, both Brown ministers may adopt a Green policy. Matters can differ if countries can act sequentially, say country *i* setting policy before country *j* does. When country *i* chooses policy, it knows only its own signal of the state of nature. If it sees an *H* signal, its posterior probability that the state of nature is High is λ_E^{Hj}. It will sign an environmental agreement only if $\lambda_E{}^{Hi} W_H(\lambda_p{}^{Hi}) + (1-\lambda_E{}^{Hi}) W_L(\lambda_p{}^{Hi}) - I > 0.$ where the posterior probability of the public equals that of the politician. If this condition is satisfied, then country *i* signs an IEA, and country *j* will also sign if it sees an *H* signal.

More interesting results apply with the following assumption, that a Brown minister adopts a Green policy only if he expects the other country to do so too:

Assumption A4. $\lambda_E{}^{Hi} W_H(\lambda_p{}^{Hi}) + (1-\lambda_E{}^{Hi}) W_L(\lambda_p{}^{Hi}) - I < 0$ but $\lambda_E{}^{Hi\wedge Hj} W_H(\lambda_p{}^{Hi\wedge Hj}) + (1-\lambda_E{}^{Hi\wedge Hj}) W_L(\lambda_p{}^{Hi\wedge Hj}) - I > 0$.

Suppose that a Green policy is irreversible, and can be adopted in either period 1 or 2. Then it cannot be a Nash equilibrium for a Brown minister to adopt a Green policy in period 1---the minister could do better by delaying to period 3, making a decision only after observing whether the other country adopted a Green policy in period 2. But it is a Nash equilibrium for no country to adopt a Green policy in either period. Given that behavior, a Brown minister who sees a *H* signal estimates the posterior probability that the state of nature is H as λ^{Hi}, which by assumption does not justify a Green policy.

We can see here how an IEA can increase welfare by adding a minimum participation constraint before it comes into force. In our sequential setting, the Brown minister will sign if he observes H because he knows it will only bind him if the Brown minister in the other country also observes H. This guarantees him that signing is the right decision (given A4).

This story can explain why countries sign IEAs even if spillover effects are small.

5. International environmental spillovers

We so far supposed that policy in a country directly affects only the citizens in that country; for a given policy, no country cares what policy is in the other country. We now extend the analysis to have environmental policy generate externalities---welfare in one country is higher if the other country adopts a Green policy. Such externalities can generate strategic behavior in the sequential case---a minister in one country may adopt an environmental policy to induce the other country to adopt also an environmental policy. We first discuss the simultaneous case.

Simultaneous action

As before, we suppose that each minister knows his own type, and the other minister's type but observes only his own signal. In the simultaneous case we need to examine the Nash equilibrium. In a Nash equilibrium, strategic behavior makes no sense: for any given action by country *j*, country *i* will want to maximize direct benefits, without considering how a change in its action will affect *j*'s action.

The net benefit of signing an environmental agreement is now a function of four parameters: $\lambda_E^i W_H(\lambda_p, x_i, x_j) + (1-\lambda_E^i) W_L(\lambda_p, x_i, x_j) - x_i I$, where x_i is a 0,1 variable that is 1 when the country signs the environmental agreement and 0 otherwise. The environmental spillovers imply that welfare in county *i* depends directly on the environmental policy in country *j* via the damage of foreign emissions. Welfare in country *i* continues to depend indirectly on the environmental policy in *j* via its effect on the posterior probability of agents in both countries. As citizens in both countries observe the same signals (signing or not by *i* and *j*), the posterior probabilities formed by the public in both countries are the same.

We again assume that Green politicians sign an international environmental agreement regardless of the state of nature. Having a Green in power has the advantage that it solves the international spillover problem but is not a clear signal to the public of the state of nature. Depending on the importance of the citizens' own investments, signing an international environmental agreement combined with low posterior probabilities of the general public may not be welfare improving.

A first interesting case is where signing an environmental agreement is only worthwhile for a country if both signals point to a High state of nature, and both countries effectively sign the agreement. We limit ourselves to the case where both countries received an *H* signal. We can distinguish two cases:

Case A Beliefs of citizens are important

We assume more precisely that it is better for a country to sign if the other signs. In addition if the other has not signed, it is better also not to This assumption is more

justified for the case where the credibility of internal policy is an important factor. More precisely **Assumption_A5:**

$$\lambda_E^{HH} W_H(\lambda_p^{HH},1,1) + (1-\lambda_E^{HH}) W_L(\lambda_p^{HH},1,1) - I > \lambda_E^{H} W_H(\lambda_p^{H},0,1) + (1-\lambda_E^{H}) W_L(\lambda_p^{H},0,1)$$

$$\lambda_E^{H} W_H(\lambda_p^{H},1,0) + (1-\lambda_E^{H}) W_L(\lambda_p^{H},1,0) - I < \lambda_E^{H} W_H(\lambda,0,0) + (1-\lambda_E^{H}) W_L(\lambda,0,0).$$

This means we have a coordination game where there are two Nash equilibria: both adopt a Green policy, and neither does. The case where both adopt a Green policy is clearly better and will be the outcome as international agreements fulfill exactly this coordination role.

Case B Beliefs are unimportant

Now we assume that the posterior probability of the agents is less important for the outcomes. What really matters is one's effort (the sunk cost *I*) to reduce emissions, generating the traditional free-rider problem. Each minister avoids a Green policy if the other did, and each adopts a Green policy if the other does

Assumption A6.

$$\lambda_E^{HH} W_H(\lambda_p^{HH},1,1) + (1-\lambda_E^{HH}) W_L(\lambda_p^{HH},1,1) - I < \lambda_E^{H} W_H(\lambda_p^{H},0,1) + (1-\lambda_E^{H}) W_L(\lambda_p^{H},0,1) \backslash$$

and

$$\lambda_E^{H} W_H(\lambda_p^{H},1,0) + (1-\lambda_E^{H}) W_L(\lambda_p^{H},1,0) - I < \lambda_E^{H} W_H(\lambda,0,0) + (1-\lambda_E^{H}) W_L(\lambda,0,0).$$

Adding the signaling function to the analysis of IEA's leads to more frequent participation in IEA's.

Sequential case

In this case strategic behavior may be present in the signals of countries. Our first goal is to demonstrate that sincere policy may not be an equilibrium. To make the problem meaningful, we suppose that country *i* moves in period 1, and country *j* moves in period 2. Suppose, as before, that a Brown minister will sign an IEA (and adopt a Green policy) only if he is sufficiently confident that the state of nature is H. Suppose all ministers are Brown.

We can now no longer require that a Brown minister needs assurance on two High signals before he signs an IEA as there would never be any agreement in the sequential case. We therefore assume that a Brown minister who only sees his own High signal would favor a Green policy

Assumption A7.

$\lambda_E^{Hi} W_H(\lambda_p^{Hi}, 1, x_j) + (1 - \lambda_E^{Hi}) W_L(\lambda_p^{Hi}, 1, x_j) - I > 0$ but
$\lambda_E^{Li} W_H(\lambda_p^{Li}, 1, x_j) + (1 - \lambda_E^{Li}) W_L(\lambda_p^{Li}, 1, x_j) - I < 0$ where the posteriors of the public equal those of the politicians.

Under sincere action and assumption A7, country *i* would adopt a Green policy only if its minister saw a High signal. Suppose it followed this strategy, and consider next the decision faced by country *j* in period 2, after it observed country *i* rejecting a Green policy. If country *j* saw a High signal, it would avoid a Green policy if

$$\lambda_E^{Li\wedge Hj} W_H(\lambda_p^{Li\wedge Hj}, 0, 1) + (1 - \lambda_E^{Li\wedge Hj}) W_L(\lambda_p^{Li\wedge Hj}, 0, 1) - I$$
$$< \lambda_E^{Li\wedge Hj} W_H(\lambda_p^{Li\wedge Hj}, 0, 0) + (1 - \lambda_E^{Li\wedge Hj}) W_L(\lambda_p^{Li\wedge Hj}, 0, 0).$$

Where posteriors of the citizens are again equal to those of the politician.

If, instead, country *i* always adopted a Green policy, then its action is uninformative, and country *j* will adopt a Green policy if

$$\lambda_E^{Hj} W_H(\lambda_p^{Hj}, 0, 1) + (1 - \lambda_E^{Hj}) W_L(\lambda_p^{Hj}, 0, 1) - I$$
$$> \lambda_E^{Hj} W_H(\lambda_p^{Hj}, 0, 0) + (1 - \lambda_E^{Hj}) W_L(\lambda_p^{Hj}, 0, 0).$$

We can now return to the decision by country *i*. It has an interest to behave strategically and to sign an agreement if the benefit of doing so is larger than the cost I:

$$\lambda_E^{LH}\left[W_H(\lambda_p^{HH}, 1, 1) - W_H(\lambda_p^{LH}, 0, 1)\right] + (1 - \lambda_E^{LH})\left[W_H(\lambda_p^{HH}, 1, 1) - W_H(\lambda_p^{LH}, 0, 1)\right] - I.$$

If the first mover behaves strategically when it sees a Low signal, adopting a Green policy, then it induces country j to adopt a Green policy. This expression is positive if the benefit spillover is sufficiently large.

6. Reputational concerns

We have so far assumed that citizens know the type of minister (Brown or Green) in each country. Here we explore behavior when citizens are unsure about a minister's type, and a minister cares about what citizens believe about his type. In particular, suppose that uncertain benefits of environmental action may lead the voters to be skeptical about a vigorous environmental policy. Whenever one's government takes unilateral action it may be considered suspect and may be a sign of not pursuing the interest of the country. Whenever more countries sign an agreement, the voters may perceive their own country's policy as better justified. The IEA can then be seen as a collusive action by politicians to protect their private interests and to help them to get re-elected.

To analyze this issue we consider again two types of politicians: Browns in the proportion β and Greens in the proportion $1-\beta$. Each minister knows his own type and the other minister's type, but the public does not. The public believes that the prior probability that the state of nature is High is λ.

Consider the reputational effects arising when ministers act independently, ignoring reputational considerations. A minister would then adopt a Green policy if he is Green, or else if he is Brown and knew the state of nature is *H*. When the state of nature is *H*, he sees a signal that it is *H* with probability *s*. Since the state of nature is *H* with probability λ, a Brown minister who has no reputational consideration would adopt a Green policy with probability λs. Therefore, the probability that the minister who adopted a Green policy is Green is $G1 = \frac{1-\beta}{1-\beta+\lambda s\beta}$.

Consider next reputational effects when ministers would adopt a Green policy only if both agree to it. That will happen only if both are Green, or if both are Brown but saw a High signal, or if one is Green and the other is a Brown who saw a High signal. Thus, the probability that a minister who jointly adopted a Green policy is a Green type is $G2 = \frac{(1-\beta)^2+(1-\beta)\lambda s\beta}{(1-\beta)^2+2(1-\beta)\lambda s\beta+\lambda s^2\beta^2}$.

G1>G2 and the more so, the more Brown politicians there are. This means that the signing of an international environmental agreement can indeed serve to protect the reputation of a Brown politician.

7. Extensions

The essential element of our model is that one agent can learn from the action or preferences of another. We have been considering only two agents per country, one politician and one representative citizen. But the model can easily be extended to more agents. A direct extension is to consider more than two countries. With two countries, the posterior probability λ^{Li} and λ^{Hj} may not be sufficiently high to induce either country to adopt a Green policy. But if more countries independently see signals that the state of nature would make environmental policy effective, then the posterior probability (say, with three countries, $\lambda^{Hi \wedge Hj \wedge Hk}$) can be sufficiently high to induce action.

The number of agents reporting on their signals can be increased in other ways. IEAs are commonly negotiated by the executive branch, but require ratification by the legislature in each country. If the legislature in a country sees a signal which is not perfectly correlated with that seen by the executive, then ratification of an IEA provides further information about the state of nature. We are not here saying merely that a country is less likely to err if both the executive and the legislature must independently agree to a policy. We are making the different point that the legislature in country *i* may be more willing to adopt a Green policy if both the legislature and the executive in country *j* favor the IEA than if only the executive in country *j* does.

Pursuing this reasoning, confidence in the advisability of a Green policy can also be raised when successive ministers, each seeing his own signal of the state of nature, finds that Green policy would be good. That is, the public, or the legislature, may be more willing to support a Green policy if successive ministers (either in their own country or in other countries) support a Green policy, rather than if only the incumbent minister did. Such desire for further information may cause delays in the ratification or implementation of IEAs.

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Notation

$W_H(\lambda_p, x_i, x_j)$ Welfare to Brown minister in country I when state of nature is H, posterior probability of High state of environment perceived by public is λ_p, country i adopts environmental policy x_i and other country adopts policy x_j.

I Cost of environmental policy for one country

s Probability country's signal on state of nature is correct

λ Prior probability that state of environment is High priority

λ_p^{XY} Posterior probability of the public who infers that signals to both countries have been X and Y (that can be either H or L)

λ_E^{XY} Posterior probability of the political agent who infers that signals to both countries have been *X* and *Y* (that can be either H or L)