A Herd Mentality in the Design of International Environmental Agreements?

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1. The Puzzle

As societies turn to markets to regulate environmental hazards an important question arises: what kind of pollution "market" is best?[1] Governments could set the *price* of environmental damage, such as through the imposition of pollution taxes. Or, governments could limit the total *quantity* of allowable pollutants, imposing a cap on total emissions and allowing firms to trade emission credits under that cap. By either route, the market is left to sort out the best adjustments in behavior and technology, but the design of the market and its outcomes are quite different. By the first route—"prices"—regulators assure that firms reflect a certain cost of pollution in their production decisions but the market itself determines the quantity of emissions. By the second route—"quantities"—regulators limit the total quantity of emissions while the market determines the cost that firms (and society) must pay to meet that limit. By setting prices, a government focuses on the *effort* required to control pollution; by setting quantities, it focuses on the *output* from that effort.

A rich literature in environmental economics has arisen around the choice of policy instrument, rooted in the seminal paper by Weitzman,[2] and applied to recent problems such as the design of instruments to regulate the "greenhouse gases" that cause global climate change. A striking finding from application of the Weitzman logic to the problem of climate change from the emission of "greenhouse gases" generally leads to the conclusion that a "price" instrument should be favored.[3] Yet, to date, every serious international effort to address global warming—most notably, the Kyoto Protocol—has been designed to limit the total quantity of emissions. This mismatch would suggest that the difficulties

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1. For a recent comprehensive review of the experience with market instruments see Stavins 2003.
2. Weitzman 1974.
3. McKibbin and Wilcoxen 1997; Kopp et al. 1997; Pizer 1998; and Pizer 2002.

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in bringing Kyoto into force as a treaty stem not just from particular political difficulties surrounding Kyoto, such as the inability of the US to meet its Kyoto targets, but are fundamental to the structure of the agreement itself. Kyoto's troubles result, perhaps, from deploying a "quantity" instrument against a problem best suited for "prices."[4]

This paper examines one possible explanation for this mismatch: the choice of a "quantity" instrument in the Kyoto Protocol reflects diplomatic experience and convention. By this hypothesis, the international diplomatic community favors the use of quantity instruments for controlling international air pollution problems because such instruments are the most common and prominent tools in the diplomatic toolbox, obscuring from view all other options. We call this the "herd hypothesis." Falsifying it would require demonstrating that the authors of past international environmental agreements knew about and considered employing instruments other than emissions caps, and yet still chose quantity instruments. We do not suggest that this hypothesis is the only explanation for the rush to quantities in Kyoto, and elsewhere we examine alternative hypotheses.[5] However, the evidence we proffer does suggest that intellectual herds are, indeed, roaming the plains of international environmental law—and they strongly favor quantities over prices.

In this essay we first summarize the "prices vs. quantities" argument—with illustrations using the problem of regulating greenhouse gases—so that readers who have not been engrossed in this debate understand the high stakes in instrument choice. Then we examine the herd hypothesis from two perspectives: 1) trends in the choice of regulatory instrument in the entire experience of international air pollution agreements, and 2) the detailed experience with one regulatory regime that is most often hailed as the model for others: the Montreal Protocol on Substances that Deplete the Ozone Layer.

2. A Brief on Instrument Choice

The choice of best policy instrument depends, in the main, on the slope and uncertainties in the benefit and cost curves. Figure 1 shows typical curves for the problem of global warming when viewed from a long-term perspective—the next 100 years. The vertical axis denotes the costs and benefits of controlling

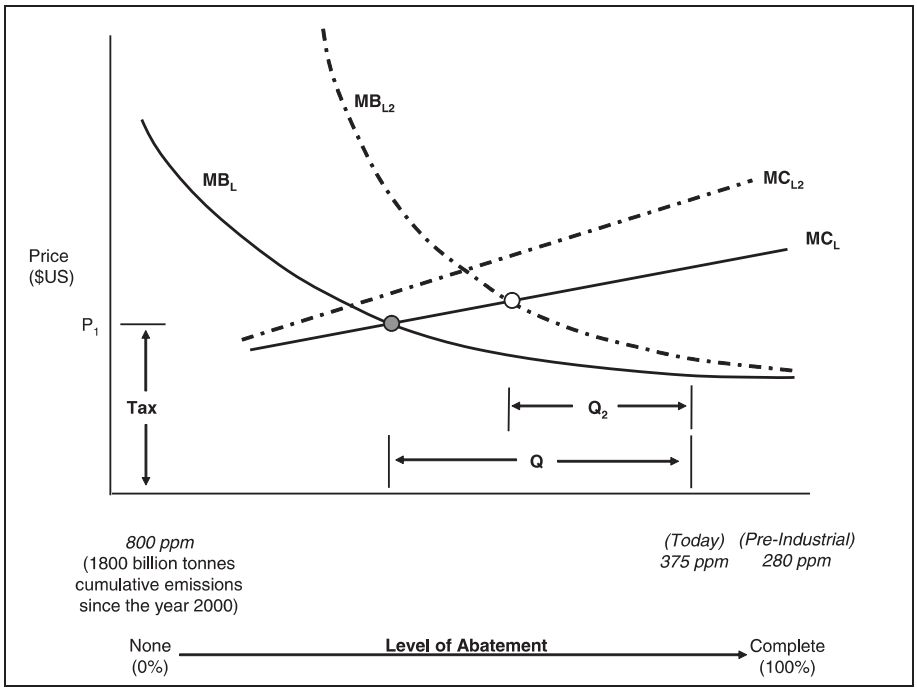
4. Victor 2001; and McKibbin and Wilcoxen 2002. In addition to the economic merits of a "price" approach there is a rich debate over whether political and administrative considerations favor prices or quantities (e.g., see the review in Aldy et al. 2003; for attention to state interests and enforcement see Barrett 2003). Most of that work reflects the choice of the Kyoto Protocol itself—namely, emission quantities coupled with an international emission trading system (e.g., see the arguments for caps and trading in Stewart and Wiener 2003). While we will show that most experience with international air pollution agreements focuses on limiting quantities, many international economic agreements use effort and policy coordination as the central instruments for cooperation. They include the GATT (Victor 2001), IMF country reviews (Chayes and Chayes 1991), and the Marshall Plan (Schelling 1998). For an argument in favor of using a price instrument to address climate change see Cooper 1998.
5. Victor and Coben 2003.

emissions. The horizontal axis shows the degree of abatement. At the left is no abatement under the most extreme emissions scenario ("A2") proposed by the Intergovernmental Panel on Climate Change.[6] This scenario involves emitting so much carbon that the concentration of carbon dioxide in the atmosphere rises to about 800 parts per million (ppm),[7] a concentration equivalent to cumulative emissions of approximately 1800 billion tons of carbon over the next 100 years.[8] At the extreme right is complete removal of CO_2 emissions from the energy system, with eventual return to the pre-industrial atmospheric concentration of 280 ppm.

The marginal benefit of abatement slopes downward, as the value of control diminishes with additional effort. Avoiding extremely high concentrations is probably highly beneficial as these probably multiply the risk of catastrophic changes in climate. In contrast, the marginal benefit of abatement is probably pretty flat (and approaching zero) as concentrations approach today's values of 370 ppm. Although careful studies show that ecosystems are already stressed in responding to the current effects of climate change,[9] so far human and natural ecosystems have been reasonably able to adapt to the increased concentrations already experienced, suggesting that cutting emissions so that concentrations fall below current levels would yield little benefit. Thus the curve MB_L starts high and then declines steeply, leveling out at the fullest degree of abatement.

6. Nakićenović et al. 2000.
7. Schlesinger and Malyshev 2001.
8. Carbon dioxide is removed by multiple processes that occur over different time horizons, and thus there is no simple relationship between emissions of CO_2 into the atmosphere and atmospheric concentration of CO_2. A small fraction of CO_2 is net removed rapidly from the atmosphere; the rest builds up and is removed by processes on the time scale of a century or longer (Maier-Reimer and Hasselman 1987). A proper full analysis of carbon dioxide abatement options must thus couple analysis of emissions with a model of the carbon cycle; the 800 ppm concentration is estimated by Schlesinger and Malyshev (2001) using one such model. In recent times about half the CO_2 net remains in the atmosphere for long periods; most models project this pattern will continue so long as emissions rise exponentially. However, one of the many uncertainties in the climate problem is the response of the carbon cycle to elevated CO_2 concentrations and to the changing climates that follow–it is possible, for example, that a much higher concentration of emitted CO_2 will net remain in the atmosphere. Indeed, desiccation in tropical zones may turn forests into net sources of CO_2 as forest lands shift to grasslands or deserts that store less carbon–amplifying the elevation of CO_2 concentrations caused by burning fossil fuels. For this paper, however, we adopt a more stylized approach–also adopted by the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) in many of its summary tables–and focus on cumulative emissions. Over timescales of a century and shorter, emissions of CO_2 accumulate in the atmosphere–the "stock" of atmospheric CO_2 builds up–because the rate at which human activities (mainly burning of fossil fuels) deposits CO_2 in the atmosphere is much more rapid than the final processes that net remove CO_2 and deposit it in the deep oceans, the soils and sediments. Our purpose here is not to derive exact results but to focus on the shapes of the curves, which in turn drives the analysis of prices vs. quantities. The IPCC scenarios are run by different models, yielding different results for emissions. Using the "AIM" model and the IPCC A2 scenario leads to 33 GtC per year emissions in 2100, with cumulative emissions from 2000 through 2100 of approximately 500 GtC. For comparison, cumulative emissions from about 1900 to 2000 were approximately 260 GtC (Marland et al. 2002). Nearly all models project the highest cumulative emissions from the A2 scenario.
9. Root et al. 2003.

Figure 1
Long-Term Analysis



Notes: The typical benefit-cost curves for the problem of global warming, where MB_L (marginal benefit) and MC_L (marginal cost) represent *long-term* estimation for the costs and benefits of mitigating emissions. MB_{L2} and MC_{L2} represent plausible alternatives, as the exact patterns of costs and benefits from emission controls are uncertain. For example, MB_{L2} reflects the risk of an abrupt change in climate, such as a shutdown of the oceanic circulation in the North Atlantic, which could be costly for ecosystems and humanity.

The marginal cost (MC_L) curve starts low on the left side, where it costs little to control a ton of emissions in a system that already has very high emissions and ample room for improvement. That curve rises as abatement becomes complete; it is probably costly to completely eliminate emissions of CO_2 from the world economy while at the same time providing energy services to a larger and wealthier world population. But MC_L is likely to be pretty flat when viewed from the long-term perspective of a whole century. If governments, firms and consumers knew today that they would be required to eliminate emissions and stabilize concentrations of greenhouse gases over the next century then they could invent cost-effective carbon-free energy sources, such as passively safe nuclear power or abundant renewable power, that probably would cost little more

than today's energy system. They could also find ways to strip fossil fuels of their carbon and sequester it under ground or in the oceans, allowing fossil fuels to continue as an important primary energy source.[10] With ample advance warning, the economy could embrace and install these technologies optimally with the turnover of the long-lived capital stock. The abundant availability of relatively low-cost options and a century to prepare the economy could, together, create a marginal cost curve that is nearly flat. Extreme abatement would require radical changes in the energy system; though seemingly daunting, viewed with from a century-long perspective, the history of energy technology is replete with such dramatic technological shifts.

The optimal response is shown where MC_L and MB_L cross. Policy-makers could reach that point with either instrument—they could impose a tax on carbon emissions or they could limit the quantity—and see identical effects on quantity and cost. However, uncertainties in MC_L and MB_L could cause policy-makers to make errors. If pollution-abatement policies produce smaller benefits or cost more than expected, policy-makers could force the economy to waste resources on excessive control of greenhouse gases. On the other hand, policies that underestimate the dangers of global warming or overestimate the costs of reduction could lead to inadequate investment in controlling greenhouse gases, perhaps even exposing the economy to catastrophic changes in climate. Figure 1 illustrates some of these uncertainties. The benefits from regulation might be greater if a buildup of CO_2 in the atmosphere were likely to trigger some catastrophe (MB_{L2}). Or, the cost curve might shift up (MC_{L2}) if it proves more difficult to find acceptable alternatives to fossil fuels or to apply at industrial scale the technologies for sequestering CO_2 from fossil fuels. With uncertainty, prices and quantities do not have equal effects on the economy. If a price mechanism were used, then the flat marginal cost curve implies that even small uncertainties—shifts up and down, or slight changes in shape—in the cost of abatement could have huge implications for the quantity of emissions. If the MB curve is uncertain and possibly steep—as shown in MB_{L2}—then a price instrument could leave humanity and ecosystems exposed to risk of climatic disaster. In these cases, the quantity instrument is superior—it allows tighter regulation of the benefits without imposing much additional cost on the economy if the relatively flat marginal cost curve shifts higher or lower than expected.

The logic shown in Figure 1 strongly suggests putting limits on emission quantities rather than prices if there are strong suspicions of dramatic threshold effects on climate such as suggested with MB_{L2}. In practice, that approach might entail allocation of credits for allowable emissions—the amount "Q" on the figure, for example—to all emitters in the world for the next century (ideally longer) and then let them trade over time and space to find the best solution. Certain that the limit Q is binding, innovators will focus their minds and capital on new low-carbon and zero-carbon energy systems.

10. On costs, see generally the chapters in Metz et al. 2001.

The problem with this solution is that it is neither politically possible, nor desirable, to establish a credible policy for a century. Even within long-standing nation states, governments and policy priorities change. The worldwide shift to democratic decision-making may make it especially difficult to establish credible long-term policies—especially policies that could have negative consequences for powerful interest groups. (Perhaps totalitarian governments are more strategic, but the costs of tyranny make that form of government largely unattractive.) Indeed, nearly every policy study of climate change concludes that an adaptive policy framework is needed—one that invests in new information and offers regular adjustment in policy.[11]

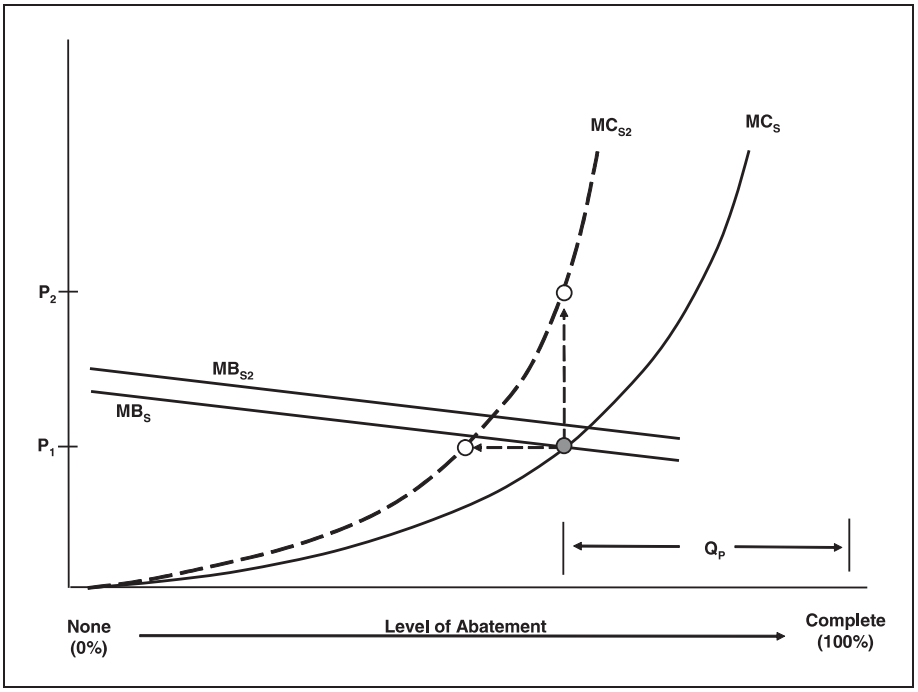
Of course, governments and firms do set long-term aspirations, but those should not be confused with binding and credible policy obligations. The British government, for example, recently issued a White Paper that imagines a 60% cut in CO_2 emissions over the next five decades.[12] BP has articulated a vision for cutting carbon in half by 2050.[13] Such visions are aspirations rather than regulatory timetables; attempts to set binding targets for 2050 would be laughable. At the international level, setting credible long-term binding limits is even more fanciful since those efforts must use weak instruments of international law to coordinate states with diverse interests. A change in the interests of one or more key states, of which there are perhaps a dozen for the case of global warming (United States, China, European Union, Russian Federation, Japan, India, Indonesia and Malaysia, in order of emissions and rough importance) could cause others to defect and easily unravel any proposed agreement.

Because long-term policies are not credible, practical policy responses to the problem of climate change have focused on a series of short-term policies. There is no magical time period, but typically commitments in international environmental treaties last no longer than about three to seven years and generally take effect after a delay of two to five years to allow for legal entry-into-force and to allow governments and firms to prepare for compliance. In the case of the Kyoto Protocol, the five year "budget period" (2008 to 2012) begins after a delay of ten years (1997 to 2007). In the case of the protocol on sulfur dioxide emissions in Europe, negotiated under the 1979 Convention on Long Range Transboundary Air Pollution, the commitments that were finalized in 1985 were expected to enter into force within a few years and then expire in 1993, by which time a new protocol would be in place. Negotiators at the Montreal Protocol on Substances that Deplete the Ozone Layer adopted long-term commitments but expected to amend and adjust them every few years—so far, approximately every three years.

The transformation from a long-run to a short-run problem leads to benefit and cost curves with completely different shapes—as shown in Figure 2.

11. For example, see Bankes and Lempert 1996; Kolstad 1993; Manne and Richels 1992; and Peck and Teisberg 1993.
12. Department of Trade and Industry 2003.
13. Browne 2004.

Figure 2
Short-Term Analysis



Notes: The benefit-cost curves representing the short-term view (about 5 years) of the global warming problem. The marginal benefit of abatement (MB_S) over only a few years is relatively low—5 years of emissions would equal only a small fraction of the total global CO_2 stock—but the short-term costs (MC_S) could be high, painfully so if the transition to lower-emissions technologies proves more difficult and expensive than anticipated (MC_{S2}). Capping the quantity of emissions (for example, with an emission trading system and an allocation of permits Q_P) could accidentally force the economy to bear a much higher cost of compliance (marginal cost P_2 rather than P_1) for little additional benefit. A better policy would regulate the price a P, and allow the quantity of emission to float with the market.

The curve showing marginal benefits (MB_S) is relatively flat because the emissions during any brief period, such as five years, have almost no impact on the total stock of CO_2 that accumulates in the atmosphere. (That stock, measured as the atmospheric concentration, is what causes global warming.) MB_S is not completely flat because there is some chance that an extra ton emitted during the period would trigger an abrupt change in the climate and each ton, however marginally, contributes to the total stock in the atmosphere and the inertia of global climate. The cost curve (MC_S), however, is relatively steep and curves sharply upward as the level of abatement increases. Because most CO_2 is emitted during the burning of fossil fuels and the lifetime of most fossil fuel tech-

nologies is long relative to the five-year policy period, it is extremely costly to make steep reductions in emissions over a brief period with only a few years of advance notice.

Again, with perfect information, both price and quantity instruments can deliver optimal results. However, neither benefits nor costs are precisely known; the benefits curve might shift up if the risks of climate change are greater than expected, but it is unlikely that policy-makers would discover that fact nor be able to use such information for regulatory purposes during the relatively brief period shown on figure 2. The marginal cost curve (MC_{S2}) is likely particularly uncertain—it could curve upward even more sharply than expected if, for example, it proves more time-consuming and difficult to site or operate low-carbon power plants or other energy technologies. Indeed, the history of technological change in energy systems is generally one of slow turnover. Even where engineers are able to identify many possible low-cost technological and behavioral changes that would reduce emissions, usually in practice those changes occur much more slowly than engineers envisioned at the outset.

In this situation, the reasoning is exactly opposite to that in Figure 1, and the best policy instrument is "prices," such as a carbon tax or some collection of coordinated policies that specify the effort required to control emissions. Errors in choosing the level of effort are unlikely to have much effect on the total stock of CO_2 that accumulates in the atmosphere, and thus little impact on the level of benefits (compare MB_S and MB_{S2}). In contrast, a policy that regulates the output of greenhouse gases—such as a cap on the quantity of emissions—could, if the marginal cost curve is steeper than expected, accidentally impose high costs on the economy.

This is the puzzle to be explained. The most basic "prices vs. quantities" analysis, such as above, suggests that prices are the best instrument for addressing the global warming problem in the real world where credible long-term commitments are essentially impossible to make. Yet Kyoto, the most far-reaching of the existing international environmental agreements, sets limits in terms of emission quantities and is largely silent on prices. Indeed, the vast majority of diplomatic attention to the design of regulatory regimes for climate change has focused on Kyoto-like quantity instruments.

3. The Practice of International Environmental Law

To explore the hypothesis that architects of the Kyoto Protocol chose quantities rather than prices because of a blinding conventional wisdom in the practice of international environmental law, we look to the record of treaty-making. We adopt two perspectives—first, the macro view through examination of all relevant international environmental agreements that form the body of experience from which the architects of Kyoto might have drawn. Second, we examine the one legal regime that in particular guided the Kyoto architects—the Montreal Protocol—and explore its lessons and relevance for the problem of global warming.

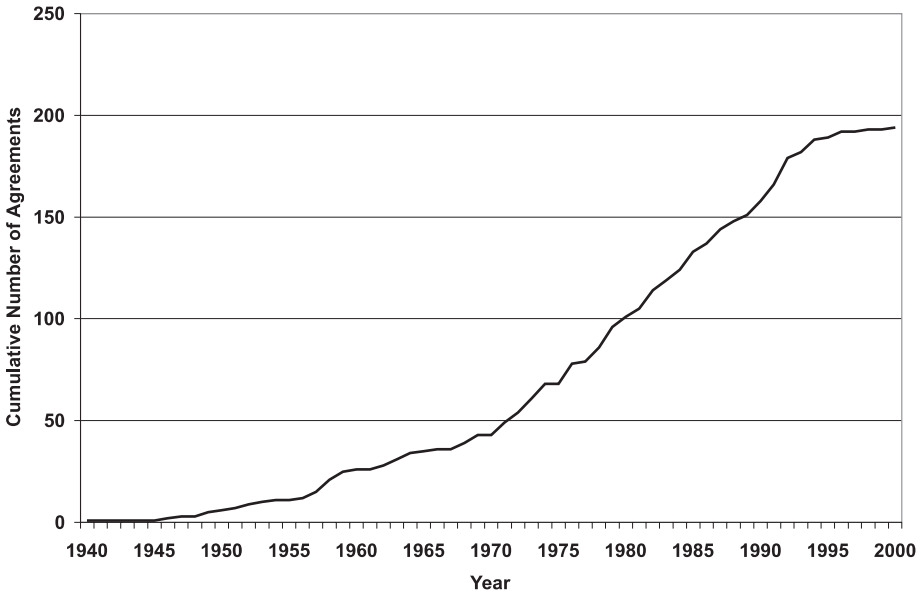
The Macro Perspective

To explore the macro perspective, we look to a database of all international environmental agreements, the ENTRI (Environmental Treaties and Resource Indicators) data set compiled by CIESIN (Center for International Earth Science Information Network).[14] This data set, which includes 196 international environmental agreements, was compiled somewhat systematically with expert guidance and is available in electronic format with links to full treaty texts. Figure 3 shows the total number of treaties in cumulative chronological order. The early 1970s marked the start of a period of rapid treaty formation, with a peak in treaty making activity 1992. After the blockbuster year of 1992—the date of the Rio Earth Summit—the cumulative curve inflects and flattens, perhaps a reflection of the exhaustion of opportunity (or exhaustion of the diplomats themselves). It may also reflect the shift away from focused, smaller agreements (e.g., the Convention on International Trade in Endangered Species) toward larger omnibus treaties—for example, the 1992 Convention on Biological Diversity—which are more time-consuming to negotiate and maintain because they, by design, link across many issues. The plateau may also reflect an artifact of the CIESIN coding, which may understate recent achievements and over-count earlier agreements. We leave to others to explore hypotheses about the rate and intensity of diplomatic activity.

There are several other published data sets that examine international environmental law from a broad perspective, but none has been systematic in the coding of which agreements "count."[15] Among the flaws in the CIESIN data set are a lack of clear criteria about which non-binding agreements to include as well as lack of systematic treatment of bilateral agreements (binding and non-binding). Nor is the data set rigorous about drawing boundaries around the field of "environment." For example, the data set includes the original GATT agreement (1947), presumably on the grounds that trade agreements affect the environment. But similar arguments could be made for other types of agreements—such as finance, investment, and customs agreements—yet they are not included systematically. The original Treaty of Rome (1957), for example, is not included—even though that treaty ultimately became a framework for the European Union, with numerous implications for international environmental cooperation. Other data sets are beset by similar (or more severe) problems. However, in our judgment, the CIESIN data set includes all of the major international environmental agreements that expert diplomats would recognize as the canon of international environmental law (and then some), and thus for our purposes we do not anticipate that problems in drawing boundaries around the data set will affect our conclusions—especially in light of the strength of the conclusions that follow.

14. Center for International Earth Science Information Network 1996–2001.
15. Birnie and Boyle 2002; Caldwell 1990; Hunter, Salzman, and Zaelke 1998; Victor et al. 1998; Porter et al. 2000; and Weiss et al. 1992.

Figure 3
The History of Environmental Agreements



Notes: Over the last half-century governments have negotiated 196 international environmental agreements. Nearly 25% of those agreements emerged from the surges in activity in the late-1970s and early 1990s. The mid-1990s saw a leveling-off due possibly to the exhaustion of opportunity and of the diplomatic community itself. Analysis of the rate of treaty-making activity reveals a significant rise in the early 1970s as awareness of environmental issues spread worldwide, with a peak at 13 agreements/year in 1992 at the time of the United Nations "Earth Summit."
Source: CIESIN 1996–2001.

We have coded all 196 agreements for whether they concern, in some central way, transboundary air pollution. We expect that air pollution agreements would be the likely body of law that would serve as the first point of reference for addressing a new air pollution problem—in this case, the problem of global warming. The CIESIN data ends at 2000; we focus our analysis on the period prior to 1995, when the signing of the Berlin Mandate (April, 1995) set the framework for the Kyoto Protocol; lessons accumulated prior to the period when those negotiations took on a life of their own (late 1995) are probably most relevant. Appendix I shows the full list of 196 and our coding.

For the 21 agreements that concern air pollution, we coded two variables. First, we asked whether the primary instrument was "prices" or "quantities" (e.g., an emission cap). We are mindful that diplomats may refrain from actually enumerating prices in agreements and thus we code "prices" as a broader con-

cept: "prices and policies," by which we mean an agreement that specifies the required level of effort. Although the "policies" approach might be less efficient economically than a pure price approach, they are two variants of the same species of instrument.

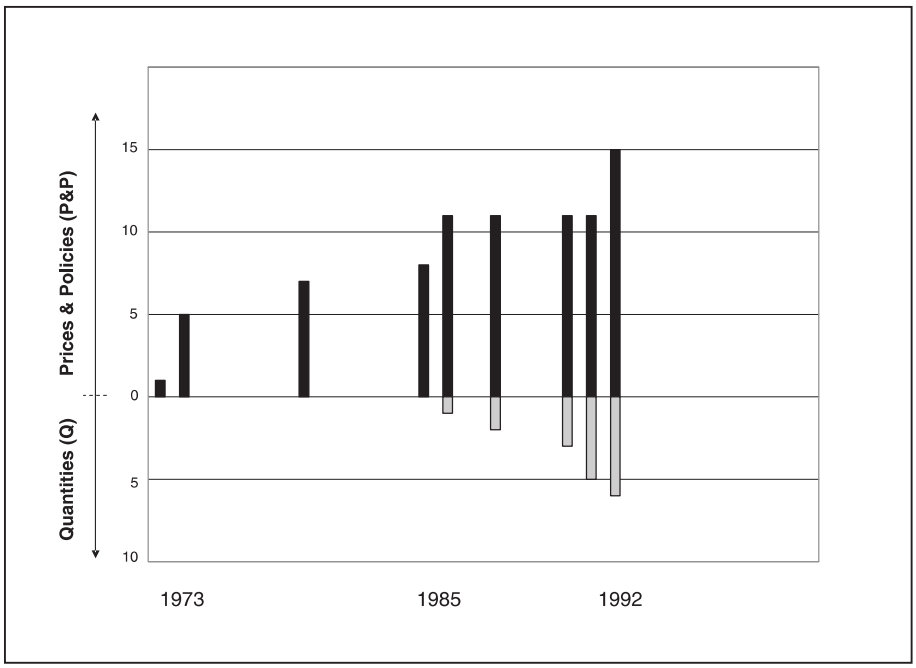
Figure 4 shows the results from this simple coding. The body of experience includes both "Prices and Policies (P&P)" and well as "Quantities (Q)," which would suggest that the herd hypothesis is invalid. Indeed, numerically the experience is stronger with P&P agreements than with Q.

Next we coded on a second dimension: specificity. Many attempts at international environmental cooperation begin with broad, general frameworks—often termed a "framework convention"—and then proceed to craft more specific commitments in later agreements. Thus, general agreements arise when parties are at the early stages of cooperation and do not know what to do; such general agreements may also arise when parties fail to agree on specific commitments yet do not wish to abandon negotiations. Indeed, international agreements are often the output when parties want the symbolic benefits of cooperation to address international environmental problems, yet are unable to agree on whether and how to cooperate.[16] In other cases, where the parties are actually able to agree to collective action that extends beyond the status quo, they usually codify their agreement with specific commitments. Even when those commitments are weak, specific obligations can signal intent to others and create a dynamic in which countries compete to offer greater commitments—what Marc Levy has termed "tote-board diplomacy."[17] In short, the specificity of commitments could be a good indicator of whether the parties are engaged in merely symbolic efforts and unable to agree on deep commitments or whether a more demanding collective effort may be in store. In this second coding we focus on the dominant commitments of the agreement, looking first to treaty texts and then to a broad collection of secondary literature. Our coding of the 21 air pollution agreements is shown in Appendix II, and we invite the reader to propose alternatives—though our own attempts to deploy varied coding methods did not yield results that differ much from what is shown here.

Figure 5 shows the striking results. Nearly every agreement in which the dominant commitments are general in nature is focused on prices and policies. Nearly every agreement with specific commitments contains a quantity instrument as the central obligation. The two exceptions are so unique as to underscore the power of the finding. One is the 1984 protocol to the LRTAP (Long-Range Transboundary Air Pollution) Convention, establishing the funding arrangements for two research centers (in Oslo and in Moscow). The other is a 1992 agreement establishing a global change research institute located in São Paulo, Brazil (the Agreement Establishing the Inter-American Institute for Global Change Research). Neither of those two cases—the only examples of

16. Raustiala and Victor 1998.
17. Levy 1993.

Figure 4
Agreements Concerning Tansboundary Air Pollution



Notes: Of the one hundred and ninety-six international environment agreements represented in the CIESIN database, twenty-one concern transboundary air pollution in some central way. Of those twenty-one, fifteen rely most heavily on commitments that set prices and policies (P&P). Six rely primarily on a quantity (Q) instrument, such as a cap on emissions. Thus history suggests that negotiators have had experience with both types of instruments.

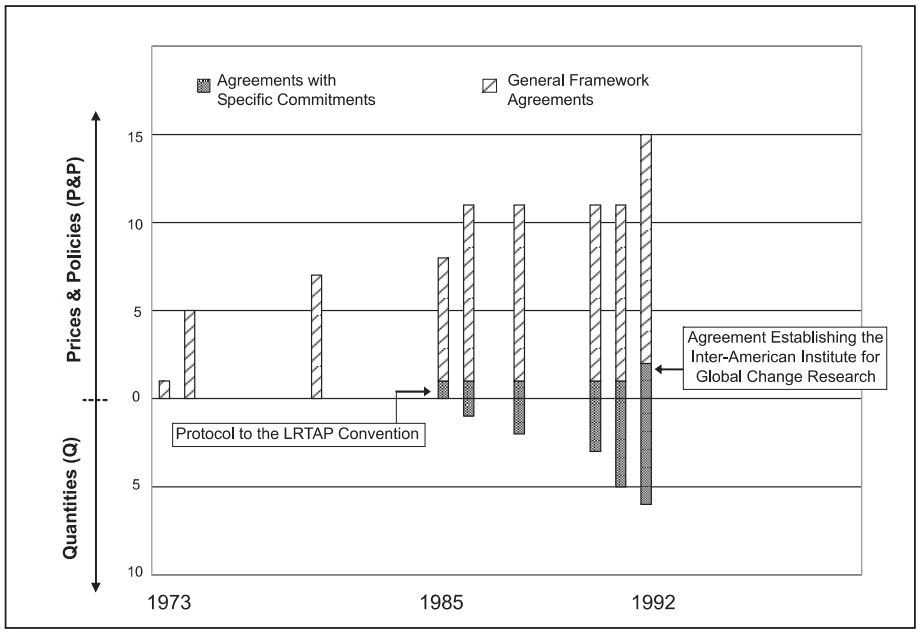
specific commitments that take the form of P&P instruments rather than quantity limitations—actually concerns regulation of an air pollutant. Rather, they both provide ancillary services to air pollution agreements—in the former case, the other protocols to the LRTAP Convention (all of which contain quantity instruments), and in the latter case, the international attempts to address global warming.

In short, all the experience in the body of more demanding international air pollution law leads to a herd of agreements that regulate quantities.

The Micro Perspective

Now we turn to the cluster of agreements related to the ozone layer—the 1985 Vienna Convention for the Protection of the Ozone Layer and the 1987 Mon-

Figure 5
Specific vs. General Agreements



Notes: Coding the CIESIN data once more—this time for the specificity of each transboundary air pollution agreement—reveals the real story: the practice of international environmental diplomacy favors the use of pricing and policy (P&P) instruments for general agreements, and quantity instruments are used in nearly all cases where countries agree to specific (usually more stringent) commitments. Two exceptions prove the rule: the 1984 Protocol to the LRTAP Convention and the 1992 Agreement Establishing the Inter-American Institute for Global Change Research. Both these include specific commitments but do not relate to regulating pollution—rather, they concern the funding of research institutions that provide information to other collective international efforts to address air pollution.

treal Protocol on Substances that Deplete the Ozone Layer with its various amendments and adjustments—that are widely seen as the most effective examples of international environmental law and also used as the central model for the international legal regime on global warming.[18] Of course, there are many differences between ozone depletion and global warming. The former involves a relatively small number of producing firms. Once political pressure forced at least a few firms to break ranks and support a shift to (more profitable) substi-

18. For attention to the Montreal Protocol as a model see, e.g., Barrett 2003. For a history of the climate regime that notes the special role of emission caps in the Montreal Protocol as a model for regulating global warming, see e.g., Bodansky 1993.

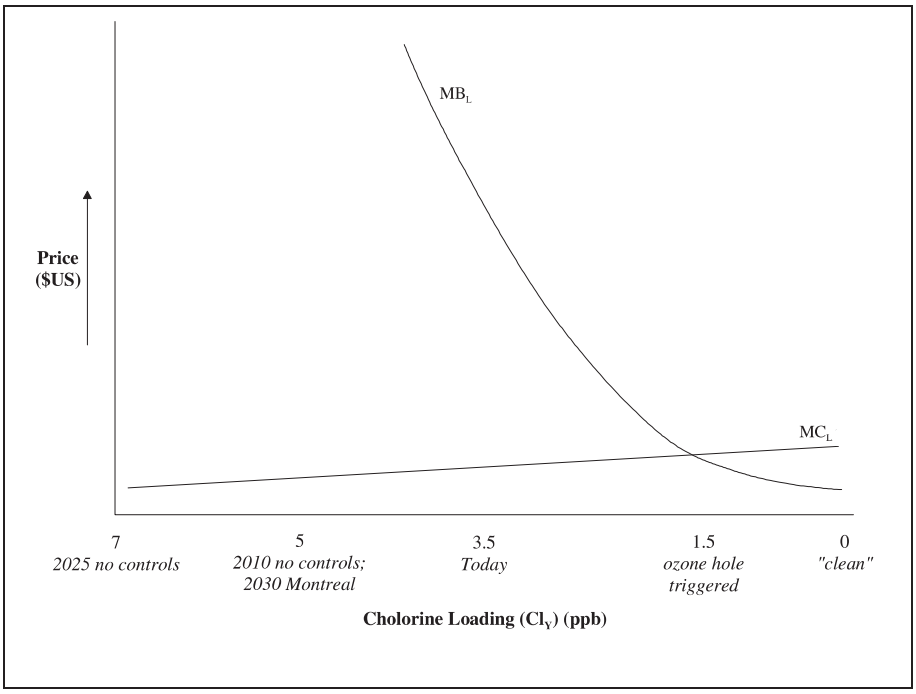
tutes it was easier to turn the rest. The substances that deplete the ozone layer were not integrated into the very fabric of the economy, unlike fossil fuels, and thus regulators could avoid political opposition. The cost of converting from ozone-depleting substances is likely to be orders of magnitude lower than for weaning the modern economy from fossil carbon. Nonetheless, as Richard Benedick has quite rightly pointed out, when negotiators set out to negotiate the Montreal Protocol they did not know that it would prove as easy to conquer in just over a decade the main technological, economic and political barriers to phasing out most ozone-depleting substances.[19] Although the problem of ozone depletion differs from climate change in many ways, what matters for our purposes is the choice between "prices" and "quantities" posed in the Montreal Protocol and the relevance of lessons from that experience for the problem of climate change.

Figure 6 shows the long-term analysis of the ozone layer problem, as it is understood today. The vertical axis is price, and the horizontal axis is the level of abatement—measured in the total "chlorine loading" of the stratosphere.[20] The actual damages from ozone depletion are not well understood, but we show the curve as rising steeply at concentrations above approximately 1.5 parts per billion (ppb), which is the concentration that triggered the early stages of the Antarctic ozone hole. As in the case of global warming, the long-term costs of switching from ozone-depleting substances to more benign substitutes are probably low and flat. These circumstances lead clearly to the preference for a quantity instrument—indeed, the ozone layer problem has been framed as one that requires a complete phase-out of ozone-depleting substances. A phase-out is the ultimate in quantity instruments—if a zero concentration is required to avoid adverse consequences then setting a cap at zero is the best instrument for assuring that the goal is met. (In reality, it might be somewhat more optimal to aim for managing the level of chlorine just below the 1.5 ppb critical level; zero concentration is probably not achievable and surely would be very costly, in part because there are some natural sources of chlorine and in part because a full global phaseout with zero tolerance would be a demanding task.)

The choice of policy instruments requires attention to shorter run analysis because long-term policies are not credible. Figure 7 shows the short-run curves that are probably typical of the 3–5 year periods between each major amendment of the Protocol. Chlorine loading, like the accumulation of CO_2 in the atmosphere, is a stock problem—thus the curve showing benefits (MB_S) is relatively flat. If both MB_S and MC_S are relatively flat and both are uncertain then the best choice of policy instruments is not clear. Since the ultimate objective of policy is complete elimination of ozone-depleting substances, rather than their

19. Benedick 1998.
20. Depletion of the ozone layer is caused by chlorine and several other halogens, notably bromine. The dominant effect is chlorine and thus, for simplicity, we focus on chlorine here. Total loading of chlorine is the sum of all potentially active chlorinated compounds in the stratosphere where the ozone layer is found.

Figure 6
A Long-Term Analysis of the Ozone Layer Problem

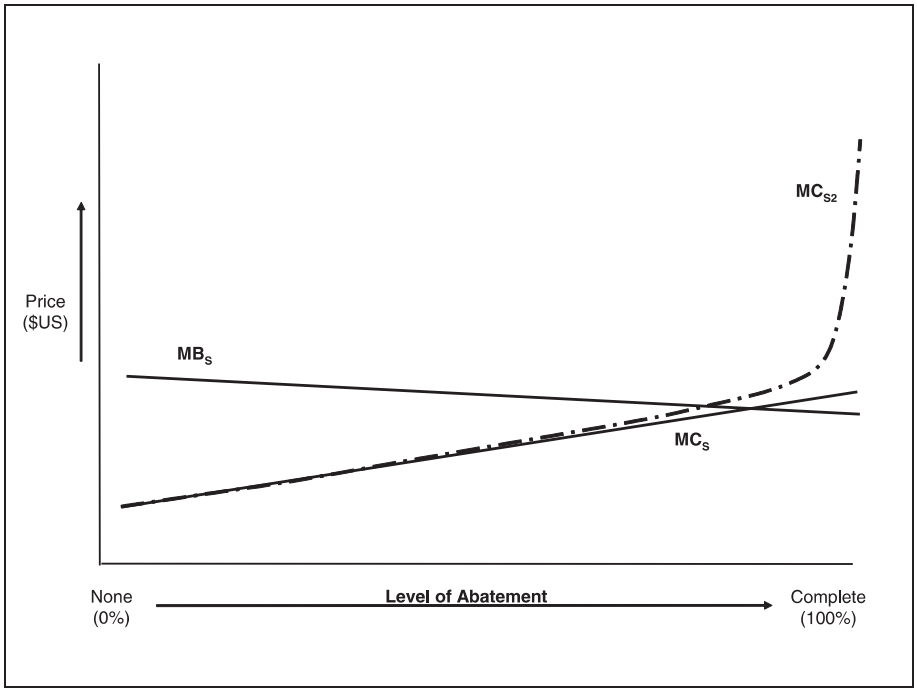


Notes: The vertical axis shows the cost and benefits of emissions abatement. The horizontal axis shows emissions abatement measured by the level of stratospheric chlorine loading in parts per billion. The marginal benefits of abatement (MB_L) rise steeply as chlorine levels (Cl_y) exceed a critical level (about 1.5 ppb)—the level at which springtime ozone holes begin to form—and the long-term costs of regulation are likely relatively low (MC_L). In this context, the problem of the ozone layer is best solved by limiting the quantity of emissions to ensure that the system does not pass this "critical point." For convenience, we show the expected concentration of Cl_y, drawn from scenarios considered during debates over how to strengthen the protocol.

management at some non-zero level, the policy-maker is drawn to a short-term instrument that mirrors the long-term goal: a quantity instrument set at zero emissions. In this sense, the practical policy problem—namely, the short-term analysis—for the depletion of the ozone layer and changing climate have quite different structures. The logical case for regulating quantities in the Montreal Protocol is sound but not overwhelming; the case for using a quantity instrument to slow climate change—where a particular abrupt threshold has not been identified with any certainty—is much weaker.

One similarity between the two problems has gone relatively unnoticed.

Figure 7
A Short-Term Analysis of the Ozone Problem



Notes: Because very little can be done to alter global chlorine levels in a few years, the marginal benefits (MB_s) of abatement remain relatively stable in the short run. So long as the costs (MC_s) remain accordingly low, the ideal policy instrument—prices or quantities—is unclear. But complete abatement could prove exceedingly expensive, thanks in part to certain "essential uses" for which there is no known acceptable substitute. In this case, because it is uncertain exactly when cost would skyrocket, a pricing mechanism is most prudent; a miscalcuation of quantities could prove an expensive error.

In practice, it has not proved easy to eliminate all uses of ozone-depleting substances. In advance of implementing strict quotas on these substances it has proved difficult to know whether substitutes would be available at acceptable cost. Indeed, for some applications such substitutes have proved elusive. The examples include some foams used on the US space shuttle and some laboratory testing equipment. By far, the most important examples are found in metered dose inhalers (MDIs) for asthmatics and others who must inhale medicines. If nations had adopted a simple zero quota for consumption of ozone depleting substances then these special applications would also be affected—a political and economic cost drastically out of proportion to the small benefit that is gained by avoiding these essential uses. In other terms, the marginal cost curve

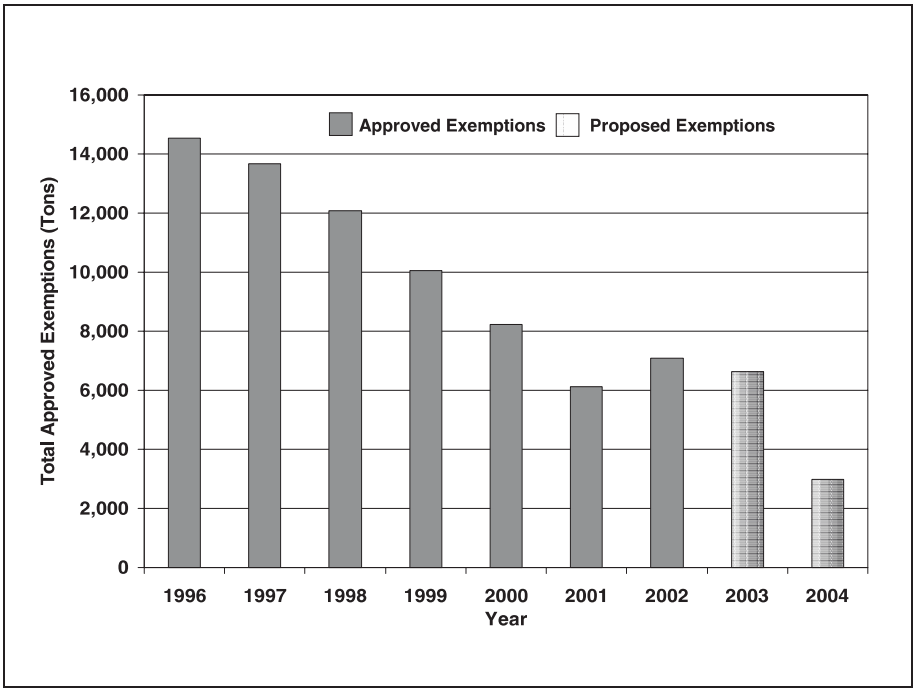
on Figure 7 might be very steep and sharp at values close to a complete phase-out (MC_{S2}). The difficulty in estimating the exact quantity at which MC_{S2} turns skyward would suggest the use of a price instrument so that policy-makers could be sure that their actions would not accidentally impose a cost of regulation that far exceeds the benefits. In the effort to squeeze this last bit of ozone depleting substances quickly from the economy, policy-makers risked creating strong opposing coalitions among astronauts and asthmatics. Since innovation is hard to plan and anticipate on tight timetables, the architects of regulation needed to find a way to avoid the possibility that their rules would create greater-than-acceptable economic and political costs.

Mindful of this problem, the architects of the Montreal Protocol installed a safety valve that prevents the costs from skyrocketing out of control. Every year parties may nominate "essential uses," which an expert committee reviews to help determine which essential uses should be exempted from a nation's total allowable quota of ozone-depleting substances. The expert recommendations on which essential uses should be allowed then frame a final decision by the Meeting of the Parties to the Montreal Protocol, the Protocol's supreme decision-making body. Figure 8 shows the total quantity of essential uses that has been exempted each year, along with proposals for exemptions for 2003 and 2004. The exemption has become progressively tighter as new technologies make some previously "essential" uses now amenable to substitutes. The determination of "essential" is, in essence, one in which the expert review committee draws the line between acceptable and unacceptable cost in requiring the phase-out. For the uses that are nominated as "essential" the Montreal Protocol regime applies an unlimited quota at zero price, but all those uses are "on notice" that they may be rescinded at the next review.[21] Innovators have an incentive to devise and test alternatives in a race to create and serve the market that will exist when the essential use exemption is lifted.

For the part of the ozone regime that is most like global warming in structure, the architects of the regime adopted a system that allows for variable quantities and, in essence, a fixed price—in other words, an instrument focused on the cost of effort rather than a cap on output. The operation of this system—which we believe is essential to maintaining the political and economic viability of the Montreal model—is barely known outside the small cadre of experts who watch closely the events surrounding the Montreal Protocol. Decisions about essential uses are buried in the reports of the Montreal Meetings of the Parties and have not become part of the conventional wisdom about the sources of the treaty's effectiveness. Most observers draw "lessons" from the Montreal experience by looking to the aggressive quotas on consumption of ozone-depleting substances and the fund that compensates developing countries for their costs of meeting the Montreal obligations. Yet the most important lesson for the choice of regulatory instrument, we suggest, leads down a very different path.

21. For more on the operation of these expert assessment committees see especially Parson 2003.

Figure 8
Declining Essential Use Exemptions



Notes: The Montreal Protocol allows for exemptions for certain "essential use" technologies such as metered-dose asthma inhalers and some aeronautical foams. As alternatives become available, countries have been expected to request—and gain approval for—fewer exemptions. Expectations have thus far been met; total exemptions for member parties dropped from just under 14,000 tons in the mid-1900s to around 7,000 tons today, a difference of nearly 50%.
Sources: UNEP Ozone Secretariat (Various Years) and TEAP (Various Years).

4. Conclusions

The choice of regulatory instrument has enormous implications for the political and economic consequences of efforts to manage air pollution. We have reviewed the logic for choosing between "price" and "quantity" instruments and applied it to the international regulation of greenhouse gases. We have suggested a logic that strongly favors the use of a "price" instrument—namely, international rules that specify the level of effort that nations should undertake rather than the output, such as a binding cap on greenhouse gases. Yet nearly all diplomacy on this issue focuses not on "prices" but on binding caps on emission quantities.

We have probed one hypothesis that could explain (at least partly) this mismatch: a herd mentality in the practice of international air pollution law that is leading the architects of new agreements to reach for a quantity instrument even when prices would seem more appropriate. In examining the full set of international air pollution agreements we found that both types of instruments—prices and quantities—have been used. However, we found that when the designers of an agreement actually sought to impose specific commitments, rather than broad and symbolic arrangements, they systematically chose quantities.

We also examined the leading model for the Kyoto Protocol: the Montreal Protocol on Substances that Deplete the Ozone Layer. We suggested that the structure of the ozone problem is quite different from global warming because the ozone problem is viewed as one that involves a known threshold effect (the ozone hole) that, in practice, requires a nearly complete phase-out of ozone-depleting substances. Under those conditions, a quantity instrument—namely, a zero quota—is the preferred policy. In contrast, the global warming problem (at present) is seen as one that may involve threshold effects that are still unknown. So far, the objectives in international attempts to slow global warming are merely to slow down the buildup of greenhouse gases at an unspecified rate and perhaps to manage the ultimate concentration at some unknown level. Those characteristics are quite unlike the ozone problem and, when coupled with the uncertain but possibly costly requirements to meet short-term emission goals, suggest that a price instrument should be adopted in the international regime to address global warming.

We also explored the one aspect of the ozone problem that is most similar in structure to global warming: the possibly high cost of rapidly phasing out ozone depleting substances that are deployed in "essential uses" such as metered dose inhalers. Continued use of these substances has little effect on the benefits of controlling ozone-depleting substances because they account for a tiny fraction of total accumulation in the atmosphere, but the high cost of a phase-out that is pushed too rapidly have led to a system of reviewable exemptions that, in effect, cap the cost of complying with the Montreal Protocol obligations.

All told, we suggest that the herd mentality is a plausible explanation for the disconnection between theory and practice. Our test of this hypothesis is hardly complete, and a more rigorous test would examine a wider range of models that comprise the canon of international environmental law, examining the heritage of key choices about regulatory instruments and perhaps the socialization of the community that designs such agreements. Nor is our herd hypothesis the only one; perhaps, for example, quantity instruments prevail because they are always superior. Or, perhaps emissions caps are easier to describe to the public, which could ease the political task of imposing costly policies.

22. Victor and Coben 2003.

Such alternative hypotheses, several of which we suggest elsewhere, deserve the attention of analysts.[22] Mindful of these caveats, we nonetheless suggest that the herd is in stampede for quantities. There appears to be an urgent need to articulate the wisdom and practical designs for effort-based regulatory instruments if theorists who champion such ideas are to see their concepts put into practice.

Appendices

Appendix I

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean 5 September 2000	2000	
Lei de Crimes Ambientais 12 de fevereiro de 1998 [Act Establishing Sanctions against Environmental Illegal Activities 12 February 1998]	1998	
Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area 24 November 1996	1996	
Resolução Conama Nfl 009, de 24 de outubro de 1996 [Resolution Conama No. 9 Protecting Forests between Primordial Atlantic Forests 24 October 1996]	1996	
Resolução Conama Nfl 010, de 24 de outubro de 1996 [Resolution Conama No. 10 Establishing Protected Areas for the Laying Down of Marine Turtles' Eggs 24 October 1996]	1966	
Code of Conduct for Responsible Fisheries 31 October 1995	1995	
Draft Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks 4 August 1995	1995	
Decree Creating the National Program of Biodiversity (1995) in Brazil 29 December 1994 [in Portuguese]	1994	
Law on the Protection of the Wild Fauna and Hunting [Parliament of Albania] 23 November 1994	1994	
United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa 12 September 1994	1994	
Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982—done 28 July 1994	1994	
International Tropical Timber Agreement 26 January 1994	1994	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
North American Agreement on Environmental Cooperation between the Government of the United States of America, the Government of Canada, and the Government of the United Mexican States 1 January 1994	1994	
Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas 29 November 1993	1993	
Agreement Establishing the South Pacific Regional Environment Programme (SPREP) 16 June 1993	1993	
Convention for the Conservation of Southern Bluefin Tuna 10 May 1993	1993	
Adjustments and Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer 23-25 November 1992	1992	X
Annex III to the Protocol of 17 February 1978 relating to the International Convention for the Prevention of Pollution from Ships of 2 November 1973 (MARPOL 73/78), as amended on 30 October 1992	1992	
Convention for the Protection of the Marine Environment of the North East Atlantic 22 September 1992	1992	
Niue Treaty on Cooperation in Fisheries Surveillance and Law Enforcement in the South Pacific Region 9 July 1992	1992	
Agenda 21 3-14 June 1992	1992	X
Rio Declaration on Environment and Development 3-14 June 1992	1992	X
Convention on Biological Diversity 5 June 1992	1992	
Act Providing for the Establishment and Management of National Integrated Protected Areas System, Defining Its Scope and Coverage, and for Other Purposes 1 June 1992	1992	
Agreement Establishing the Inter-American Institute for Global Change Research 13 May 1992	1992	X
United Nations Framework Convention on Climate Change 9 May 1992	1992	X
Protocol on Protection of the Black Sea Marine Environment Against Pollution from Land Based Sources 21 April 1992	1992	
(OECD) Control of Transfrontier Movements of Wastes Destined for Recovery Operations 30 March 1992	1992	
Convention on the Transboundary Effects of Industrial Accidents 17 March 1992	1992	
Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes 18 November 1991	1991	X
Protocol on Environmental Protection to the Antarctic Treaty 4 October 1991	1991	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Administrative Order Establishing Protection and Conservation of Philippine Wild Birds, Mammals, and Reptiles 13 September 1991	1991	
Convention on Environmental Impact Assessment in a Transboundary Context 25 February 1991	1991	
(OECD) Recommendation of the Council on the Reduction of Transfrontier Movements of Wastes 31 January 1991	1991	
Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes Within Africa 30 January 1991	1991	
Administrative Order Establishing Guidelines Governing the Confiscation, Seizure, and Disposition of Wild Flora and Fauna Illegally Collected, Gathered, Acquired, Transported, and Imported Including Paraphernalia 1991	1991	
Agreement Between the Government of Canada and the Government of the United States of America on Air Quality 1991	1991	X
Convention for a North Pacific Marine Science Organisation (PICES) 12 December 1990	1990	
International Convention on Oil Pollution Preparedness, Response and Cooperation 30 November 1990	1990	
Cooperation Agreement for the Protection of the Coasts and Waters of the North-East Atlantic against Pollution 17 October 1990	1990	
Agreement on the Organization for Indian Ocean Marine Affairs Cooperation 17 September 1990	1990	
Adjustments and Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer 29 June 1990	1990	X
Agreement on Cooperation in Research, Conservation and Management of Marine Mammals in the North Atlantic 19 April 1990	1990	
Protocol to the Kuwait Regional Convention for the Protection of the Marine Environment Against Pollution from Land-Based Sources 21 February 1990	1990	
Amendment to the Annex to the Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 3 November 1989	1989	
Protocol Concerning Marine Pollution Resulting from Exploration and Exploitation of the Continental Shelf 29 March 1989	1989	
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal 22 March 1989	1989	
Convention on the Regulation of Antarctic Mineral Resource Activities 2 June 1988	1988	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation 10 March 1988	1988	
Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms Located on the Continental Shelf 10 March 1988	1988	
Agreement on the Network of Aquaculture Centres in Asia and the Pacific 8 January 1988	1988	
Act Prohibiting the Catching of Cetaceans in Brazil December 18 1987	1987	
European Convention for the Protection of Pet Animals 13 November 1987	1987	
ASEAN Resolution on Sustainable Development 30 October 1987	1987	
Montreal Protocol on Substances that Deplete the Ozone Layer 16 September 1987	1987	X
Resolutions of the 3rd Meeting of the Conference of the Contracting Parties to the Convention on Wetlands of International Importance Especially as Waterfowl Habitat 5 June 1987	1987	
(OECD) Recommendation of the Council on Further Measures for the Protection of the Environment by Control of Polychlorinated Biphenyls 13 February 1987	1987	
Protocol Amending the 1978 Agreement Between the United States of America and Canada on Great Lakes Water Quality 1987	1987	
Protocol Concerning Cooperation in Combating Pollution Emergencies in the South Pacific Region 25 November 1986	1986	
Protocol for the Prevention of Pollution of the South Pacific Region by Dumping 25 November 1986	1986	
Convention for the Protection of the Natural Resources and Environment of the South Pacific Region 24 November 1986	1986	
Agreement Between the Government of the United States of America and the Government of Canada Concerning the Transboundary Movement of Hazardous Wastes 1986	1986	
International Agreement on the Use of INMARSAT Ship Earth Stations within the Territorial Sea and Ports 16 October 1985	1985	
South Pacific Nuclear Free Zone Treaty 6 August 1985	1985	
ASEAN Agreement on the Conservation of Nature and Natural Resources 9 July 1985	1985	
Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 Per Cent 8 July 1985	1985	X
Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region 21 June 1985	1985	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region, Nairobi, 21 June 1985	1985	
(OECD) Control of Air Pollution from Fossil Fuel Combustion 20 June 1985	1985	X
(OECD) Declaration on Environment Resources for the Future 20 June 1985	1985	X
Vienna Convention for the Protection of the Ozone Layer 22 March 1985	1985	X
1984 Protocol Amending the Interim Convention on Conservation of North Pacific Fur Seals 12 October 1984	1984	
Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Long-Term Financing of Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmissions of Air Pollutants in Europe (EMEP) 28 September 1984	1984	X
(OECD) International Conference on Environment and Economics: Conclusions 21 July 1984	1984	
Protocol to Amend the International Convention on Civil Liability for Oil Pollution Damage 25 May 1984	1984	
Protocol to Amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 25 May 1984	1984	
International Tropical Timber Agreement 18 November 1983	1983	
Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and Other Harmful Substances 13 September 1983	1983	
Supplementary Protocol to the Agreement on Regional Cooperation in Combating Pollution of the South-East Pacific by Hydrocarbons or Other Harmful Substances 22 July 1983	1983	
Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region 24 March 1983	1983	
Protocol Concerning Cooperation in Combating Oil Spills in the Wider Caribbean Region 24 March 1983	1983	
United Nations Convention on the Law of the Sea 10 December 1982	1982	
Protocol to Amend the Convention on Wetlands of International Importance Especially as Waterfowl Habitat 3 December 1982	1982	
Agreement Concerning Interim Arrangements Relating to Polymetallic Nodules of the Deep Sea 2 September 1982	1982	
Benelux Convention on Nature Conservation and Landscape Protection 8 June 1982	1982	
Protocol Concerning Mediterranean Specially Protected Areas 3 April 1982	1982	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Convention for the Conservation of Salmon in the North Atlantic Ocean 2 March 1982	1982	
Protocol Concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency 14 February 1982	1982	
Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment 14 February 1982	1982	
World Charter for Nature 1982	1982	
Agreement on Regional Cooperation in Combating Pollution of the South-East Pacific by Hydrocarbons and Other Harmful Substances in Cases of Emergency 12 November 1981	1981	
Convention for the Protection of the Marine Environment and Coastal Area of the South-East Pacific 12 November 1981	1981	
Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region 23 March 1981	1981	
Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency 21 March 1981	1981	
Convention on Future Multilateral Cooperation in North-East Atlantic Fisheries 18 November 1980	1980	
1980 Protocol Amending the Interim Convention on Conservation of North Pacific Fur Seals 14 October 1980	1980	
Amendment to the Annex to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 24 September 1980	1980	
Convention on the Conservation of Antarctic Marine Living Resources 20 May 1980	1980	
Protocol for the Protection of the Mediterranean Sea Against Pollution from Land-Based Sources 17 May 1980	1980	
(OECD) Waste Paper Recovery 30 January 1980	1980	
Protocol Amending the International Convention Relating to the Limitation of the Liability of Owners of Sea-Going Ships 21 December 1979	1979	
Convention for the Conservation and Management of the Vicuna 20 December 1979	1979	
Convention on Long-Range Transboundary Air Pollution 13 November 1979	1979	X
Convention on the Conservation of European Wildlife and Natural Habitats 19 September 1979	1979	
South Pacific Forum Fisheries Agency Convention 10 July 1979	1979	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Convention on the Conservation of Migratory Species of Wild Animals 23 June 1979	1979	
European Convention for the Protection of Animals for Slaughter 10 May 1979	1979	
(OECD) Assessment of Projects with Significant Impact on the Environment 8 May 1979	1979	
(OECD) Declaration of Anticipatory Environmental Policies 8 May 1979	1979	X
Directive on the Conservation of Wild Birds 2 April 1979	1979	
Amendments to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter Concerning Settlement of Disputes 12 October 1978	1978	
Treaty for Amazonian Cooperation 3 July 1978	1978	
Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution 24 April 1978	1978	
Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency 24 April 1978	1978	
MARPOL Optional Annex Annex IV: Regulations for the Prevention of Pollution by Sewage from Ships 17 February 1978	1978	
Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships (MARPOL) 17 February 1978	1978	
Agreement Between The United States and Canada on Great Lakes Water Quality 1978	1978	
United Nations Conference on Desertification (UNCOD) Plan of Action to Combat Desertification and General Assembly Resolutions 29 August–9 September 1977	1977	
Protocol to the International Convention on Civil Liability for Oil Pollution Damage 19 November 1976	1976	
Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 19 November 1976	1976	
(OECD) Comprehensive Waste Management Policy 28 September 1976	1976	
Convention on Conservation of Nature in the South Pacific 12 June 1976	1976	
Agreement Concerning the Protection of the Waters of the Mediterranean Shores 10 May 1976	1976	
Convention on Conservation of North Pacific Fur Seals 7 May 1976	1976	
European Convention for the Protection of Animals Kept for Farming Purposes 10 March 1976	1976	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Convention for the Protection of the Mediterranean Sea Against Pollution 16 February 1976	1976	
Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft 16 February 1976	1976	
Protocol Concerning Cooperation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency 2 February 1976	1976	
(OECD) Control of Eutrophication of Waters 14 November 1974	1974	
(OECD) Declaration on Environmental Policy 14 November 1974	1974	X
(OECD) Energy and the Environment 14 November 1974	1974	X
(OECD) Implementation of the Polluter-Pays Principle 14 November 1974	1974	X
(OECD) Strategies for Specific Water Pollutants Control 4 November 1974	1974	
Convention on the Prevention of Marine Pollution from Land-based Sources 4 June 1974	1974	
Nordic Environmental Protection Convention 19 February 1974	1974	X
Agreement on Conservation of Polar Bears 15 November 1973	1973	
International Convention for the Prevention of Pollution from Ships (MARPOL) 2 November 1973	1973	
Protocol Relating to Intervention on the High Seas in Cases of Pollution by Substances Other than Oil 2 November 1973	1973	
(OECD) Measures to Reduce All Man-Made Emissions of Mercury to the Environment 18 September 1973	1973	X
Convention on Fishing and Conservation of the Living Resources in the Baltic Sea and Belts 13 September 1973	1973	
(OECD) Protection of the Environment by Control of Polychlorinated Biphenyls 13 September 1973	1973	
Convention on International Trade in Endangered Species of Wild Fauna and Flora 3 March 1973	1973	
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 29 December 1972	1972	
Convention for the Protection of the World Cultural and Natural Heritage 23 November 1972	1972	
Convention for the Conservation of Antarctic Seals 1 June 1972	1972	
(OECD) Environment and Economics Guiding Principles Concerning International Economic Aspects of Environmental Policies 26 May 1972	1972	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft (as amended) 15 February 1972	1972	
International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 18 December 1971	1971	
Amendments to the International Convention for the Prevention of Pollution of the Sea by Oil Concerning the Protection of the Great Barrier Reef 12 October 1971	1971	
Agreement Concerning Cooperation in Taking Measures Against Pollution of the Sea by Oil 16 September 1971	1971	
Convention on Wetlands of International Importance Especially as Waterfowl Habitat 2 February 1971	1971	
Agreement for the Establishment of a Commission for Controlling the Desert Locust in North-West Africa (as amended) 1 November 1970	1971	
Benelux Convention on the Hunting and Protection of Birds (as amended) 10 June 1970	1971	
International Convention on Civil Liability for Oil Pollution Damage 29 November 1969	1969	
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties 29 November 1969	1969	
Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil 9 June 1969	1969	
Vienna Convention on the Law of Treaties 23 May 1969	1969	
European Convention for the Protection of Animals During International Transport 13 December 1968	1968	
European Agreement on the Restriction of the Use of Certain Detergents in Washing and Cleaning Products 16 September 1968	1968	
African Convention on the Conservation of Nature and Natural Resources 15 September 1968	1968	
International Convention for the Conservation of Atlantic Tunas 14 May 1966	1966	
Agreement for the Establishment of a Commission for Controlling the Desert Locust in the Near East (as amended) 2 July 1965	1965	
Convention for the International Council for the Exploration of the Sea (as amended) 12 September 1964	1964	
Agreed Measures for the Conservation of Antarctic Fauna and Flora 2 June 1964	1964	
Fisheries Convention 9 March 1964	1964	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
Agreement for the Establishment of a Commission for Controlling the Desert Locust in the Eastern Region of its Distribution Area in South-West Asia (as amended) 3 December 1963	1963	
Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water 10 October 1963	1963	
Optional Protocol to the Vienna Convention on Civil Liability for Nuclear Damage Concerning the Compulsory Settlement of Disputes 21 May 1963	1963	
Agreement Concerning Cooperation in Marine Fishing 28 July 1962	1962	
Convention of the African Migratory Locust Organization 25 May 1962	1962	
International Convention for the Safety of Life at Sea 17 June 1960	1960	
Agreement Concerning Cooperation in the Quarantine of Plants and Their Protection Against Pests and Diseases 14 December 1959	1959	
Antarctic Treaty 1 December 1959	1959	
Convention Concerning Fishing in the Black Sea (as amended) 7 July 1959	1959	
North-East Atlantic Fisheries Convention 24 January 1959	1959	
Convention on Fishing and Conservation of the Living Resources of the High Seas 29 April 1958	1958	
Convention on the Continental Shelf 29 April 1958	1958	
Convention on the High Seas 29 April 1958	1958	
Convention on the Territorial Sea & the Contiguous Zone 29 April 1958	1958	
Optional Protocol of Signature Concerning the Compulsory Settlement of Disputes Arising out of the United Nations Conference on the Law of the Sea 29 April 1958	1958	
Wages, Hours of Work and Manning (Sea) Convention (Revised), 1958 (No. 109)	1958	
International Convention Relating to the Limitation of the Liability of Owners of Sea-Going Ships 10 October 1957	1957	
Food and Catering (Ships' Crews) Convention, 1946 (No. 68) 24 March 1957	1957	
Interim Convention on Conservation of North Pacific Fur Seals 9 February 1957	1957	
Plant Protection Agreement for the South-East Asia and Pacific Region (as amended) 27 February 1956	1956	
International Convention for the Prevention of Pollution of the Sea by Oil (as amended on 11 April 1962 and 21 October 1969) 12 May 1954	1954	
Accommodation of Crews Convention (Revised) 29 January 1953	1953	

Treaty Name	*Year*	*Agreements Concerning Atmospheric Issues*
International Convention for the High Seas Fisheries of the North Pacific Ocean (as amended) 9 May 1952	1952	
Agreement Concerning Measures for Protection of the Stocks of Deep-Sea Prawns (Pandalus borealis), European Lobsters (Homarus vulgaris), Norway Lobsters (Nephrops norvegicus) and Crabs (Cancer pagurus) (as amended) 7 March 1952	1952	
International Plant Protection Convention 6 December 1951	1951	
Convention for the Establishment of the European and Mediterranean Plant Protection Organization (as amended 18 April 1951 Paris) 18 April 1951	1951	
International Convention for the Protection of Birds 18 October 1950	1950	
Agreement for the Establishment of a General Fisheries Council for the Mediterranean (as amended) 24 September 1949	1949	
Convention for the Establishment of an Inter-American Tropical Tuna Commission 31 May 1949	1949	
General Agreement on Tariffs and Trade (GATT) 1947	1947	
International Convention for the Regulation of Whaling 2 December 1946	1946	
Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere 12 October 1940	1940	

Appendix 2

Treaty Name	*Year*	*Instruments Prices & Policies (P&P) vs. Quantities (Q)*	*Scope Specific vs. General (S/G)*
Adjustments and Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer 23-25 November 1992	1992	Q	S
Agenda 21 3-14 June 1992	1992	P	G
Rio Declaration on Environment and Development 3-14 June 1992	1992	P	G
Agreement Establishing the Inter-American Institute for Global Change Research 13 May 1992	1992	P	S
United Nations Framework Convention on Climate Change 9 May 1992	1992	P	G

Treaty Name	*Year*	*Instruments Prices & Policies (P&P) vs. Quantities (Q)*	*Scope Specific vs. General (S/G)*
Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes 18 November 1991	1991	Q	S
Agreement Between the Government of Canada and the Government of the United States of America on Air Quality 1991	1991	Q	S
Adjustments and Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer 29 June 1990	1990	Q	S
Montreal Protocol on Substances that Deplete the Ozone Layer 16 September 1987	1987	Q	S
Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 Per Cent 8 July 1985	1985	Q	S
(OECD) Control of Air Pollution from Fossil Fuel Combustion 20 June 1985	1985	P	G
(OECD) Declaration on Environment Resources for the Future 20 June 1985	1985	P	G
Vienna Convention for the Protection of the Ozone Layer 22 March 1985	1985	P	G
Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Long-Term Financing of Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmissions of Air Pollutants in Europe (EMEP) 28 September 1984	1984	P	S
Convention on Long-Range Transboundary Air Pollution 13 November 1979	1979	P	G
(OECD) Declaration of Anticipatory Environmental Policies 8 May 1979	1979	P	G
(OECD) Declaration on Environmental Policy 14 November 1974	1974	P	G
(OECD) Energy and the Environment 14 November 1974	1974	P	G
(OECD) Implementation of the Polluter-Pays Principle 14 November 1974	1974	P	G

Treaty Name	*Year*	*Instruments Prices & Policies (P&P) vs. Quantities (Q)*	*Scope Specific vs. General (S/G)*
Nordic Environmental Protection Convention 19 February 1974	1974	P	G
(OECD) Measures to Reduce All Man-Made Emissions of Mercury to the Environment 18 September 1973	1973	P	G

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