Chapter 2
Public Choice Issues in International Collective Action: Global Warming Regulation

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Abstract Although there is a growing literature on scientific estimates and regulatory instruments for international efforts to control greenhouse gas emissions, the underlying political collective action processes have been neglected. We focus on the impact of uncertainty in assessing the benefits and costs of global warming regulation on constituencies and politicians in the bargaining countries. Uncertainty arises due to basic information problems about emissions and their link to global warming, the possible range of temperature changes, and their likely effects across the planet. These information problems also create uncertainty in calculating the net effects of global warming, determining its effective regulation, and assessing compliance by sovereign countries that may be differentially affected. We outline a two-stage analytical framework that describes the positions taken by representatives of negotiating countries and the internal public choice tradeoffs facing politicians when constituents are faced with differential and uncertain effects. We apply the framework to the Montreal Protocol to Control Substances that Damage the Ozone Layer of 1987 for insights in analyzing the Kyoto Protocol of 1997. Additional information will reduce uncertainty over time, and until uncertainty is lowered we conclude that limited regulatory efforts are most likely to generate internal political support within negotiating countries for international collective action.

2.1 Introduction

Concerns about the accumulation of greenhouse gases in the atmosphere and possible effects on global temperatures have led to a series of international initiatives for

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collective action (Houghton et al. 1990; Houghton and Callander 1992; Houghton 1995). These include the United Nations Framework Convention on Climate Change (FCCC) signed at Rio de Janeiro in 1992 where countries pledged to voluntarily reduce carbon emissions to 1990 levels by 2000; a meeting in 1995 in Berlin of the Conference of Parties (COP), created at the Rio conference, to define a structure for further action; and the Kyoto Protocol on Global Warming of December 1997 (Sparber et al. 1998).

Under the Protocol, thirty-eight developed countries are to reduce greenhouse gas (GHG) emissions by approximately 95 percent of 1990 levels by 2008–2012. The United States is to lower its discharges of carbon dioxide (CO2) to 93 percent of 1990 emissions. These actions will not be without costs, although neither the costs, nor the benefits of emission controls are known with much certainty.

Uncertainty arises because of a lack of conclusive information about (a). The human sources and pace of temperature change; (b). The costs and benefits of global warming and their distribution across countries; (c). The costs, benefits and effectiveness of different forms of regulation; and (d). The extent of treaty compliance by sovereign countries.

The costs and benefits of global climate change and its regulation will be spread unevenly both across and within countries. These heterogeneous and uncertain constituent effects create challenges for politicians in fixing positions during international negotiations. The associated public choice bargaining issues have been neglected in the literature and are the focus of this paper.[1] Our analysis reveals why it is in the interest of politicians in developed countries, such as the U.S., to delay action until more information is obtained.[2] In the following section, we outline a two-stage political bargaining framework for international collective action that emphasizes the role of uncertainty in reducing expected benefits for constituents and politicians. Implications are developed for analyzing the Montreal Protocol on Substances that Deplete the Ozone Layer and the Kyoto Protocol to the United Nations Framework Convention on Climate Change.

[1] A large and growing literature on regulatory instruments and some of the scientific and economic issues involved has emerged, including Hoel (1997), Hollick and Cooper (1997), Houghton (2009), Moore (1998), Paterson (1996), Shogren and Toman (2000), Weyant (1993), and Wiener (1999a, b) examines some of the constituency issues of concern here.

[2] In the spring of 2001, the U.S. and Australia, two countries likely to bear the greatest share of treaty costs, chose to delay action on global warming. Although subject to international criticism, our analysis suggests why these actions were reasonable for domestic politicians.

2.2 Theoretical Framework for Analyzing International Collective Action to Address Open-Access Resource Problems

In this section we develop a simple model that frames the international negotiation of environmental treaties as a collective-action problem. Consistent with the empirical treatment of the two treaties studied in the paper, the model emphasizes the important public choice issues arising during both internal and international negotiation. International negotiations do not take place detached from the underlying political realities within each of the bargaining countries. Rather, a country is represented by an agent who is accountable to domestic constituencies. This agent must adopt an international negotiating position that simultaneously leads to a resolution of the international common-property problem *and* generates the greatest political support among the electorate.[3]

The collective-action literature makes clear the importance of mitigating differences between bargaining parties and inducing important economic actors to join.[4] In our theory, side payments can be used to accomplish both of these ends. The theory incorporates transfer payments because they arise in the empirical section of the paper. In particular, side payments are frequently used to mitigate perceived differences across countries in treaty net benefits. Agreement on side payments also is made more difficult by uncertainty in benefit and cost estimation.

We model the international collective-action problem in two parts: first, we address the international negotiation task, and second, we examine how underlying public choice concerns give way to a single negotiating position in international negotiations. The framework is consistent with and is motivated by Olson's (1971) rational choice basis for collective action.

Consider first international negotiations. Suppose that a group of I countries is negotiating to resolve an open-access resource problem. The total utility that country i derives from treaty agreement is the sum of the expected net benefits of the treaty, θ_i, whose value is determined in the way described below, and any transfer payments t_i that it receives from or provides to other countries as a condition of agreement. Hence, each country *i's* preferences can be expressed in terms of whether there is

[3] See the readings in Keohane et al. (1996) and Putnam (1988). The impact of uncertainty in international negotiations is examined also by Helm (1998). In our model, the benefits and costs of an international treaty are borne not only by the underlying constituencies, but also by the elected agent. Hence, the agent will be very cautious before committing his/her country to an agreement because imposing even minor costs on a constituency, or constituencies, without commensurate benefits may lead to large defections in political support. The political problem faced by politicians is exacerbated if there is considerable uncertainty in estimating constituent benefits and costs from international action.

[4] Consider the problem of forming a cartel where there are large cost differences. It is difficult to get low cost producers to join if their share of excess profits do not reflect the cost differences. Also, having the largest producers under agreement is critical to the success of any production cartel.

agreement, the expected net benefit of agreement and the transfer payment that is conditional on agreement as follows.

$$u_i(agreement, \theta_i, t_i) = \theta_i + t_i,$$
$$u_i(noagreement, \theta_i, t_i) = 0 \tag{2.1}$$

Given individually rational representative agents, no country will participate in the international agreement unless the sum of expected benefits of the treaty, including transfer payments, is greater than its value of non-agreement.[5]

Realizing that success in negotiations may depend upon the viability of transfer payments, we employ the well-known AGV mechanism suggested by d'Aspremont and Gérard-Varet (1979) and Arrow (1979). The mechanism provides a convenient transfer payment formula that guarantees "budget balance," or that any monies transferred to one country are paid in full by other countries.[6] More importantly, the approach illustrates the importance of transfer payments in international negotiations, and how small changes in the transfer scheme, such as defection by one of the international players, or alternatively, a reduction in uncertainty following new information, can have large consequences for the overall agreement.

Initially, countries' agents do not know each other's expected net benefits, θ_i. Because of uncertainty regarding constituent benefits and costs, agents may be unsure of the nature of domestic support for the treaty, and hence their own θ_i. Camps in support and in opposition to international treaties may solidify only after actual negotiations begin. We assume, however, that the distribution of each θ_i, $(i = 1, \ldots, I)$, is common knowledge.[7]

Each negotiator aggregates constituency preferences, according to a procedure described below, to determine the expected net benefit to report during the international negotiations. Let θ_i denote the expected net benefit reported by the agent for country i. The AGV mechanism's decision rule is to implement the treaty if and only if the aggregated reported expected net benefit is positive, or

[5]Note that we have assumed without loss of generality that each country's expected net benefit is reported in relation to a non-agreement value of zero.

[6]Essentially, the AGV transfer payments compensate "losers" by paying them the expected net benefit of all the others conditional on their own report. Although there is a strong sense in which the AGV mechanism is incentive compatible, to avoid technical issues that distract from the focus of this paper, we assume that negotiators truthfully report to the negotiations an expected net benefit that derives from a vote maximization calculation described below. This assumption is consistent with our view that the agent acts in his/her own political interest because the agents future political support depends on how faithful the constituency believes the agent is in representing their views. It is likely that, where the benefits of an agreement accrue over a long period of time, as is typically the case in environmental treaties, it may be very difficult for the agent to persuade a constituency that acting in violation of their stated views is, in fact, in their best interest.

[7]A regularity condition required for the AGV mechanism is that each country's expected net benefit distribution is common knowledge (d'Aspremont and Gérard-Varet 1979, p.38).

$$\sum_{i=1}^{I} > 0. \tag{2.2}$$

The transfer payments implied by the AGV mechanism if the treaty is implemented are given by d'Aspremont and Gérard-Varet (1979).

$$t_i(\theta) = E_{\theta_{-i}}\left[\left(\sum_{j \neq i} \theta_j\right) I\left(\left\{\sum_{j \neq i} \theta_j\right\} + \theta_i > 0\right)\right] + \tau(\theta_{-i}), i = 1 \ldots, I \tag{2.3}$$

where $\theta = \{\theta_1, \ldots, \theta_I\}$, $\theta_{-i} = \{\theta_1, \ldots, \theta_{i-1}, \theta_{i+1}, \ldots, \theta_I\}$, $\tau(\theta_{-i})$ does not depend on θ_i and is chosen to ensure budget balance, and $I()$ is and indicator function that takes value one if $\sum_{j \neq i} \theta_j + \theta_i > 0$ and is zero otherwise.

The first term on the right hand side of Eq. 2.3 is the sum of other countries' expected surplus conditional on the reported net benefit of country *i*. The second term in Eq. 2.3 is a function whose value is independent of country *i's* report and which is chosen to ensure budget balance, or that

$$\sum_{i=1,I} (\theta_i) = 0. \tag{2.4}$$

Before moving on, it is worth noting that the model thus far yields several well-known results from the collective-action literature. First, the reported expected net benefits $\{\theta_i\}_{i=1,I}$ in conjunction with Eq. 2.2 will determine the initial feasibility of successful collective action. If the $\{\theta_i\}_{i=1,I}$ are highly heterogenous and include both positive and negative values, then implementing the international treaty requires transfer payments.[8] Furthermore, if parties view the status quo as more attractive than the expected utility of agreement (net of transfers), a collective agreement is not likely. Indeed, where the agreement value is close to the status quo, a transfer payment may still be needed to move a party from its initial position.

It would be possible to proceed relying solely on the above framework, but such an approach would ignore important public choice issues that are central to our analysis, and which we believe will have a sizeable impact on any attempt to negotiate an international global warming treaty. For instance, the empirical analysis described later in the paper suggests that successful negotiations must account for the potentially highly heterogeneous preferences of underlying constituencies within a country. The way the country's agent fixes the negotiation position depends on these preferences,

[8] Heterogeneous in this context refers to the difference across countries of net benefits versus the status quo. For example, if half of the countries expect positive gains from agreement and the other half expects losses, agreement is far less likely (without transfer payments) than when all countries receive positive benefits from agreement. Instances where side payments have been used successfully are often characterized by differences that are calculable. For a different view on the motivation for countries to take action, see Gruber (2000).

and as political economy research has made clear, agents must be responsive to important interest groups in order to secure and maintain political office.

Suppose that there are N_i constituencies to which the agent for country i must respond, and denote the expected net benefit of the treaty to group n_i by B_{n_i}. For now we take B_{n_i} as given. In the sequel we discuss the way in which its value is determined. Our model captures the simple idea that a constituent's expected net treaty benefits affects the negotiation position they prefer their agent to adopt in the international treaty negotiations. Let $V - n - i(B_{n_i})$ denote this preferred position. That is, constituency n_i with expected benefits B_{n_i} prefers that the agent report $\theta_i = V_{n_i}(B_{n_i})$ at the treaty negotiations. It is natural to assume that $V - n_i$ is increasing. We assume that the constituency wants neither a report that is too far above nor too far below its preferred point. Extremely high reports at the international negotiations raise the possibility that agent *n's* country, and potentially constituency i, might be asked to fund large transfer payments to other countries (see Eq. 2.3). Lower reports than preferred, on the other hand, leave it relatively too likely that the treaty will not be implemented (see Eq. 2.2).

The agent for country i is interested in maintaining political office and, consequently, in maximizing political support.[9] In the spirit of Peltzman (1976), suppose that the likelihood that any member of group n will vote for agent i is a positive and differentiable function of their preferences, $p_n(V_n(B_n) - \theta_i)$, where p achieves its maximum at zero, is increasing to the left of zero, is decreasing to the right of zero, and takes values in the interval [0, 1]. It follows that the number of votes the agent expects to obtain from group n if there is an international agreement is $m_n p(V_n)$, where m_n is the number of voters in constituency n.

The agent's goal, therefore is to choose an expected net benefit position to report at the international treaty negotiations that solves the following simple vote maximization problem:

$$max_{\theta_i} \sum_{i=1,N} m_n p_n(V_n(B_n) - \theta_i). \tag{2.5}$$

It is worth emphasizing that the agents must choose the expected net benefits, θ_i, to report at the international negotiations based only on their knowledge of the expected values that their constituencies place on the treaty. A feature of many actual treaty negotiations, including those that we discuss below, is that these political calculations must be revisited as more information becomes available to the agent and his/her constituencies. In some cases, particularly in the event of noncompliance, this can lead initially promising treaty negotiations to break down, or alternatively, in the case of important uncertainty in constituent net benefit calculations, new information may make a treaty more politically feasible.

An interior solution to the agent's vote maximization problem Eq. 2.5 is characterized by the following easily derived first-order condition:

[9]To avoid cumbersome repetition of the i double-script, we will suppress this notation whenever it is clear from the context that we are discussing features of a country *i's* domestic political setting.

$$max_{\theta_i} \sum_{i=1,N} m_n p_n'(V_n(B_n) - \theta_i) = 0. \tag{2.6}$$

This has the immediate implication that larger (more powerful) constituencies will have a greater influence over the position taken by the agent than will smaller (weaker) constituencies. On the other hand, it also follows that even very large and powerful constituent groups that are highly in favor of a treaty might not have this message perfectly conveyed at international negotiations, particularly if there are several opposition constituencies. The reason is that opposing constituencies always have some voice, and at some point reporting excessively high θ_i could begin to erode the agents political support substantially. This type of tradeoff reflects the underlying public choice concerns that we find in all of the treaties examined in the empirical part of this paper.

Our model is closed by specifying the way in which the agents constituents determine their expected net benefit, B_n. The benefit that any group derives from a particular treaty depends upon that treatys outcome. Imprecise information about the nature of the environmental problem, the effects of a successful treaty, and the likelihood of international compliance, will generate uncertainty over a treatys outcome. This uncertainty will affect the expected net benefits that constituencies report to their political agents.

Let x be a scalar index of a treatys efficacy, with higher values of x indicating a more efficacious result. The advantage of this abstract index is that the treaty negotiations discussed below can each be mapped into this framework. For example, the efficacy of the Montreal Protocol might include some measure of the amount of CFC reduction. From the point of view of any constituent group, before the treaty is signed, x is a random variable whose value has not yet been realized. We assume that each constituency n can associate a net benefit $b_n(x)$ to any treaty outcome x. Moreover, it is natural to assume that $b_n(x)$ is increasing and concave. In the case of CFCs, this implies that the marginal benefit of reduction is non-increasing.

This formulation means that the uncertainty is over the outcome of the treaty, and that the constituents must be able to assign a net benefit to any realized outcome. It follows that the expected net treaty benefit that the constituent reports to its political agent is simply

$$B_n = \int_x b_n(x) dF_n(x) \tag{2.7}$$

where $F_n(\dot{})$ represents group *n's* subjective beliefs about the likelihood of various treaty outcomes.

This framework provides predictions about the effect of increased uncertainty on constituency *n's* reported expected net benefit. Following the classic treatment of Rothschild and Stiglitz (1970), define the distribution of a second index y by

$$y = x + \varepsilon \tag{2.8}$$

where $e[\varepsilon|x] = 0$ Hence, the distribution of y is derived by adding noise to the distribution of x. In relation to the distribution of x, the distribution of y provides a natural way to represent a situation where the constituents face more uncertainty about a treatys efficacy, stemming from greater risk of noncompliance, less precise information about the extent and distribution of the environmental problem and hence, the treatys effects. It then follows immediately from the results of Rothschild and Stiglitz (1970) that, as long as b_n is strictly concave, the expected benefit that the constituent will report when it faces y will be less than its report under the situation characterized by x.

Typically, one would expect changes in uncertainty to be roughly the same for all constituents. If all constituents face greater uncertainty and report lower expected net benefits, then the agent will report a lower expected net benefit at the international negotiations (this comparative static is easy to derive from the first order condition Eq. 2.6. Hence, an international agreement becomes less likely. Conversely, reducing the uncertainty surrounding a treatys outcome can improve the chance of its implementation even if this information does not indicate a more efficacious outcome (that is, the expected efficacy is the same under x and y, yet the situation characterized by x receives greater constituent support.)

It is worthwhile to point out that new information about the environmental problem, particularly that which affects the uncertainty surrounding the costs and benefits of addressing it, is effectively a public good. Once available, it allows for more precise determination of all individual constituents benefits and costs of international action, in that it affects their expected net benefits B_n associated with taking particular actions. Moreover, as a practical matter, less uncertainty about outcomes likely makes it easier to arrange transfer payments and other treaty provisions. Viewed in this way, one might expect information about treaty outcomes to be underprovided, and for there to be a role for a central authority to coordinate information accumulation. Pursuing this point rigorously is important, but beyond the scope of this paper.

Important implications of our model, most of which are intuitive, are summarized as follows. Successful collective action is most likely when each country reports an expected net benefit that is large and positive (see Eq. 2.3). In this case the sum of the reported net benefits will be positive, and it is efficient to implement the treaty. A country will provide a large, positive report when all of its constituencies expect the net benefits of the international action to be substantial (see Eq. 2.5). Increased uncertainty within countries over the aggregate gains from collective action, however, can reduce the likelihood of international cooperation. This uncertainty will be reflected in lower reported expected net benefits by each agents domestic constituencies, which in turn leads the agents to report lower expected benefits in international negotiations. Transfer payments from those countries expecting positive net benefits to those expecting zero or negative effects will be necessary to elicit cooperation. Finally, delaying immediate action until more information is available may make subsequent, more extensive international regulation politically feasible. We now apply this framework to the analysis of international environmental problems. Our empirical focus is on constituencies within the U.S., although the approach applies to political agents and constituent groups in other countries as well.

2.3 The Montreal Protocol on Substances that Deplete the Ozone Layer of 1987

The experience of negotiating the Montreal Protocol illustrates how high levels of uncertainty regarding the expected net benefits of action impeded international action initially. As more information about the benefits of controlling emissions appeared, a consensus, particularly among industrialized countries, developed and the Protocol was drafted in September 1987. The Protocol limits the release of gases into the atmosphere that might damage the earths shield against Ultraviolet B (UVB) rays from the sun. Table 2.1 outlines the implications of the model described in Sect. 2 and what is actually observed regarding the progress and nature of international negotiations

Our theory speaks to three important features of this protocol. One is timing. Although the potential consequences of damage to the ozone layer were raised in the early 1970s, the impetus for collective action did not arise until the mid 1980s. The theory explains why the U.S. became the principal proponent, while Britain and France were skeptical. Initially, strong constituencies in those countries were very uncertain about the benefits of such action. A second feature of this protocol is the important role played by transfer payments from developed to developing countries to elicit international cooperation. The final feature is difficulty with compliance.

Table 2.1 Montreal protocol

Framework implications	Empirical observation
Collective action occurs when there are large expected net benefits among constituencies within negotiating countries, i.e., B_{n_i} high within negotiating countries	Collective action takes about 15 years of negotiation. U.S. constituencies eventually see benefits, those in Britain and France do not. Developing countries see few benefits
Uncertainty reduces expected net benefits and thereby reduces collective action. Reduction in uncertainty promotes collective action, i.e., large standard deviation of ε in treaty index y. Reduction in uncertainty promotes collective action, i.e., small ε in treaty index y	Limited information about the problem, alternative technologies, and commercial position limits action by developed and undeveloped countries. New information about ozone holes spurs action
Transfer payments $t_i(\theta_i)$, are necessary to offset differences in expected net benefits	Developing countries still anticipate few benefits, demand fund and technology transfers and lenient treaty provisions
Compliance problems raise uncertainty and reduces collective action	Cheating in transitional and developing economies lowers benefits to adhering constituents

We argue that noncompliance increases uncertainty over the outcome of the treaty, thus reducing developed countries constituents expected net benefits and reducing the likelihood of successful, long-term agreements.

2.3.1 Timing: New Information and the Reduction in Uncertainty

Depletion of the ozone layer emerged as a political concern in the U.S. in the early 1970s in debate over the SST (supersonic transport). While the U.S. had terminated investment in the SST in 1971, British, French, and Russian development of the Concorde and TU 144 continued. The U.S. sought to limit access of SSTs to American airports because of possible negative effects of exhaust emissions in the stratosphere. The Europeans saw this as a ploy to limit use of their planes, and generally dismissed the charges. Important to the continued political debate, however, was new scientific evidence released in the mid 1970s regarding potential damage to the ozone layer from ODS (ozone depleting substance) emissions. This evidence raised the expected benefits of ODS regulation. Studies by both the Department of Transportation and the National Science Foundation in 1974 and 1975 supported concerns about SST exhaust (Morrisette 1989). Additionally, (Molina and Rowland 1974) and Stolarski and Cicerone (1974) described the accumulation of chlorine in the upper atmosphere from CFC accumulation and associated potential deterioration in ozone levels. National Academies of Science (1976a) and National Academies of Science (1976b) outline additional negative environmental effects of CFCs. The EPA and FDA began regulatory proceedings on non-essential use of aerosol sprays under the 1976 Toxic Substance Control Act and the 1977 Clean Air Act Amendments. Public awareness of the issue rose, CFC aerosol sales dropped, and their use banned unilaterally in the U.S. in 1978.[10]

Despite this additional evidence, in the late 1970s and early 1980s there was still no domestic or international political consensus to halt all CFC use. Besides propellants, CFCs were used widely as low-cost refrigerants, solvents, and in the production and cleaning of electronics. The United States accounted for 30 percent of world production of CFCs in 1985, with most made by five firms, DuPont, Allied Signal, Pennwalt, Kaiser, and Racon (Sandler 1997, p. 111). The chemical industry was a politically powerful constituency with a vital interest in regulation, and it initially saw no benefits. The Chemical Manufacturers Association and the lobby group, Alliance for Responsible CFC policy, claimed that CFCs were "incorrectly

[10]See Morrisette (1989) and Litfin (1994). Canada, Sweden, Norway, and Denmark also banned CFCs in aerosols. Noll and Krier (1990) discuss public reaction to low probability catastrophic events.

being blamed for the alleged decreases in atmospheric ozone."[11] The industry argued that more information was needed before taking further action. The atmospheric mechanisms involved with CFCs were incompletely understood, the extent of ozone depletion was unclear, and substantial economic dislocation seemed possible from restricting an industry where the U.S. had a commercial advantage. Consequently, in 1983 the EPA advised Congress that no additional action should be taken until the relationship between CFCs and ozone depletion was better understood (Nangle 1988, p. 543, Hollick and Cooper 1997, p. 157).

By the mid 1980s, however, two events spurred international regulatory efforts. A key factor was the 1985 report of a British Antarctic Survey indicating a 40 percent drop in atmospheric ozone from 1964 levels during the period 1977 to 1984. Although not directly linked to CFC accumulations, the Antarctic ozone "hole" seemed vital new evidence about the problem. This information further increased the expected net benefits of international action among constituencies in developed countries. Second, domestic political opposition in the U.S. diminished with development of low-cost alternatives to CFCs. DuPont announced the company would no longer make CFCs, and lobbied Congress for international restrictions on CFC production and use. An important goal was to help ensure that the CFC-substitute customers, who would bear substantial costs in retrofitting to accommodate the new technology, could not shift to alternative foreign sources of CFCs (Wiener 1999b, p. 772). European firms, particularly British and French companies, however, remained more wary of regulation. They had increased their share of the CFC market and had not invested as much in substitutes (Scott et al. 1995). Agents from European governments initially took more cautious positions in international negotiations for CFC regulation.

The first international action was the 1985 Vienna Convention for the Protection of the Ozone Layer. With estimated benefits in the U.S. of controlling ODS emissions of over $3 trillion at a cost of around $21 billion (Barrett 1994), the U.S. was the major proponent, and it ratified the convention in August of 1986.[12] The convention established broad international objectives, but disagreements among agents of participating countries blocked any substantive CFC control measures. European and American negotiators could not agree on the extent of regulation, and representatives of developing countries did not see elimination of CFCs as beneficial. For constituents in developing countries, the net benefits of international action were assessed as either near zero or negative. CFCs were attractive to developing countries because they were refrigerants that did not require sophisticated technology. Additionally, developing countries objected to trade restrictions and other costs associated with banning CFC imports and exports. In response, developed countries sought to reduce treaty costs (increase side payments) to developing countries. The Vienna Conference established a special category for developing countries that had less than

[11] Comments by Elwood P. Blanchard, Group Vice President for Chemicals and Pigments, DuPont, and by the Chemical Manufacturers Association, May 1987 before the Senate Subcommittee on Stratospheric Ozone Depletion to the Committee on Environmental and Public Works.

[12] Vienna Convention for the Protection of the Ozone Layer, May 2, 1985, Treaty Doc. No. 9, 99th Congress 1st Session, 1985.

0.3 kg per capita consumption of CFCs. Initial international control efforts were to focus on developed countries with consumption levels above the threshold.

The divide among agents of developed countries was closed with additional information on CFC levels and the ozone layer coming in 1986 and 1987 (World Meteorological Organization 1986; Watson et al. 1986; Environmental Protection Agency 1987). At the same time both U.S. and European firms improved their technologies for substitutes. A second round of international negotiations led to the Montreal Protocol of 1987. The protocol defined more precise measures to reduce consumption and production of CFCs and related substances.[13] In Montreal, agents from developed countries were treaty advocates. Under the agreement, developed countries were to cut production and consumption of CFCs by 20 percent of 1986 levels by 1993 and by 50 percent by 1998. CFC trade with countries not adopting the restrictions was to be stopped. Developing countries, however, still required side payments as a condition for participation. Under the notion of "common but differentiated responsibilities," they were allowed an extra 10-years delay to reach reduced production targets and were authorized to exceed their 1986 levels of production by up to 10 percent to satisfy "basic domestic needs."

2.3.2 International Transfers to Induce Participation

Even with these concessions, there was a split between the two groups of countries. 22 of the 50 countries that participated in the Montreal Protocol were developed, and of those, 19 (86 %) signed the agreement. By contrast, of the 19 developing countries that participated, only 6 (34 %) signed (Ling 1992). Two years later, in 1989, just 14 of the worlds developing countries had ratified the Montreal Protocol, whereas most developed countries had. Further, China and India stated they would not participate in the agreement unless more technical and financial aid was forthcoming.

A Second Meeting of the Parties to the Montreal Protocol was held in June 1990 in London to devise additional side payments and to add other chemicals to the control list that had been found to be damaging to the ozone layer. With reduction in uncertainty about the effects of CFCs and related compounds on the ozone layer, developed countries consented to bear more of the costs of regulation. They agreed to end production and consumption of CFCs earlier, by the year 2000. In exchange, developing countries were to stop exporting CFCs to non-participating countries by 1993 (Nangle 1988, 531). A Multilateral Fund was established to provide developing countries with financial and technical assistance. The World Bank became the implementing agency in 1991, and by December 1998 had disbursed $156.2 million with additional commitments of $336.08 million.[14] Administration of the Fund was

[13]Montreal Protocol on Substances that Deplete the Ozone Layer Treaty Doc No. 10, 100th Congress, 1st Session, 1987.

[14]Data from World Bank. The United National Environmental Ozone Secretariat reports a larger disbursement of fund, $768 million to phase out CFCs.

criticized for a lack of accountability, and chemical companies in developed countries were reluctant to relinquish control over substitute technology (DeSombre and Kauffman 1996).

Developing countries still faced major uncertainties with respect to the substitution process (HCFCs, initial substitutes, were found also to be damaging to the ozone layer), costs of compliance, and the extent to which their incremental costs would be covered by the Fund. Hence, agents of developing countries like China and India were not been enthusiastic for the treaty. Only very general language stating that the parties must take "every practicable step" to control CFC emissions could be agreed to by all parties. Many developing countries still had not ratified the Amendments to the Montreal Protocol that placed new chemicals under control (United Nations, Ozone Secretariat 1998). Under the delays granted developing countries, their CFC production continued to rise through 1994 and Halon (another ODS) output increased, so that ozone layer depletion rose at least through 2000, despite strict controls in developed countries (United Nations, Ozone Secretariat 1998).

2.3.3 Enforcement and Uncertainty Treaty Benefits

In addition to resistance by key developing countries to proposed international controls on CFCs, enforcement became an issue in the 1990s. Enforcement was not a critical problem initially since the U.S. was responsible for a large share of total CFC production and the EPA could monitor U.S. firms compliance relatively easily. Throughout the 1990s, however, there were reports of rising production of CFCs in developing countries, the Russian Federation and other transitional economies. There was also evidence that CFCs were being smuggled into regulated areas (Benedictk 1998; Dorfman 1997; Sandler 1997). Cheating resulted in more chlorine in the atmosphere, and complying firms found that their substitute products were facing new competition, while being restricted in order to continue to reduce chlorine levels. Migration of CFC-intensive industries to less regulated countries also reduced the benefits of the agreement within countries that adhered (Chemical Marketing Reporter 1996). Representatives of DuPont complained before the Congressional Subcommittee on Stratospheric Ozone Depletion that developing countries were relying too much on CFCs rather than on substitutes. Company officials testified "at least six CFC plants have started up or are under construction in less-developed countries since the Montreal Protocol was available for ratification."[15]

Systematic cheating raises a significant possibility that the political coalitions that supported the Montreal Protocol could unravel. At a minimum, the presence of cheating increases uncertainty over the net benefits of cooperation. Moreover, a single non- cooperative country raises the uncertainty for all cooperators. The result,

[15]Testimony by Dwight Bedsole, business manager, DuPont Freon Products Division, U.S. House of Representatives Committee on Energy and Commerce, subcommittee on Stratospheric Ozone Depletion, January 25, 1990, CIS 90H361-38, 271–73.

as we showed in Sect. 2.2, can be a reduction in the aggregate expected net treaty benefits and, therefore, an increased likelihood that the treaty will end in failure. A natural way to prevent such cooperative decay is to increase monitoring and transfers to developing countries. Whether developed countries constituencies perceive the benefits of the Montreal Protocol as large enough to offset higher monitoring and transfer costs is an open question. Additionally, since international environmental treaties are voluntary, forcing the compliance of constituencies in sovereign countries may not be possible at any reasonable cost.[16]

2.4 The Kyoto Protocol to the United Nations Framework Convention on Climate Change of 1997

Like with the Montreal Protocol, the experience of the Kyoto Protocol illustrates how uncertainty in the expected net benefits of emission controls across countries has limited international action. As with the Montreal Protocol, it may be that as more information appears, an international consensus on regulation eventually will develop. This point underscores the importance of information generation as a public good in international collective action. Table 2.2 outlines the implications of the theoretical framework for the progress and content of international negotiations to control emission of greenhouse gases (GHG) and empirical observations up to this point.

The theory explains why uncertain constituent net benefits within developed and undeveloped countries that are major carbon emitters makes global warming regulation so politically controversial. It also suggests why delay in adopting significant international commitments is a reasonable position for political agents in those countries. Important differences in the anticipated benefits and costs of GHG regulation across countries means that significant transfer payments to build support for international actions are required. The theory indicates, however, that these will be politically difficult to design because of the uncertain constituent net benefits of regulation. Finally, because of the high costs of regulation in some countries treaty compliance is an issue. As with the Montreal Protocol, cheating adds more uncertainty for all countries in calculating the net benefits of international action.

[16] Chang (1995) presents a case for the use of trade sanctions by countries in support of international environmental treaties. In narrowly focused agreements trade sanctions might serve as an enforcement mechanism. In broad treaties, like the Kyoto Protocol where the range of industries and countries is much larger, trade sanctions are less likely to be effective. Barrett (1994) argues that the Montreal Protocol accomplished relatively little over a non-cooperative outcome.

Table 2.2 Kyoto protocol

Framework implications	Empirical observation
Collective action occurs when there are large expected net benefits among constituencies within negotiating countries, i.e., B_{n_i} high within negotiating countries	Collective action remains controversial. Key U.S. constituencies see few benefits, those in Britain and France anticipate gains. Constituencies in most developing countries do not
Uncertainty reduces expected net benefits and thereby reduces collective action. Reduction in uncertainty promotes collective action, i.e., large standard deviation of ε in treaty index y. Reduction in uncertainty promotes collective action, i.e., small ε in treaty index y	Limited information about the problem, costs, and regulatory approach limits action by developed and undeveloped countries. New information might promote action
Transfer payments $t_i(\theta_i)$, are necessary to offset differences in expected net benefits	Developing countries still anticipate few benefits, demand fund and technology transfers and lenient treaty provisions
Compliance problems raise uncertainty and reduces collective action	Lack of enforcement raises concern about benefits of collective action

2.4.1 Uncertainty and Calculation of Net Benefits from Political Action

International collective action to regulate general GHGs is much more complex than is effort to control CFCs and related chemicals. The number of gases involved, the constituencies affected, and the range of economic costs and benefits are far much larger, and the extent of uncertainty is greater. There are numerous sources of uncertainty that affect assessment of the benefits and costs of GHG abatement, hence affecting political stands by agents in negotiations. Despite the availability of new information about higher temperatures, the magnitude of global warming remains undetermined. The rate at which greenhouse gas concentrations will increase and the relationship between accumulation of GHG in the atmosphere and the extent of warming is not quantified. Offsetting effects of other factors, such as the oceans and forests are unknown. The human role is disputed, and the reaction of the oceans and ice caps to higher temperatures is difficult to gauge.[17] The global change models that are used to simulate possibilities are particularly imprecise about regional effects, masking regional variation. These regional patterns, however, are crucial for motivating country participation and adherence to international efforts.

There are substantial heterogeneities within and among countries in the anticipated effects of global warming and in the costs of reducing greenhouse gas emissions

[17] For disputes of GHG effects, see the testimony of Patrick J. Michaels of the University of Virginia before the U.S. House Committee on Small Business, July 29, 1998. For summary discussion of the many issues and uncertainties involved see Paterson (1996); Hollick and Cooper (1997); Shogren and Toman (2000). (Houghton 2009, pp. 1–8) seems more confident in the consistency of the patterns.

(Holtz-Eakin and Selden 1995). Current global circulation models (GCMs) indicate that some areas might benefit from moderate global warming, others might be moderately affected, and some might be seriously harmed. Those countries vulnerable to a rise in sea levels seem to have most at stake, including small island states, Bangladesh and the Netherlands. China, Russia, other Northern European countries, and Canada might benefit through increased agricultural production. Studies indicate a possible increase in agricultural production in the U.S. (Kane et al. 1992; Mendelsohn et al. 1994; Mendelsohn and Neumann 1999). In the tropics, predictions are less clear, but there may be little change.

Estimates of the costs of GHG abatement vary widely, according to assumptions used about the speed and amount of reduction, adjustment flexibility, advent of new energy technology, and the whether emission-permit trading or other market mechanisms are allowed. To meet Kyoto objectives, the U.S. will have to reduce emissions by 30 % of their 1990 level by 2020, a large amount in a short time.[18] U.S. GDP losses by 2010 range from 1 to 4.2 %.[19] These differences add uncertainty for constituents and politicians in calculating the net benefits of global warming regulation. If regulations were gradually put into place, world GDP growth over the next 50 years would decline from a projected 2.3 to 2.25 % annually. More abruptly implemented controls, however, could cost 2.5 % of world GDP by 2043 or $2.25 trillion (Burniaux et al. 1992; Weyant 1993).

The costs will be the greatest for the countries that produce the most CO2. In 1996 the U.S. and Canada, both of which rely on coal-based electricity production, accounted for about 25 percent of global CO2. Because of subsidized reliance on coal, China is projected to be the largest producer of CO2 by 2015 and India the second largest (Burniaux et al. 1992; Poterba 1993). Among countries, Canada, U.S., Italy, Japan, France, and Australia will bear the greatest costs. Among U.S. states, Alaska, Montana, New Jersey, Florida, Texas Louisiana, and Wyoming will be the hardest hit (WEFA 1998). And among industries, coal and energy-intensive sectors, such as steel, aluminum, paper, chemicals, and transport will incur the greatest costs. More broadly, consumer prices will rise with higher energy costs.

Differences in anticipated net benefits of regulation create conflicting stands among political constituencies. Proponents of regulation are environmental groups and firms like BP and Royal/Dutch Shell with large holdings of natural gas and investment in alternative energy sources, such as solar and wind.[20] Within the U.S. and other countries, such as Australia, another large and powerful group of constituents

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[18] Weyant (1993), Hollick and Cooper (1997), National Academies of Science (1992), and Manne and Richels (1990) estimate that reducing CO2 emissions by 20 % would cost the U.S. between $800 billion and $3 trillion between 1990–2010, or about 5 % of total macroeconomic consumption.

[19] The U.S. Energy Information Agency compared the cost estimates provided by WEFA, Charles River Associates, Pacific Northwest National Laboratory, MIT, the Electric Power Research Institute, and DRI, Inc. See also Kirova (1999).

[20] For the position of some groups, see US House of Representatives (1998). BP and Shell have large holdings of natural gas that would be in greater demand with restrictions on other fossil fuels. BP also has invested in alternative energy sources and the value of the investment would rise with restrictions on carbon use (Murphy 2002).

that anticipate harm have mobilized to oppose GHG regulation. For example, during 1998 Congressional hearings, representatives of the American Petroleum Institute and the American Council for Capital Formation presented treaty cost estimates that were much higher than those presented by the Clinton Administration

(U.S. House, 1998d, 53–78). Also, powerful small business and farm groups have voiced concerns about substantially higher energy costs (U.S. House, 1998a, 4–37; 1998b, 3–40).[21] As outlined in Sect. 2.2 above, these heterogeneous, uncertain net benefits make it difficult for political agents to support rapid, major cuts in GHG emissions or transfers to other countries to facilitate international action.

2.4.2 Transfer Payment Demands

With existing information, agents of developing countries have taken the position that a global warming treaty would provide few benefits, but have high domestic economic costs. China and India have claimed that they would not participate in international emissions reductions unless there were large compensating transfers from developed countries (Agarwal and Narain 1991; Hollick and Cooper 1997). In response, agents from developed countries initially proposed more lenient treaty provisions for developing countries similar to those granted in the Montreal Protocol. In the 1992 United Nations Framework Convention on Climate Change (FCCC), only Annex 1 countries, which included developed countries in the OECD and transitional economies in Eastern Europe and the former Soviet Union, were called upon to voluntarily reduce GHG emissions. Developing countries were exempted from taking direct action: the FCCC explicitly recognized that these countries had common, but differentiated responsibilities.

Given the continued buildup of gases that damage the ozone layer due to developing country exemptions to the Montreal Protocol, there was similar concern that GHG abatement goals could not be met. The issue was raised during the Conference of Parties of the FCCC in Berlin in April 1995, but no new commitments were requested of developing countries. In this spirit, the 1997 Kyoto Protocol to the Framework Convention adopted binding emission reduction targets only for Annex B or industrialized countries.[22] Even within that group, differences were allowed. Total CO2 emissions were to be reduced by 5.2 percent of 1990 levels. European Union countries were allowed to follow an inclusive or bubble reduction target of eight percent and the U.S. a seven percent reduction by the period 2008–2012. Transition economies were allowed to use a different base year, and developing countries were not required to take any action. Abatement exemptions, however, add more

[21] For example fear about possible job losses in the US led the Byrd-Hagel Resolution to pass 95 to 0 in July 1997 that insisted that developing countries participate in any global warming effort, 143 Congressional Record S8113-05, daily edition, July 25, 1997.

[22] United Nations Framework Convention on Climate Change S. Treaty Doc No. 102-38, 31 ILM 849. Kyoto Protocol to the FCCC, FCCC Conference of the Parties, 3d Sess, UN Doc.

uncertainty to estimations of the effects of any global warming treaty. With current rates of economic development and fossil fuel use in developing countries, net emissions by participating countries would have to become negative by the middle of the 21st century in order to lower GHG accumulations. The associated higher costs could stimulate political opposition to international cooperation.

Accordingly, the magnitude of international financial and technical transfers to secure participation by developing countries is far larger than in the past (Jacoby et al. 1998, p. 90). Such transfers are implicit in the Clean Development Mechanism (CDM) and Joint Implementation projects outlined in the Kyoto Protocol, whereby developed countries obtain emission abatement credits for investing in carbon reduction in developing countries. Neither mechanism, however, has been defined. They are tied up with international debate over the nature and extent of emission rights trading. The much larger amounts that would be transferred from developed countries to any new international GHG fund, similar to the Montreal Protocols Multilateral Fund, remain unresolved.

2.4.3 Compliance and Enforcement

There is no underlying enforcement mechanism within the Kyoto Protocol. No consequences of noncompliance could be agreed upon, and the compliance provisions that are included apply only to Annex 1 or industrialized countries (Breidenich et al. 1998). Monitoring depends on annual self-reports by countries using ostensibly comparable methodologies. Absent effective enforcement, there will be incentives for countries to defect whenever the internal political costs of regulation become too high.[23] While there are growing enforcement problems with the Montreal Protocol, compliance will be a much greater issue with GHG regulation. Controls must be more sweeping across sectors, involving higher economic costs. With heterogeneous, uncertain net benefits of regulation, there will be differential incentives to comply even with transfers. But widespread cheating will only add to uncertainty regarding the returns to international cooperation.

2.5 Conclusion

Theory and research regarding collective action addressing local open-access resource problems indicates that success in controlling externalities comes when: (a). There is a consensus on the aggregate benefits to be gained, (b). The parties perceive positive net gains from agreement, and (c). They are homogeneous with respect to bargaining

[23] See Chang (1995) for use of trade sanctions as a means of enforcement. Few international environmental agreements contain substantive commitments (US General Accounting Office 1999). Bac (1996) discusses free riding.

objectives and in the distribution of the costs and benefits to be incurred. Agreements reached under these conditions tend to be self-enforcing because it is in the interest of all parties to insure success (Ostrom 1990). Collective action may also achieve its objectives if the parties are heterogeneous with respect to the net gains from cooperation if: (a). The spread is not too great, (b). There is little uncertainty as to the consequences of agreement, and (c). There are bases for constructing side payments to compensate those parties that may bear more costs or receive fewer gains. The resulting property rights structure must be secure so that the side payments are long term and predictable. These conditions require an enforcement arrangement that is binding for all parties. Negotiating international agreements for collective action regarding the control of environmental externalities confronts the same requirements for success. But the challenges are much more formidable.

The experience of the Montreal Protocol to Control Substances that Damage the Ozone Layer is insightful for understanding the issues raised by the Kyoto Protocol on Global Warming. The magnitudes of the problems faced by political constituencies in assessing net benefits and by politicians in assembling domestic coalitions for international action are much larger. As suggested by our framework, as new information emerges and uncertainty is reduced, political agreement may be forthcoming. In the meantime, strict GHG regulations are unlikely to gather much political support in countries that anticipate high costs of regulation. Moderate R&D and information development objectives also avoid premature adoption of long-term, irreversible abatement technologies where the opportunity costs exceed those of GHG stock irreversibilities (Kolstad 1996; Pindyck 2000).

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