

# Global Carbon Pricing

## We Will If You Will

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Includes recent climate policy papers by

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## Purpose

This book is about climate cooperation—what it means, why it’s needed, and how to attain it. The key insight is that national self-interests can be realigned by a well-structured collective agreement. Parties will remain self-interested, but their objectives can be realigned with the public good. This insight appears to have been understood, at least intuitively, by negotiators of the Kyoto Protocol, but, due to repeated, unnecessary failures, it has been lost.

To explain this insight, we must dispense with two narratives about climate negotiations that have become dominant over the last twenty years:

1. Successful negotiations must rely on “ambition”—a code word for altruism.
2. Nations will commit only to what is in their narrow self-interest.

The first over-promises, while the second promises nothing and delivers too little. “Ambition” is not defined, but its use in optimistic exhortations makes it clear that it means more than doing what you would do anyway out of narrow self-interest. In fact, commitments to do only what is best for your own country are now referred to as zero-ambition pledges.

The first narrative, altruistic ambition, grew in dominance as the Kyoto Protocol waned in credibility, and became completely dominant after the Copenhagen debacle. It may have reached its peak in popularity toward the end of 2014, which Christiana Figueres, the UN climate chief, prominently declared to be the “Year of Ambition.” However, as of October 2015, she appears to have decided that self-interest, the antithesis of altruism, is the “most powerful driving force” motivating nations, and warns that this may surprise us. It is a radical departure from the ambition narrative. As she also explains, the pledges for the Paris Conference of 2015 now follow the second narrative precisely.

The United States or China or Tuvalu ... none of them are doing this to save the planet. All of these countries are putting their best foot forward because they understand it's good for their economies. And that is the most powerful driving force — the self-interest of every country is what is behind all of these measures. It's not because they want to save the planet. Maybe it surprises you that I say that. Let's be realistic here.

—Christiana Figueres, Executive Secretary of the UNFCCC  
Interview with [CBS News, 2 October 2015](#)

Her conclusion, “Let’s be realistic,” signals the inevitable victory of narrow self-interest (doing what’s “good for their economies”) over altruistically doing anything because they want to save the planet. Given the nature of the upcoming Paris agreement, she is indeed being realistic.

We first observed such zero-ambition pledging in December 2014 when the Chinese pledged to do exactly what they had previously decided was required to restrain the deadly air pollution plaguing so many Chinese cities. In their announcements at the time, they made no mention of any intended benefit for the climate.

But surely we did not need twenty years of negotiations to convince countries to help themselves and ignore the planet? They’ve been doing this since time immemorial. It seems clear that Figueres feels trapped by the inevitability and immutability of self-interest. This predicament and its solution can be well illustrated with the famous prisoners’ dilemma game. The climate dilemma is just such a game but with more players. In a multi-player prisoners’ dilemma, the players could all cooperate altruistically as in the first negotiation narrative.

However, if any single player decides to defect out of narrow self-interest, that player will be better off. Since, as Figueres pointed, self-interest is the most powerful force among countries, all are likely to succumb to the temptations of narrow self-interest and the group will suffer. Climate change will not be overcome. This is the second and present negotiation narrative.

In the standard prisoners' dilemma game, there is no possibility of the players negotiating a collective agreement, so they are indeed trapped between unrealistic altruism and destructive, narrow self-interest. And these are the only two narratives that present negotiators seem to imagine. But this is a destructive fallacy, because the real world allows for collective agreements.

Elinor Ostrom, the Nobel Prize winning political scientist, has explained how poor communities have, for centuries, invented collective agreements that solve similar common-pool resource dilemmas. In such dilemmas, and also in the Paris negotiation, what is needed is to replace "nationally determined contributions" with collectively determined contributions, in other words, to use a common commitment instead of individual commitments.

The source of the fallacy that no useful collective agreement is possible can be found in the pre-Kyoto assumption that the only meaningful climate commitments are emission-quantity commitments. This is far from true. But environmentalists, oriented toward command-and-control, insisted on quantity. This stymied the Kyoto negotiators who invented ten collective quantity-commitment formulas none of which could gain general acceptance. But they were right to prioritize this effort, and they struggled valiantly. As Ostrom found, to change the self-interest of a group, a common commitment rule is necessary. Unfortunately, the quantity-restriction makes finding an acceptable common rule impossible.

The result was that the U.S., Australia and all developing countries refused any commitment at all. And, when the Kyoto Protocol was up for review, Japan, Canada, Russia, and New Zealand reneged on their past pledges. After another 18 years of searching by academics, still no plausible common quantity-formula has been found. Two decades of failure has led to the now-prevalent belief that no acceptable collective agreements can be found.

But, if we can jettison the dogmatic use of command-and-control, a simple answer awaits. Countries could commit to charge for emissions—to price carbon. The trivial common-commitment formula is already agreed on almost universally. The price charged by each country should equal the agreed-upon global price. No, this is not a global tax on carbon. Any or all countries could use cap-and-trade with a floor price, or combine that with various fossil fuel taxes and a few other measures. All that is required is attaining the right *average* price.

A common commitment says "I will do what is required for the common good as long as you do as well." This type of reciprocity is almost universally what drives human cooperation. It is not new. It is ancient and has now been well documented by the various sciences that study human cooperation. It is universally used by governments when, for example, they fund highways or toxic waste cleanup. It is more difficult to achieve without the strong arm of a government. Explaining how that is done was the entire point of Ostrom's life-long research, and her conclusion was: "trust and reciprocity." Explaining how to apply this to the earth's atmosphere is the purpose of this book.

## Frequently Asked Questions

# About “Global Carbon Pricing”

### **Q1. Does it mean a global tax?**

No. It does not require that any carbon taxes or fossil fuel taxes be implemented. See Q3.

### **Q2. What is it?**

An agreement between countries responsible for most of the world’s greenhouse gas emissions to price their own fossil-fuel emissions at least as high (on average) as the agreed upon global price,  $P$ .

### **Q3. What does “to price their own emissions” mean?**

Quite simply, a country’s average carbon price — carbon revenue per unit emissions — must be at least as high as the global carbon price. The simplest way would be with a carbon tax, which could be used to replace other taxes. Cap-and-trade could also be used, as well as few other methods. Renewables could be given credit based on carbon saved and the global price.

### **Q4. What does “on average” mean?**

Countries could price gasoline at one level, diesel at another and coal at another. All that matters is  $(\text{total carbon revenue})/(\text{total carbon emissions}) \geq P$ . There could even be averaging from one year to the next.

### **Q5. Who would set the global price?**

It would be negotiated by a “coalition of the willing,” AKA a Carbon Club. This will be a group of countries that encompass most emission and are willing to set a reasonably high price.

### **Q6. Why does a price-agreement help?**

It forms a common commitment, so each country in the coalition is saying “We will price carbon at  $P$  if all of you will too.” Read the preface to see how this works.

### **Q7. Is it fair to poor countries?**

A green climate fund is needed, because without one there would be no international payments. This must be a separate but related negotiation. The UNFCC requires “common but differentiated responsibilities.” The global price is the common part and the climate fund is the differentiated part. Read the Introduction, sections 5 and 6.

### **Q8. Why not stick with global cap-and-trade?**

There’s a reason it’s been getting less popular for 20 years. It was accidentally designed to be hard to negotiate. The idea was to make it safe for the climate but risky for countries (see the Introduction, section 8). Global pricing was scientifically designed for cooperation, and it can be adjusted to hit climate targets just as well, probably better, than global cap-and-trade.

### **Q9. Who’s in favor of it?**

Everyone on the list of contributors is in favor of global carbon pricing. The authors have alternative views on how best to implement it.

**For more questions and answers, click [here](#).**

## Preface

# Change the Game

Pledge and review was invented for the UNFCCC by Japan in 1991. And it hasn't changed much since. It's what happened in Kyoto, although they tried hard to avoid that fate—agreeing to do whatever each country wanted. It's what happened under the Copenhagen Accord and the Cancún Agreements. It's happening again in Paris.

At least under Kyoto there was a bit of structure. Countries picked commitment levels relative to 1990. But within the EU, these ranged from a 30% cut to a 40% increase. For Paris, you can pledge almost anything. Then they will review it. That's about it.

Elinor Ostrom, a political scientist, won the 2009 Nobel Prize in economics for her life-long studies of common-pool dilemmas—one of which is climate change. And her work is part of an enormous literature describing hundreds of real-world systems, thousands of laboratory experiments, and a great deal of theory. Certainly the science is primitive by the standards of physics or biology. But is that any reason, after 24 years of failure, to stick with a non-strategy that ignores what we do know about human cooperation?

To save a commons, the users of the commons must cooperate. That requires trust, and trust requires reciprocity—I will if you will, and you will if I will. For a group, especially a group of ten or 100 countries, reciprocity requires a common commitment. Finding that commitment, and finding how to strengthen and stabilize it—that's the job undertaken by this volume. But before you delve into that, we would like to show you a sort of magic trick.

We will now take a group of ten completely selfish individuals, and show you how they cut each other's throats in one game. Then, changing one rule—so they make common commitments instead of individual commitments—you will see those very same people, their temperaments unchanged, cooperate like angels.

You and nine other cut-throat individuals (representing countries) play a game. Each player has \$1,000, of which they simultaneously pledge some part to the common pot. A referee makes sure they honor their pledges. Every dollar (for CO<sub>2</sub> abatement) placed in the pot will be doubled (by climate benefits) and distributed evenly to all players. So putting a dollar in the pot will return 20¢ to each player.

First, in the "individual commitment" game, pledges are independent of those of others. This is the classic public-goods game, and the rational strategy for the narrowly self-interested is to contribute nothing, since this makes a player better off no matter what the others do. The result is the famous tragedy of the commons. Cooperation does not occur, except perhaps on the part of a few committed altruists, who correctly note that if only everyone cooperated, everyone would be better off".

Second, consider the "common commitment" game in which the same players commit to reciprocally match the contribution of others, but that's all. More specifically, suppose the referee simply makes sure that all contribute the amount of the lowest submitted pledge. After enforcing this common commitment, the money is doubled and distributed evenly, exactly as before.

This changes everything. Pledging \$0 will mean simply keeping your \$10, while pledging \$10 could result in ending up with anything between \$10 and \$20, depending on what others pledge. So, even though you are completely selfish, since you cannot lose and could gain by pledging \$10, that's what you would do. So, assuming that all play in their narrow self-interest,

all pledge \$10 and the group's \$10 is doubled and all end up with the maximum amount of \$20.

Because the common commitment protects against free-riding, selfish behavior has been changed from "contribute nothing" to "contribute everything"; the outcome from no cooperation to full cooperation. With the common commitment, all know that "We are in this together."

Of course there's a long way to go before we turn these ideas into a viable climate treaty, but there's something refreshing about seeing that human behavior can be changed without changing human nature, or even attitudes. Those players were just as greedy in the second game as in the first.

In a way, this is an extremely optimistic view. It says, we are not as uncooperative as we have appeared to be for the last 25 years. The problem was just that we were trapped in the wrong game



Walt Kelly, Earth Day, 1971

# Global Carbon Pricing

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# About this eBook: *Global Carbon Pricing*

Edited by

Peter Cramton, Axel Ockenfels and Steven Stoft

September 2015

In early 2014 we asked *Economics of Energy & Environmental Policy* to let us organize a “Symposium” on the design of international climate negotiations. They agreed and on September 1, 2015 published four articles that form the core of this book. Those articles, found below, are by Christian Gollier and Jean Tirole, Joseph Stiglitz, Martin L. Weitzman and ourselves.

Financial support of the German Research Foundation (DFG) through the Research Unit “Design & Behavior” (FOR 1371) is gratefully acknowledged.

We would also like to thank Editor-in-Chief Jean-Michel Glachant and Managing Editor Ilaria Conti for their unwavering helpfulness and encouragement. And we thank the authors for contributing to the Symposium a wonderful set of papers, which reflect a prolonged and informative discussion as well as a tremendous effort.

After getting the symposium underway we have been delighted to secure three more papers by Richard N. Cooper, by William Nordhaus and by Stéphane Dion and Éloi Laurent, and would like to thank them all for their generous efforts and cooperation.

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## Price Carbon — I Will If You Will

David J. C. MacKay, Peter Cramton, Axel Ockenfels & Steven Stoft

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To forge a strong climate accord in Paris, nations must agree on a common goal in everyone's self-interest, say David J. C. MacKay and colleagues.

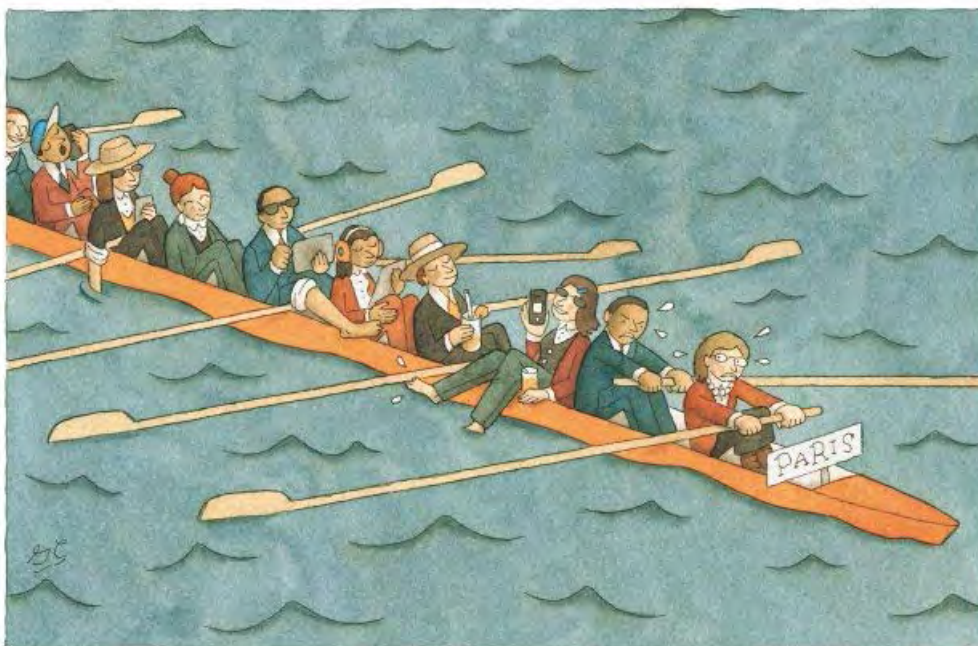


Illustration by Greg Clarke

Negotiations at the United Nations climate summit in Paris this December will adopt a 'pledge and review' approach to cutting global carbon emissions. Countries will promise to reduce their emissions by amounts that will be revised later. The narrative is that this will “enable an upward spiral of ambition over time”<sup>1</sup>. History and the science of cooperation predict that quite the opposite will happen.

Climate change is a serious challenge because the atmosphere gives a free ride to countries that emit. If some nations sit back and rely on others' efforts, the incentives for anyone to act are weakened. Review of the first phase of the Kyoto Protocol at the 2012 UN climate meeting in Doha, for instance, resulted in Japan, Russia, Canada and New Zealand leaving the agreement, frustrating those who kept their promises.

Success requires a common commitment, not a patchwork of individual ones. Negotiations need to be designed to realign self-interests and promote cooperation. A common commitment can assure participants that others will match their efforts and not free-ride. A strategy of “I will if you will” stabilizes higher levels of cooperation. It is the most robust pattern of cooperation seen in laboratory and field studies of situations open to free-riding<sup>2</sup>.

A global carbon price — so far excluded from consideration in international negotiations — would be the ideal basis for a common commitment in our view. A price is easy to agree and handle, relatively fair, less vulnerable to gaming than global cap-and-trade systems, and consistent with climate policies already in place, such as fossil-fuel taxes and emissions cap-and-trade.

Only a common commitment can lead to a strong treaty. Forty years of empirical and theoretical literature on cooperation confirms that individual commitments do not deliver strong collective action. Cooperators find that defectors take advantage of them. Ambition declines when others are revealed to be free-riding<sup>3</sup>. Dishes often stack up in the sinks of shared apartments. But in the Alps, villagers have successfully managed shared land for hundreds of years, with a common commitment governing grasslands<sup>4</sup>.

### **Common commitment**

Imagine that you and nine other self-interested players (representing countries) take part in a game. Each player has \$10, some or all of which they may simultaneously pledge to a common pot. A referee makes sure that they honour their pledges. Every dollar (for carbon dioxide abatement) placed in the pot will be doubled (by climate benefits) and distributed evenly to all players. So putting a dollar in the pot will return 20 cents to each player.

Consider two variants of the game. First, in the 'individual commitment' version, pledges are made independently. This is the classic public-goods game, in which the rational selfish strategy is to contribute nothing, because this makes a player better off no matter what the others do. The result is the famous tragedy of the commons. Cooperation does not occur, even though everyone would gain from it.

Second, in the 'common commitment' version, players condition their contributions on others' pledges: a referee ensures that all contribute the amount of the lowest pledge. After enforcing this common commitment, the money is doubled and distributed evenly, exactly as before.

This changes everything. Pledging \$0 will mean simply keeping your \$10, whereas pledging \$10 could result in ending up with anything between \$10 and \$20, depending on what others pledge. So, because you cannot lose and could gain by pledging \$10, that is what you would do, even if you are completely selfish. Since all parties would pledge \$10, the group's \$100 is doubled and all end up with the maximum amount of \$20.

Selfish behaviour has been changed from 'contribute nothing' to 'contribute everything', because the common commitment protects against free-riding.

In 1997, the Kyoto negotiators initially did try to agree a common commitment, expressed as a formula for national emissions caps, but failed. In the end, each nation was simply asked to submit their final numbers for insertion into the draft annex<sup>5</sup>. The result was a patchwork of weak and unstable commitments. Similarly, in response to the 2009 Copenhagen Accord, China pledged emissions equal to those considered 'business as usual' before the accord; and India pledged even less.

Enforcement is widely thought to be the missing ingredient in the Kyoto Protocol and crucial for the success of a Paris agreement. This is only half right — both enforcement and a common

commitment are required. For example, if drivers chose their own speed limits, there would be no use enforcing them, because everyone would drive at their desired speed. Instead, because it limits others as well, people agree to a common speed limit that is lower than almost everyone's individual limit. In other words, with individual commitments, there is nothing meaningful to enforce, whereas enforcement strengthens a common commitment.

What could all countries commit to? National limits on the quantity of emissions will not work. Kyoto negotiators suggested at least ten formulae to determine the reductions that each nation should make, but could not agree. When attention turned to reducing emissions by some percentage relative to 1990 levels, individual commitments ranged from an 8% decrease to a 10% increase. The United States and developing countries made no commitments at all.

Percentage pledges failed because countries differ; for instance, some economies declined after 1990 and some grew. Developing countries fear caps that curb their growth. Instead they see it as fair to allocate emission permits on an equal per capita basis. Because permit sales would result in huge wealth transfers to poor countries, rich countries find such proposals unacceptable<sup>6</sup>.

There is no longer any serious discussion of a common commitment to reduce the quantity of carbon emissions.

### **Global carbon price**

We, and others, propose an alternative: a global carbon-price commitment<sup>7</sup>. Each country would commit to place charges on carbon emissions from fossil-fuel use (by taxes or cap-and-trade schemes, for example) sufficient to match an agreed global price, which could be set by voting — by a super-majority rule that would produce a coalition of the willing.

A uniform carbon price is widely accepted as the most cost-effective way to curb emissions. Carbon pricing is flexible, allowing fossil taxes, cap-and-trade, hybrid schemes and other national policies to be used (unlike a global carbon tax). All that is required of a country is that its average carbon price — cost per unit of greenhouse gas emitted — be at least as high as the agreed global carbon price.

Unlike global cap-and-trade, carbon pricing allows countries to keep all carbon revenues, eliminating the risk of needing to buy expensive credits from a rival country. Taxes need not rise if a nation performs a green tax shift — reducing taxes on good things such as employment by charging for pollution. Shifting taxes from good things to bad things could mean there is no net social cost to pricing carbon, even before counting climate benefits<sup>8</sup>.

A global price does not automatically result in acceptable burden sharing. A 'Green Climate Fund' will be needed to transfer funds from rich to poor countries. To minimize disputes, the objective of climate-fund transfers should be to maximize the global price of carbon. This can be implemented in a way that encourages rich countries to be generous and poor countries to vote for a higher global carbon price<sup>9</sup>, for example, by making all climate-fund payments proportional to the agreed carbon price.

After decades of failure, a fresh approach is needed — one that is guided by the science of cooperation. A common price commitment would harness self-interest by aligning it with the common good. Nothing could be more fundamental.

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**Chapter 1**  
**A Simple Introduction to**  
**Global Carbon Pricing**

Peter Cramton, Axel Ockenfels and Steven Stoft

October 12, 2015

This introduction covers the basics of global carbon pricing, also known as a global carbon price commitment, and compares it to its two main competitors, the plan for the “Paris Protocol — pledge-and-review, and global cap-and-trade. It also provides some guidance to the papers in this volume, occasionally analyzing parts of them in detail.

Section 1 does not cover global carbon pricing directly. Rather it orients the reader to a different way of thinking about international climate negotiations. For a more direct approach, read the preface or start with “The Solution” in Section 2.

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## 1. The Ambition Distraction and the Science of Cooperation

Christiana Figueres called 2014 the Year of Climate Ambition. Ten thousand UNFCCC web pages tell us ambition is essential for a strong agreement. And the UNFCCC Newsroom informs us that developed countries are expected to lead the global drive to raise ambition. Ambition is what we want. But how do we get it?

Elinor Ostrom, a political scientist, won the 2009 Nobel Prize in economics for a lifetime studying “common-pool resource dilemmas” (such as global warming). She worked in the field, analyzed a thousand field studies by others, did game-theory experiments, and developed her own theories. She never mentions ambition. Instead, in her report on climate policy to the World Bank (2009), she says her research on collective action identifies a “necessary central core of trust and reciprocity.”

In fact, all disciplines dealing with human cooperation find that the reciprocity of a common commitment—“I will if you will”—is the key principle underlying collective human cooperation. Ostrom (Poteete, 2010) goes on to note that “Trust and reciprocity are mutually reinforcing. A decrease in either can generate a downward cascade leading to little or no cooperation.” In other words, insufficient reciprocity will not lead to an “upward spiral of ambition,”<sup>1</sup> as is hoped for with “pledge-and-review” (the approach planned for Paris).

This is the crucial lesson for the Paris negotiations: ambitious aspirations mean little, and trust cannot be legislated, but reciprocity can be designed into a treaty. If that design is effective, trust will follow, and then ambition.

This book is about how to design a climate treaty that builds in reciprocity.

Pledge-and-review omits built-in reciprocity. So it leaves out Ostrom’s “necessary central core.” That’s why pledge-and-review will fail. This is the conclusion of every paper in this book. Instead of ambition, the papers collected here focus on designs that, when put into practice, produce reciprocity.

What Ostrom finds in every successful cooperative system are rules governing everyone’s contributions to, and use of, the common resource. She also finds penalties for breaking those rules. These rules and penalties are the reciprocity mechanisms, and they build trust. Exhortation to be ambitious is helpful but not enough. Common rules and sanctions for breaking them are always required in real-world settings.

### 1.1. Getting Out of the Ambition Trap

So why are negotiators so focused on ambition? There’s no way to know, but when we suggest to people that we should not depend on altruism to fix the climate, but should instead rely on self-interest, they are taken aback. So we explain that self-interest can be aligned with the public good. And they are baffled. That just sounds impossible. But actually, all of them are experts at changing the self-interest of others. They just don’t realize that’s what they’re doing.

That may be why people fall back on ambition. Exhortations to ambition sounds like exhortations to be good, or to have more team spirit. People we talk to seem to believe it’s much easier to get people (and countries) to behave altruistically (like they should) than to change their self-interest. That’s just backwards.

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<sup>1</sup> Ad Hoc Working Group on the Durban Platform. Non-Paper, ADP.2014.6. 7 July 2014.

Reciprocity is what changes self-interest. I will do X for you, if you do Y for me. It is not in your self-interest to hand \$20 to your local cleaners. And it is not in their self-interest to clean your coat. But if you want your coat cleaned and they tell you that would cost \$20, you may well decide to change their self-interest and make them want to clean your coat. Or perhaps that's too much money. So you may negotiate to see if you can change their self-interest at a lower cost. You are good at changing the self-interest of others.

It's trickier for a group to change its self-interests. That requires a special form of reciprocity, a *common* commitment. I will do X, if all of you also do X. (Of course X can be a rule that takes circumstances into account.) And it's trickier still when there is no government to organize or enforce the common commitment. That's why we are publishing a number of papers, and why there are still open questions.

But we know it's possible. Ostrom's central point is that people can self-organize what she calls "self-governance" when there is no government to do it for them. And this can often be better than having it done by a higher government. (However, Ostrom (2012) does not say this is always best: "People want to make me argue that community systems of governance are always the best: I will not walk into that trap.")

At the global level there is no government. The papers in this book discuss how the countries of the world can self-organize a global system of climate *governance* that builds in reciprocity and allows trust to develop. For a global public good, a global governance (not government) is required.

## 1.2. A Polycentric Approach

Ostrom argues that climate change requires a polycentric approach. When asked what that meant, she [replied](#), "Not at a single level. Most of the problems that we face today are difficult and multi-tiered. ... So it's not just local and it's not just global." In spite of this, her World Bank report primarily focuses on non-global approaches. But Ostrom (2009) explains that this imbalance is due to a frustration with the "policy literature," and that it "is not meant to challenge the need for global policies related to climate change."

We believe that all of the authors in this volume agree with Ostrom's (2009) proposal of "a polycentric approach at various levels with active oversight of local, regional, and national stakeholders."

Our point is to hasten and strengthen the largely missing but critical global component to this polycentric system. And we are particularly concerned to address the mispricing of fossil fuels which has caused the bulk of the problem and is continuing to do so.

There are many other aspects of the problem, particularly land use, technological progress, and the dissemination of accurate scientific information, all of which are tremendously important. But there is slow progress on all fronts, and these other approaches will not solve the problem on their own.

We should also note that what is proposed here is fully multi-level, in other words polycentric. There would be an international agreement on price, but each country would decide *all* of the pricing details, what to do with revenues and monitoring and enforcement details. Countries would be free to delegate responsibility to provinces, and provinces could delegate to cities. And most actual change would happen at the local and even individual level.

## 1.3. Free Riding

The atmosphere is a common-pool resource, a type of public good. And so it is susceptible to over-use. Obviously it's a *global* public good. But imagine for a moment that it was not. Imagine



that the US could only damage its own climate, and the same for other countries. What would change? We would still need climate science, and there might still be climate-change deniers running for president of the United States. But there would be no reason for international negotiations. There would be no reason for any other country to be upset with US or Chinese emissions, since they would affect no one else.

So, the entire reason for international negotiations is the public-goods nature of the atmosphere. The essence of a common-pool resource is that everyone has access to the common pool, hence all can over-use it to their own benefit and to the detriment of others. This is the very definition of free riding. So the only reason international negotiations are needed, or make sense, is because of free riding. Nevertheless many forget or deny this basic truth.

### *Deniers of free riding*

Sometimes we have noticed climate advocates denying the importance of free riding. One reason given is that climate deniers make use of the free-riding argument. But your opponent's use of a fact does not make the fact wrong.

Another reason for dismissing the importance of free riders is a simple lack of understanding. One highly placed climate policy expert has argued that free riding means doing little and expecting to "benefit sufficiently from other countries' mitigation." The expert then pointed out that there is not much action so far from which to benefit. In other words, if there are few actions to free-ride on, then free riding can't be a big problem.

This is backwards. The main characteristic of the most severe free-rider problem is that when all try to free ride, there is no one left to give rides. In the most severe version of the free-rider problem, there is no free riding!

But this confusion runs even deeper. As Ostrom notes, the destruction of trust is the most pernicious aspect of free riding. It causes those with no inclination to free-ride to act just like free riders. This is the insidious mechanism that causes the unraveling of cooperation. Here's one way that could happen.

### *One bad apple spoils the whole bunch*

Consider ten equal countries, nine of which do not want to free-ride, but also don't want to be taken advantage of. But one nice, but poor country (a "classic" free rider) will not cooperate even if others do their part. Also suppose that

- One country will tolerate no defecting (free riding) countries
- One will tolerate one defector
- One will tolerate two defectors
- And so on down to the most tolerant country that will tolerate eight defectors.

What happens? Well, the classic free-rider country defects, so the zero-tolerance country defects, so two have now defected, and the country that will only tolerate one defector defects, and so on down to complete unravelling. Even though only one in ten was a free rider in the classic sense of wanting to do nothing, disaster ensued. And notice that, contrary to our highly placed expert, in the end, no one had anyone to free ride on, even though free riding was what caused the whole problem.

This example has only one equilibrium—disaster. A common commitment by itself will not fix this version of the problem, but that coupled with a green climate-fund payment to the poor country could very well work and achieve total cooperation. So reciprocity could still overcome free riding.

In other examples, everyone will cooperate if enough others cooperate. But the world can still get stuck with no cooperation if there's no trust and no reciprocity to start with. But then all it takes is a common-commitment to serve as a coordinating mechanism to shift everyone from no cooperation to full cooperation.

### *Not being a sucker*

Ostrom (2009) described another aspect of the problem in her climate report to the World Bank. "When participants fear they are being "suckers" for taking costly actions while others free ride, more substantial effort is devoted to finding deceptive ways of appearing to reduce emissions while not doing so." This is what pledge-and-review will lead to. The free-rider problem is so essential that at the start of her classic book, *Governing the Commons*, she defines her "central question" as finding out "how a group ... can organize and govern themselves to obtain continuing joint benefits when all face temptations to free-ride."

These are not theoretical judgments. As Ostrom reported, in Törbel, Switzerland, the common-commitment rule is "no citizen can send more cows to the alp than he could feed during the winter," and this is still enforced, by "substantial fines for any attempt by villagers to appropriate a larger share of grazing rights." Those two reciprocity mechanisms prevent free riding and generate trust.

### *What the US Senate understood*

During the Kyoto negotiations, developing countries said "you go first" to the others. And the US Senate voted 95 to zero to say, in effect, "No. You must come along with us. You can't free-ride." Even if this is not what the senators were thinking, there is a profoundly true message in that unprecedented vote. The message is "make a reciprocal deal we can trust."

Some claim the senators' expressions of concern were a cover for baser motives. But suppose that was true of all 95 senators. No one is more calculating and no one listens to the electorate better than professional politicians. When they calculate the same answer 95 to zero, you'd be a fool not to listen. This is what they understood:

Americans have a powerful and abiding fear that they will be taken advantage of in the international arena. They don't trust "foreigners." So do not depend on their altruistic cooperation. They want a reciprocal deal they can trust.

That is the indisputable message of the Senate's vote on Kyoto. That is not just what the Senators said, that is what they were betting their careers on.

And now, in 2015, the main argument in the US against the Iran nuclear treaty is, "you can't trust Iran," or any of our partners in the negotiations—China, France, Russia, the United Kingdom, and Germany. Nothing has changed. But the US is hardly alone in this. During the 2009 Copenhagen climate negotiations China became convinced and angry that the US, Europe and other developed countries were actively trying to turn the developing world against it.

And already, Japan's Paris pledge is [being attacked](#) by the Climate Action Network, a network of more than 950 non-governmental organizations. They claim Japan is "using smoke and mirrors (shifting baselines) to fake ambition." That's a claim of free riding. And [China's pledge](#) is for slightly less than they found they needed to do to curb domestic pollution. And when they announced it, they made no claim that it was motivated by concern for the climate. This may be free riding or fear of it. But we are not blaming China, it's just rational.

### *Ignoring the problem is not solving it*

Without doubt there are many impediments to national climate actions besides free riding. And we are all indebted to those trying to overcome these. But that does not prove that the free-rider problem will not be there waiting for them the next time they approach success.

Those advocating national climate policies face climate-change deniers pointing out that other countries could free ride on our efforts. In defense, they tend to deny the free-rider problem and make up baseless theories, such as Al Gore's notion that "If we lead China will follow." In the long run, it will be far more constructive to solve the free-rider problem—the most central problem of cooperation—rather than to deny there is a problem. Solving the free-rider problem is the heart of the solution proposed in this volume.

## 2. The Problem and the Solution

For twenty years, almost all climate negotiators have agreed on the need for strong climate-change mitigation. There is even a strong consensus that 2°C should be the goal. But this aspiration has not been translated into commitments and actions. The negotiation process has failed.

### 2.1. The Problem

The real problem is not the climate, or the lack of climate-science knowledge, and it's not the lack of a common aspiration or goal. It's not even the lack of blueprints for global action. The trouble is that negotiations end in acrimony or hollow victory statements. So the problem is to find and fix the cause of these negotiation failures.

A better approach to negotiation is needed, and so we have made "how to negotiate," the focus of this volume. This focus requires a distinction that is often overlooked. Two things matter most to the success of a negotiation: what outcome you aim for and how you go about getting there. Everyone knows this, but it is easier to focus on what you want than on how to structure the negotiations. So the "how" part is usually ignored and almost never analyzed systematically. In fact, the "how" part is so important that Weitzman (2014, chapter 5) and Cramton et al. (2012a, 2012b) argue it is decisive. But "what" and "how" are interrelated, and that just adds to the tendency for the "how" part to be forgotten.

Consider free riding. As discussed in the previous section, an agreement that allows free riding will break down. As Ostrom explains, it will "generate a downward cascade leading to little or no cooperation." But she is not concerned with *how* to negotiate so this is purely a consideration of *what* works. But if negotiators see that an agreement allows free riding, that will make it hard to negotiate a strong commitment within that framework. So the *potential* to free-ride—the "what" part—affects the negotiation process—the "how" part.

This is not a general principle. A treaty that will work poorly may be easy to negotiate, because it demands little. And one that would solve the problem brilliantly may be impossible to negotiate because of coordination problems—parties can't agree on who should play which role.

Also, an agreement must cover three separate areas—abatement, burden sharing, and enforcement. It must get the "what" and "how" part right in each area. But to avoid being too ambitious we will mostly leave much of the enforcement question to Nordhaus (chapter 4). This leaves the two closely related areas, abatement and burden sharing. So the challenge is to find a treaty design that solves the free-rider problem for abatement and solves the fair-

burden-sharing problem, and to find a way to negotiate the two solutions that will lead to a strong treaty and not to a deadlock or to weak commitments.

## 2.2. The Pledge-and-Review Non-Solution

Pledge-and-review was first proposed by Japan in a memo to the UNFCCC in 1991, and was much discussed starting in 1992. It is now the model for the hoped-for Paris Protocol. Intended Nationally Determined Contributions (INDCs) are the pledges, and these will be reviewed and, hopefully, upgraded occasionally. These are individual commitments. But the situation is actually much worse than this implies.

The Kyoto Protocol was based on individual commitments, but all countries committed to some percentage emission reduction below their 1990 emissions level. This provided some hope of comparability. But pledge-and-review commitments are quite free-form even for developed countries and entirely free-form for developing countries. This will make them essentially impossible to compare.

Being both individual and non-comparable will open the door wide to free riding. Many countries will do their best either to lock in a free ride, or to prevent others from free riding on them. Either strategy results in weak pledges. Hence we conclude that this approach will fail. For a further discussion, see the papers by Weitzman (chapter 5) and by Gollier and Tirole (chapter 6).

## 2.3. Problems with Cap-and-Trade

Global cap-and-trade, is likely the oldest of the three major approaches, although the early (standard) versions were not global and worked quite differently. There are variations of global cap-and-trade, but we will adhere to the most up-to-date and authoritative one, presented by Gollier and Tirole in this volume.

This approach first negotiates a global cap,  $Q$ , which is a quantity limit on emissions. However, no country is responsible for it, and at this stage, nothing has been decided about how to share responsibility for it. So what looks like simplicity has actually left us in a worse negotiating predicament than the one faced by the Kyoto negotiations. In Kyoto, countries just signed up for whatever abatement reduction they wanted. So naturally they reached agreement, just as they will in Paris with INDCs. But that would not likely work under this new global cap-and-trade approach, because voluntary pledges probably would add up to too more than the agreed  $Q$ . It is easy to be ambitious for the group when choosing  $Q$ , and then easy again to allocate your own country a lot of permits and explain that others should be taking fewer.

To solve this problem, it is necessary to agree on a formula for allocating any  $Q$  that the coalition selects. But in Section 10 we examine the twenty-year search for such formulas and find that little progress has been made. Moreover, since the formula is negotiated after  $Q$  is chosen, every country will evaluate the formula by computing its share of  $Q$  under the formula and judging the formula on that basis. This will make a successful negotiation even more difficult than choosing a formula first (as was tried unsuccessfully in Kyoto).

In addition, we will find in Section 8 that a strong global cap-and-trade would cause enormous trading risks. Concern over such risks will make negotiating a strong treaty even more difficult as poor countries seek large permit allocations for protection. In short, the chances of negotiating a global cap-and-trade agreement appear to have been receding for twenty years, and if a strong agreement were ever implemented, it would almost certainly unravel due to trading risks.

## 2.4. The Solution: A Global Carbon Price Commitment

A global carbon price commitment evolved from the idea of a global carbon tax and (to our knowledge) was first published by Cooper (2008). One key new feature in his paper was the idea that countries could commit to a minimum price and then meet that commitment with either standard cap-and-trade or with fossil-fuel taxes. Compared to a uniform global tax on carbon, this allows tremendous flexibility, which is clearly necessary for political reasons.

When fleshed out, the proposal can be seen quite similar to global cap and trade but with quantities replaced by prices, as is shown in Table 1.

**Table 1. Comparing Global Commitments: Cap-and-Trade versus Carbon Pricing**

Global Commitment	Target	Missed Target? Buy or Sell:	Allowed National Policies
Quantity cap, $Q$	$Q_i = ???$	Emission credits	Everything
Price, $P$	$P_i = P$	Pricing credits	Cap, tax, or similar

Notice that no rule for allocating target  $i$  to country  $i$  is provided. This is missing part of the specification is one of the main criticisms of global cap-and-trade. Also notice that global cap-and-trade allows any national (or regional or local) abatement policy, and hence it does not require the pricing of carbon emissions, while global pricing provide a great deal, but not complete, flexibility.

Besides that flexibility, the paper also suggested the need for some burden sharing. In fact this would appear to be crucial to any effective global climate agreement. Hence the defining features of global carbon pricing can be summarized as follows:

1. Negotiate green-climate-fund payments,  $G_j =$  some formula, for each country  $i$ .
2. Negotiate a global price-floor,  $P(t)$ , to be flexibly met by each country.

The price path,  $P(t)$ , is the “common responsibility” of all countries, while climate-fund payments,  $G_j$ , are their “differentiated responsibilities” under the UNFCCC. It is essential that  $P$  be a common commitment in order so solve the free-rider problem with trust and reciprocity as described by Ostrom. However,  $P$ , could be a flexible commitment, provided all countries are granted the same flexibility. For example, if a country’s price is too low in one year, it could be allowed to buy pricing credits<sup>2</sup> from another country that has over-performed. Also note that  $P(t)$  should be adjusted every five years or so as ambitions increase.

Price is also defined flexibly within a country as total carbon revenues divided by total emissions. And carbon revenues include the market price of freely allocated cap-and-trade permits because these price carbon just as effectively as a tax. Because price is defined in terms of carbon revenue, tax rates on fossil fuels can vary from fuel to fuel and between customer classes.

It is important to negotiate the green climate fund first because the results determine what common price countries will accept. If the climate fund is meager, poor countries will demand a low carbon price, while if it is too generous, rich countries will attempt to stymie the price negotiations. Consequently, in Section 6, we propose that the generosity of the green fund be determined with only one goal in mind—to maximize the global carbon price. To do this is must satisfy both rich and poor reasonably well so that the second-phase, price

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<sup>2</sup> These would likely be carbon-revenue credits, in other words credit of collecting, say, \$ million of revenue from carbon charges.

negotiations will succeed. To arrive at such a fair compromise, we suggest that the generosity of the climate fund be decided by a group of countries that are midway between donors and recipients. These countries will care most about the success of the climate policy and worry least about their climate fund payments, either into or from the fund.

### *Summary*

This completes the sketch of the solution—the path to a strong and negotiable climate treaty. First, a common climate-fund formula is negotiated, guided by the goal of achieving the strongest possible climate commitment. This means it must be seen as reasonably fair by rich and poor alike. Then a common price commitment is negotiated, which prevents free riding.

It would likely be best to start the negotiation process in a small group of big emitters, so that certain basics are agreed on before involving the UN. Of course, it would also be best if the UN proceeded in parallel. And the UN could play a key role from the start by funding a study group within the IPCC to look at the science of human cooperation in common-resource dilemmas.

## 3. A Simple Treaty to Change Self Interest

When it is not kept in check, free riding produces the tragedy of the commons. The Kyoto negotiations looked for a way to keep it in check and failed. But that search was based on good intuition, and the governance concepts explained by Ostrom (1990) were never articulated. So failure led to a permanent loss of understanding. Global carbon pricing searches along a different path, and finds the common commitment that eluded the Kyoto negotiators. This section explains the basic idea of that common commitment and how it defeats free riding.

Few doubt that self-interest is a powerful force. And few believe we can redirect it to solve the tragedy of the commons that now controls climate change. This pessimism is a bit surprising considering the popularity of Elinor Ostrom, who won the 2009 Nobel Prize in economics for explaining how communities, many of them poor, have been doing this for centuries. In keeping with her work, we've argued that a strong climate agreement can be attained by using reciprocity to redirect self-interests towards the common good.

In this section we sketch an ultra-simple climate treaty that demonstrates Ostrom's principles. It begins with an independent-commitment game among ten purely self-interested countries, and argues that they would be trapped as expected by the tragedy of the commons. We then change one rule in the negotiation game and nothing else. The result is that, while the ten selfish countries remain as selfish as ever, they cooperate perfectly. The new rule is a common price commitment.

### 3.1. A Simple Global Climate Model

First we need a simple model of the climate-policy world. If you weight countries by their size (so the little ones don't count much), the average-size country has about one-tenth of the world's population. Imagine then, that the world has ten identical countries. This turns out to be a good first model to use to find out how countries might cooperate or free-ride on each other's efforts.

Suppose that a ton of emissions does \$50 of climate damage to the whole world, but only \$5 of damage to each country. So the world is better off if it stops emissions worth less (in non-climate benefits) than \$50/ton and an individual country is better off stopping emissions worth less than \$5/ton.

A carbon price of \$50/ton will stop emissions that cause a net loss to the world, but a single selfish country will only want to price its carbon at \$5/ton in order to allow local project worth \$6/ton. These bring it a net benefit of \$1, but do \$45 of damage to the rest of the world. Remember that the tax itself does not cost the country anything, it just shifts money around. (From here on we will often drop the per-ton units.)

## 3.2. Two Climate Treaties

### *Enforcement*

Can these ten countries negotiate a strong treaty? The answer is “yes, if there is enforcement.” So assume there will be enforcement, but only of voluntary agreements. We won’t force anyone to comply with an agreement they don’t like. Imagine that if one country reneges, this enforcement will be carried out by the other nine countries (perhaps with trade sanctions). So if you voluntarily sign a deal to cut emissions by 20%, that will be enforced. But if you don’t like the treaty, you can just not sign it, and then nothing will be enforced. That’s pretty mild enforcement—saving face might even be a strong-enough motive to accomplish this. Again we assume that all countries are completely selfish and know that the others are as well.

### *An individual-commitment treaty*

In the spirit of the 2015 Paris conference, all countries could agree to the following Individualistic treaty:

**Individualistic Treaty:** Each country will pledge to implement a carbon price of its choosing.

Of course, this will be enforced as discussed above. There would be long negotiations and discussions first, but nothing would be known for sure until the written pledges are opened simultaneously on the deadline.

Selfish countries would set a carbon price no *lower* than \$5, because that would allow emissions that directly caused them more climate damage than the non-climate benefit they would gain.

So individual pledges made simultaneously will lead to a complete lack of cooperation. This is how it works when there is a tragedy of the commons. And as Ostrom found, it takes reciprocity to prevent this outcome—and that’s missing.

**Outcome:** All countries would pledge \$5; that is, no country would cooperate to address climate change—the same outcome as if there were no negotiations.

### *A common-commitment treaty*

Suppose instead that the ten countries ask their treaty-design team to invent a treaty and a way to negotiate it. The team reports back: Every country should pledge their “conditional price” with the understanding that they will only implement that price if all others pledge that much. Otherwise, they will implement the lowest conditional price pledged by any country. With this treaty design, once the pledges are in, the lowest pledge becomes the common global price commitment. And this will be enforced for all countries, because all have voluntarily agreed to that particular price—the lowest “conditional price” that was pledged. So, as before, any country can pledge zero without any penalty, so it can fully defect.

**Treaty:** Every country agrees to price carbon at the lowest price pledged by any country.

So what will countries pledge? The easiest way to find out is to guess the right answer and then check it. So we guess they will all pledge to price at \$50. If that’s what they did, could any

country make a profit by pledging differently? If they could, they would, so our guess would be wrong. But if they all find that sticking with a \$50 pledge is the best they can do, given that others are doing that, then it makes sense that they would all do that. It's also possible to show that if they starting doing something else, they would want to switch to a \$50 pledge, but that's too much work for this introduction.

So if all pledge \$50, would anyone want to pledge higher? No, because it would make no difference unless others went along (and thereby increased the lowest pledge). We could stop here with our upside analysis, but let's be extra cautious. If others went along, with say a \$60 pledge, that carbon price would stop them from all using a ton of fossil fuel that had a \$59 local benefit. But such a project is good because, with 10 of these there is only \$50 of climate damage per country and they all gain a net benefit by \$9 (a \$59 local benefit and \$50 climate cost). So a \$50 carbon price is as high as anyone would want.

And if all pledge \$50, would anyone want to pledge lower? If someone pledged, \$40, that would be lowest and all would price a \$40. So companies in all countries would emit carbon that only had a \$41 benefit to them (\$1 more than the tax they pay). But with identical countries, all would do this, and again with 10 countries each emitting 1 ton, the damage is \$50 per country, but they only get \$41 in local benefit from burning the fossil fuel. So all would lose.

So \$50 is the best carbon price for the world, and if all countries are forced to have the same carbon price, then it is also the best carbon price for each country.

**Outcome:** All countries would pledge \$50, and that would be the global price of carbon—all countries would fully cooperate to optimally address climate change.

### 3.3. Conclusion

In a simple world with identical, completely selfish countries, and with enforcement of voluntary commitments, we can change the negotiation game and thereby change selfish *behavior*—even though the intention remains selfish. This can be done by introducing a common commitment into the negotiations. This changes the outcome from no cooperation to full cooperation. Note that both a common commitment and some enforcement are required. After discussing some practicalities and fairness, we will return and discuss how to make this simple story more realistic.

## 4. Does Global Cap-and-Trade Price Carbon?

For economists, the central goal of global cap-and-trade, as well as standard, local cap-and-trade has been economic efficiency—its ability to get the job done much more cheaply than traditional command-and-control approaches. It does this by (supposedly) putting a “uniform price” on carbon emissions. Standard cap-and-trade actually does do this—by requiring emitters to have emission permits.

But global cap-and-trade, which works like the Kyoto Protocol, will fail to achieve the central objective of cap-and-trade for the same reason Kyoto did—emitters are *not* required to have permits for their emissions or to price carbon at all. Here we explain this essential flaw in global cap-and-trade and how a global carbon price commitment would avoid this.

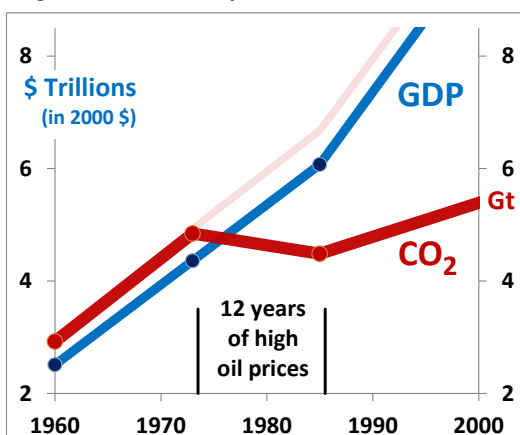


### 4.1. Why Price Carbon?

Until recently, emitting carbon (by which we mean emitting CO<sub>2</sub> from fossil-fuel or certain other easy-to-track greenhouse gasses) has generally been free. Disposing of carbon into the atmosphere, unlike taking your garbage to the dump, had a price of zero. But carbon emissions turned out to have a cost, which is increasing as the concentration of atmospheric carbon increases.

As with any good, when the price is too low, it is overused. However, burning carbon produces valuable services, and the damage from disposal may be only \$30 or \$40 per ton at present. Certainly, no one would suggest we immediately stop driving, heating and using electricity. So we must admit there is a tradeoff. Economics shows that if carbon is correctly priced and we are rational, we will make that tradeoff perfectly. The net benefit (value minus damage) will be maximized. The result won't actually be perfect, but to a good approximation, it will maximize net benefit—carbon benefits minus climate damages.

Figure 1. Oil Price Impact on U.S. CO<sub>2</sub> Emissions



#### Price matters

In 1972 and 1973 U.S. CO<sub>2</sub> emissions rose by 4.6% and 4.2% respectively. In October 1973 the Arabs declared an oil embargo and oil prices rose sharply. In 1974 and 1975 CO<sub>2</sub> emissions declined by 3.5% and 4.2% respectively. As Figure 1 shows, at the end of 12 years—which is when the Saudi's stopped propping up oil prices and took back their market share, emissions were down, not up. Doubters claim this was caused by the introduction of nuclear power, but if all those plants had emitted as much CO<sub>2</sub> as coal plants, emissions would have been only 9% higher and still would have been down, not up, from 1973 levels. In fact even in this fictitious (no nuclear) scenario they would have been down about 37% relative to a trend-line based on GDP. Note also that the decline was not at all caused by a decline in GDP.

Prices work in an uncountable number of ways. For example, US refrigerators were made more efficient. But this was the direct result of work by the brilliant particle physicist Art Rosenfeld, who explained that “I was prompted by the 1973 Organization of Petroleum Exporting Countries (OPEC) oil embargo to switch to improving energy end-use efficiency, particularly in buildings.” That was after he realized “why we in the United States used so much energy; oil and gas were as cheap as dirt or water, and so they were treated like dirt or water.” Art Rosenfeld’s brilliant work on energy efficiency was a direct result of higher carbon prices.

Of course prices also change individual consumer decisions, but it is important to remember their impact on politics, how cars are advertised, regulatory hearings, and the

environmental movement itself. The impact is enormous and most of it is long-run so it is not immediately apparent. This is one reason pricing carbon matters.

### *Why carbon charges are cheap*

It is cheap to price carbon. For simplicity think of a \$100 billion per year carbon tax. How much does that cost the country? The tax itself costs nothing. The money collected is not lost to the country and can either be returned directly to its citizens or used in place of some other tax—as a “tax swap.” As long as revenues are not returned in proportion to the tax collected, the carbon charge will still do its job. For example, if a gasoline tax collects \$500 per person on average, and everyone is given a refund of \$500 regardless of their gasoline usage, every dollar of tax saved by buying less gasoline will be kept, and the incentive to use less is unaffected.

A direct and complete refund is the best way to prove the carbon charge costs nothing. It is also fair, since it is equivalent to saying each person has an equal right to the atmosphere, and those who use more should have to buy extra rights from those who use less, and not just take the rights for free (usually from the poor). Nonetheless, a tax swap will likely be politically more popular and will also demonstrate that the tax itself is free.

There is, however, an indirect and nearly invisible cost to pricing carbon. No matter how it is done, or what is done with the revenues, pricing carbon will cause reduced emissions—abatement. And abatement is costly. It will cost somewhere between nothing and the price of carbon, because there is no use in paying more—it’s better to just pay the charge. So the standard formula for that cost is  $P \times A/2$ , where A is the amount abated. If a \$30 price reduces emissions from 1 billion tons to 0.8 billion, then  $0.8 \text{ billion} \times \$30 = \$24 \text{ billion}$  will be collected in revenue. But since abatement is only 0.2 billion, the cost of abatement will be only  $\$30 \times 0.2/2 = \$3 \text{ billion}$ , eight times less than the carbon revenues collected (and recycled).

So to summarize, the carbon charge itself costs nothing. It just causes money to change hands. But the induced abatement does have a cost. However, people will be quite creative in figuring out how to minimize this cost, and will consider far more possibilities than regulators possibly can. This is what makes carbon pricing much cheaper than regulatory subsidies.

A uniform global carbon price is certainly not a full solution to the climate problem, but it is by far the broadest, simplest and most efficient (cheapest) partial solution. So it should be high, perhaps even highest, on the list of important policies to implement. This is the well-known, traditional economic argument for pricing carbon.

### *A new reason to price carbon*

The point of this section is that global cap-and-trade fails at its mission—pricing carbon emissions. But we don’t want to give the impression that that is the only mission of global carbon pricing, but cause it also fails at an equally important mission that it ignores.

The broken climate negotiations suggest an arguably more important reason to price carbon. As we just saw, free riding and the fear of it have prevented the world from taking meaningful action to limit climate damage. To overcome this problem, we need a common commitment. As it turns out, global carbon pricing makes an ideal common commitment and nothing else seems to work. So this is the new, and probably most important reason, to price carbon. We will return to this in Section 6.

## 4.2. How Can We Price Carbon Emissions?

There are two well-known ways that governments can price carbon emissions: cap-and-trade and taxing fossil fuel. Although both of these could be operated as a global *policy*, this would require complex international institutions that presently seem quite improbable. Cap-and-

trade would require that all emitters in all countries trade permits in one unified market. The EU ETS (emissions trading scheme) is such a policy, but it covers only half of emissions and only exists because the EU has a government, which the world does not. A global tax would require that all fossil fuels be taxed at the same rate. This seems nearly as impossible as global cap-and-trade.

Consequently, it is far more realistic to consider simple global commitments instead of complex global policies. Global cap-and-trade only means committing to a set of country-specific permit allocations and to restricting emission to permits. A global price commitment only means national commitments to a global price. In both cases, countries would choose from such policies as domestic cap-and-trade, the EU ETS, various fossil fuel taxes, and other pricing policies. None of these policies would be governed from the top.

The Kyoto Protocol is a model for global cap-and-trade. It covers a broader territory than the EU, and so the Protocol has no corresponding government. A similar protocol could potentially support a global cap-and-trade treaty. But the Kyoto Protocol is a form of cap-and-trade that *does not price carbon emissions*, and neither would global cap-and-trade. We explain this below.

### *Global cap-and-trade*

The Kyoto Protocol implements a small version of global cap-and-trade, but it does not implement anything like the EU ETS, or California's cap-and-trade, or REGGI in the Northeastern US. All these are markets that require emitters to own carbon permits. They all price carbon emissions. The Kyoto Protocol does not.

Under the Kyoto Protocol, governments, not emitters, must own all the carbon permits for their whole country, even if the government itself were to emit nothing. This creates a disconnection. Kyoto's international carbon permits are called Assigned Amount Units (AAUs). If the AAU market worked (which it does not) and priced AAUs at say \$30/ton, that would not mean that any emitter would be charged \$30 for a ton of carbon emissions. The government must curb emissions, but it can do that however it pleases. It is not required to price carbon. Of course it is allowed to price carbon, and it might do so. But if the EU ETS is any guide, it will not price carbon emissions at the price of international carbon permits—the AAU price.

Suppose a government has 1.2 billion AAUs and its country is emitting only 1 billion tons of carbon. It can sell its 0.2 billion AAUs at the global market price of, say, \$30/ton, and it doesn't need to cut back on its emissions at all. Therefore it has absolutely no need to price carbon. So why is there an almost universal pretense that global cap-and-trade would price all carbon emissions at a uniform AAU price?

In effect, the following is the economic story behind this pretense. The government will freely choose to tax carbon usage at \$30 per ton (the AAU price). It's a clever tax, because it will cause the country to emit less than 1 billion tons, and this will free up more permits, say 0.1 billion more, to sell to other countries. Now the government can sell a total of 0.3 billion permits on the international market for \$9 billion instead of selling 0.2 billion permits for \$6 billion.

It's a nice theory. But for the government, there is a cost to this. It must impose a potentially unpopular carbon tax (or permit requirement) that collects \$30 times 0.9 billion tons, or \$27 billion domestically. And some will ask, Why? Especially when the country has more than enough permits to start with.

It didn't work like the economists' theory predicted under the Kyoto Protocol. Russia and other East-European countries didn't do that. The same theory says that all of Europe would

have done this. But no country did. The EU did implement the ETS and some countries did impose a carbon tax, but not for these reasons. Mainly they chose to subsidize solar and efficiency measures.

This would seem to be a problem for global cap-and-trade advocates who rely on economic efficiency as their premier (and perhaps only) argument for adopting it. For example in their paper below, Gollier and Tirole's Section 2 is entitled "A Uniform Carbon Price Is Necessary," and their subtitle is "Economic approach vs. command-and-control." They then say that a "[global] cap-and-trade mechanism is a prominent strategy for organizing an efficient, uniform pricing of CO<sub>2</sub> emissions." But instead, they find that a command-and-control approach caused "implicit carbon prices" to range from 0 to 1,000 €, instead of being uniform. They note that this substantially "increases the cost of environmental policies," which is a "clear demonstration of the inefficiency of this command-and-control approach." But the command-and-control approach they refer to is largely what happened under the Kyoto Protocol, which is in this context equivalent to the global cap-and-trade approach they are advocating.

In other words, in a major, real-world test of global cap-and-trade, the leading advocates of that approach found that it did not price carbon emissions—it did not come even remotely close to accomplishing its central purpose.

### *A global carbon price commitment*

A global carbon price commitment is a commitment made by countries to price their domestic carbon emissions, on average, at least as high as the agreed global carbon price. Like global cap-and-trade, a global carbon price commitment does not specify national policies. It would allow the EU ETS or fossil taxes, or a combination as actually exists, and various other policies. But unlike global cap-and-trade, a global carbon price commitment will not count pure command-and-control policies. This does not mean countries cannot continue such policies. A global carbon price commitment simply ignores them.

In fact, command-and-control policies could even continue to be part of a separate international pledge-and-review system. Hopefully, the most wasteful of these policies would die out, and the beneficial, well-designed ones that plug holes in the carbon-pricing approach would be retained. (Later we will see that the climate fund used with a global carbon price commitment can provide incentives for good, non-price policies.) A global carbon price commitment would also prominently raise the question of how much it is really costing a country to abate carbon. This will expose the wastefulness of some policies, and we believe this will strongly encourage greater efficiency through the use of price-based approaches.

A strict version of a global carbon price commitment would allow only true carbon pricing, such as cap-and-trade, fossil taxes, and bonus-malus (AKA feebate) pricing schemes. But at the start it will be best, for political reasons, to count renewable energy subsidies as well. These would be credited only for carbon abated and not for the money spent on subsidies. An estimate would be made of the carbon price the country would have needed to abate as much without the renewable subsidies. It would then be credited with that carbon price.

So a global carbon price commitment, while not interfering with command-and-control measures, would actively encourage countries to engage in the efficient carbon pricing (to meet their commitments) that global cap-and-trade claims as its central goal. At first it would likely allow borderline pricing policies (like the renewable subsidies just mentioned), but eventually a global carbon price commitment would become far more efficient than global cap-and-trade is likely to be. But even then, a carbon price commitment will be tremendously

flexible. Different emissions from different fuels and different polluters can be priced differently. Automobile efficiency can be subject to highly effective bonus-malus pricing to address consumer myopia. And of course countries can use cap-and-trade, or even join regional or global cap-and-trade networks. Also price-credits could be traded and banked from one year to the next.

While this flexibility will not lead to a completely uniform price by any means, it should lead to a much more uniform cost of abatement (implicit price) than global cap-and-trade, and it would make sense to put some restriction on the non-uniformity of carbon prices used to meet the global price commitment.

**Figure 2. Pricing of Carbon Emissions**

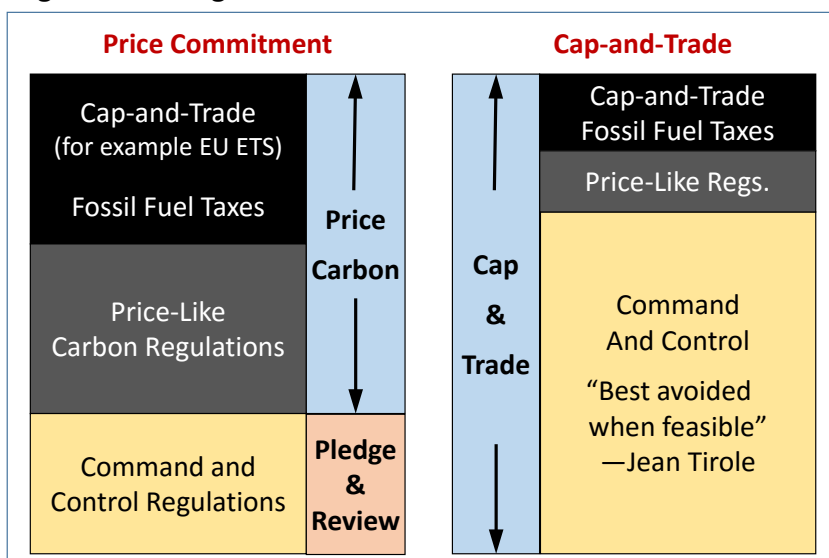


Figure 2 illustrates both the similarities and differences between the two approaches. Both allow all possible climate policies, but global carbon pricing will not count pure command-and-control policies toward the global commitment whereas global cap-and-trade will. Instead carbon pricing will accommodate parallel pledge-and-review commitments, while global cap-and-trade will not. At least for a while at the beginning, policies like subsidies for renewables would have their abatements counted towards pricing. In these ways global carbon pricing will shift the policy mix away from command-and-control and towards pricing carbon emissions (although it will provide some incentive through climate-fund rules for good non-price policies).

The end result will be that global cap-and-trade will do little if anything to price carbon emissions, while global carbon pricing will do much to shift national policies in this direction by only giving credit for true carbon pricing or for a price-equivalent value of measured abatement.

## 5. Fairness

Perhaps the toughest problem for international negotiations is burden sharing. Who will bear the cost of stopping further atmospheric damage? The essence of the problem would seem to be fairness, a subject notoriously susceptible to bias. But the only focal point for fairness is to

divide rights to the atmosphere equally among the entire human population. This is called the “ethical” solution by Gollier and Tirole (chapter 6).

This proposal might be as fair as possible for a simple rule. But there are two decisive arguments against making use of it. First, it will continue to be blocked by a large number of claims for alternative “fair” ways to share the burden. Second, it would surely be blocked by many richer countries.

Because this approach is decisively blocked, we suggest considering a focal principle that is not based directly on fairness but that would nonetheless contain checks and incentives that would pull it substantially toward a fair solution. This principle can be stated as follows.

**Burden-sharing principle:** The costs of improving the climate should be assigned in such a way that the climate is most improved.

This not such a new idea. It has been long employed by Frankel (2014) in his quest for an effective common-commitment formula for the allocation of free carbon-emission permits. It has also been used by Cramton and Stoft (2010, 2012) in their green climate-fund design for a number of years.

This principle has advantages some important. First, its only built-in bias is towards countries that will be harmed most by climate change—since its goal is to maximize climate benefits. In principle this could be problematic. But in reality, there are stronger opposing biases, such as one caused by free riding on future generations.

Second, the principle provides concrete guidance on how to negotiate equity transfers. In the next section we use this principle to help allocate payments into and from the climate fund.

## 6. A More Realistic Treaty Design

We have now demonstrated (in Section 3) how a common commitment to a carbon price could lead to cooperation in a highly simplified model world. That involves a commitment to the lowest pledge submitted, which works perfectly, even though it sounds like a weak approach. From here on we will refer to it as consensus voting because the lowest pledge is also the highest pledge that could elicit a consensus (100%) in its favor. This section introduces the two toughest problems facing climate negotiators:

1. Low motivation
2. Fairness questions

For various reasons, some countries may want to do much less than others; hence they might vote for a carbon price as low as zero. As a result, consensus voting is ruled out as an effective negotiation tool. Second, some countries will need help with the costs of abatement, so a climate fund will need to be included in negotiations.

### 6.1. Preventing Too Low a Price

The first problem, low motivation, arises for several reasons. First, poor countries may heavily discount the future because they are so concerned with the present. Second, some northern countries may be somewhat ambivalent about being warmer. Also, countries that export oil may want the carbon price to be zero because a higher price suppresses the demand for oil and reduces their profits.

Because some countries may want too low a price, the minimum-price rule of the previous section would produce an unacceptably low carbon price commitment if applied to all countries. To fix this, we must limit voting rights by excluding, in some way, the lowest votes from the determination of the global price. This can be done by forming a “coalition of the willing,” which is essentially the same as the idea of a Climate Club suggested by Nordhaus (chapter 4). Such a coalition could be formed through informal negotiation or through a formal voting procedure.

While it is easy to think of a procedure, such as forming the coalition from countries that vote for the highest global price, there are subtle incentive problems with many of these, so an informal procedure may be best. It is clear however, that if the coalition has some power to reward those who cooperate with its pricing policy or punish those who do not, it will be easier to form a large coalition that agrees on a high price. In fact, enforcement is recommended by Nordhaus (chapter 4), Stiglitz (chapter 3) and Tirole (chapter 6).

Fortunately, enforcement may be less necessary than is predicted by standard economics. Ostrom (1990) finds that “the fines assessed in these [common-pool governance] settings are surprisingly low. Rarely are they more than a small fraction of the monetary value that could be obtained by breaking the rules.”

In any case, we will postpone the discussion of enforcement until the next section, and simply assume here that we can form a coalition that excludes uncooperative countries. With this coalition we can use consensus voting to select the highest global price that is acceptable to all.

## 6.2. A Green Climate Fund

The problem of burden sharing has been the most divisive, and was address by UN’s famous phrase, in its Framework Convention on Climate Change (UNFCCC 1992), stating that countries have “common but differentiated responsibilities.” The interpretation of this phrase has been most contentious. A global carbon-price commitment resolves this tension by making carbon pricing the common responsibility of all countries. Differentiated responsibilities are then handled by differing contributions to and receipts from a green climate fund.

Carbon prices should not be differentiated for two reasons. First, this wastes money. More importantly, as demonstrated in the example agreement of Section 3, if coalition members commit to an enforceable common price, this eliminates free riding at least within the coalition. This simplifies the negotiation and greatly strengthens the outcome. Since fixing the 20-year-old negotiation impasse is our primary objective, it’s best not to undo the progress we’ve made so far.

So differentiation of responsibilities should be accomplished with a climate fund and not by differentiating prices. This poses the obvious problem of how much each country should contribute or receive, which could be as complex a problem (although smaller according to Weitzman (chapter 4)) as deciding carbon permit allocations under global cap-and-trade. But just as that problem is solved by replacing individual commitments with a common commitment, so can the climate-fund problem be solved with a common-commitment formula.

The most obvious climate-fund formula was invented independently by both cap-and-trade and carbon-pricing proponents and can be found in Cramton et al. (2010, 2012) and in Gollier and Tirole (chapter 6). Admittedly it is too simple, but it is quite instructive, and

demonstrates most of the good properties that could be approximated with a more realistic formula. The formula is:<sup>3</sup>

$$\text{Payment into the climate fund by country } i, G_i = g \times X_i \times P, \quad (1)$$

where  $g$  is the generosity parameter,  $X_i$  is the excess emissions of country  $i$ , and  $P$  is the global price. Excess emissions are defined as emissions above what would occur if the country had the global-average per capita emissions rate. Negative values of  $G_i$  (resulting from below average per-capita emissions) indicate a payment from the climate fund. Because there is a high correlation between emissions per capita and income per capita, this formula transfers funds from rich to poor countries. However, a realistic formula would need to be a bit more complicated to compensate for various anomalies.

The climate-fund formula has one primary effect and three beneficial side effects.

- Primary effect: because of  $g$ , the formula makes successful negotiations possible.
  1. It provides an incentive for poor countries to vote for a higher level of  $P$ .
  2. It provides every country with an extra incentive to reduce emissions.
  3. It can be used as a friendly enforcement mechanism for compliance with  $P$ .

The primary effect of the formula is to simplify the  $n$ -dimensional problem of negotiating payments for  $n$  countries into a one-dimensional problem of negotiating  $g$ , the overall generosity of payments from rich to poor. While this is essential, the side effects are also surprisingly beneficial and important.

The first side effect, an incentive to vote for a higher  $P$ , is most essential. As already noted, poor countries will tend to favor a low value for  $P$ . The climate-fund formula overcomes this problem, because poor countries see that if the price is doubled, their climate-fund payments will double. This gives them an incentive to pledge and lobby for a higher carbon price,  $P$ .

The second beneficial side effect, an additional incentive to abate, happens automatically because any additional abatement reduces a country's excess emissions. So a rich country would pay less and a poor country would receive more. The third benefit is activated by making a rule that the climate fund is paid only to countries that are in compliance with the global carbon price. This also makes rich countries feel like they are "getting something for their money," which makes these payments more palatable. However, contributions by developed countries still make them less likely to participate, but techniques described below, for maximizing the coalition's chosen price, should still help produce strongest possible price agreement.

### 6.3. How Carbon Price and the Climate Fund Interact

We have now specified a two-phase negotiation process that works as follows:

1. Negotiate climate-fund generosity  $g$  (Payment =  $g \times X_i \times P$ ).
2. Negotiate a "Climate Club" price  $P$  for a "coalition of the willing."

Breaking the negotiation in half, as this does, is enormously beneficial. Otherwise when countries attempt to reduce their own burden, they unintentionally destroy the climate ambition of the treaty. This happens under cap-and-trade negotiations, where individual-

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<sup>3</sup> Gollier and Tirole give the formula in terms of permits, and equation (1) converts it to dollar transfers by using the price of permits.



country permit allocations add up to the total cap. As an additional benefit, these two negotiation phases also interact beneficially. These are the two complementary interactions:

1. The climate-fund negotiation over  $g$  is used to improve  $P$ .
2. Subsequent negotiation over  $P$  makes the  $g$ -outcome acceptable.

To understand interaction 1, note that if too high a level of  $g$  is selected, rich countries will pledge a low  $P$  in order to hold down their payments into the climate fund (see equation 1). Similarly, if too low a level of  $g$  is selected, poor countries will pledge a low  $P$  in order to avoid the abatement costs that come with higher values of  $P$ . So with either extremely-high or extremely-low values of  $g$  (generosity) one group or the other will opt for a very low global price.

If either rich or poor pledge too low a price, the global carbon price will be too low. So, with a coalition of rich and poor, both extremes of  $g$  must be avoided so that neither group will pledge too low. So by setting  $g$  at the right intermediate value, the highest possible price will be agreed on. This is in keeping with the Burden-Sharing Principle suggested earlier.

Consequently, it is best if  $g$  is determined by countries that do not have a conflict of interest regarding climate-fund payments. These will be countries that have near-zero excess emissions and hence participate little in the climate fund. Such countries will be inclined to focus on getting a successful climate treaty with a high carbon price.

The second interaction guarantees that countries in the coalition of the willing will find both their climate-fund obligation and the global price acceptable. If they did not, then they would have pledged a lower value of  $P$  and that value would then have become the coalitions agreed upon value. In the extreme, this could lead to a price of zero and no climate-fund payments, but for two reasons this should not happen. First, the coalition will be selected to contain cooperative countries.

Second, offering the protection of the second interaction will make those selecting  $g$  especially careful to select a reasonable value. The result should be that very few countries feel they need protection from the chosen  $g$ . So they will be willing to vote for a high global price in phase 2 of the negotiations.

#### 6.4. Conclusion

We have considered two factors that tend to weaken a climate treaty, low motivation and fairness questions. Our strategy has been to avoid disrupting the common price commitment that serves to solve the free-rider problem. To maintain this common price, we have separated the “willing” from the unwilling and handled “differentiated responsibilities” with a climate fund.

To simplify climate-fund negotiations, we suggest using a formula, and to make this easier to negotiate we allow countries to opt out of a climate-fund formula they perceive as unfair by not joining the coalition—although there will eventually be some penalties for opting out. This also motivates construction of a fair formula, so that few will opt out.

#### *Why price negotiations work better than quantity negotiations*

Compare this process with negotiating a Kyoto-style treaty. Such a treaty allocates quantities,  $Q_i$ , of free carbon permits to participating countries. These serve double duty. The total of all  $Q_i$  determines world carbon emissions, and individual  $Q_i$ 's determine wealth transfers to each country. If your  $Q_i$  is higher by one ton, you will be richer by the price of a ton of carbon. So

every country will be paid handsomely to negotiate as high a  $Q_i$  as possible—which means every country is paid to do all they can to increase global carbon emissions.

Price negotiations eliminate this incentive to obtain a free ride from the negotiations. Some will see this flexibility and accommodation as a weakness and will want to enforce the “scientifically correct” commitment. This view is backwards. A heavy-handed approach will only produce conflict or, at best, a treaty that quickly unravels. The source of this weakness is the lack of a global government. Given this weakness, procedures that reduce risk and eliminate adverse free-riding incentives will produce the strongest possible sustainable treaty.

## 7. Climate Clubs, Enforcement, and Reciprocity

Some say enforcement is the key to cooperation. This is half true, but we’ve already seen that enforcing independent commitments does not produce cooperation. Think of a road speed limit. If we independently set our own speed limits, there would not be much use enforcing them. But if the limit applies to all, we have good reason to choose a moderate limit, and then enforcement is necessary and effective.

Fortunately, there are gentle types of enforcement, such as “internal enforcement” discussed next, social pressure, and rewards for poor countries that comply with the common commitment. These will be particularly useful at the beginning. The paper in this volume by William Nordhaus discusses Climate Clubs (coalitions) and a strong style of enforcement, but makes little mention of a common commitment. However, as he explains he still considers a common price commitment essential.

No other papers in this volume focus on clubs, but several of the papers agree (and none disagree) that some enforcement, probably trade sanctions, will eventually be necessary. This section shows why Climate Clubs and Carbon Price Commitments are just two different views of the same carbon-pricing-with-enforcement policy, although Nordhaus advocates stronger enforcement than some of the other authors.

### 7.1. Internal Enforcement

Scott Barrett (1994) discusses self-enforcing international environmental agreements, and the first type he discusses uses what Nordhaus refers to as “internal enforcement.” This is a particularly gentle kind of enforcement. To understand it, suppose the world consists of countries that are identical except for their size. This means that if one country is half the size of the other, the larger country will experience twice the climate damage, and if it abates the same amount per capita, it will incur twice the abatement cost. Now suppose that the world has the following cost and benefit functions

$$C = cA^2 \quad B = bA \quad (3)$$

where  $A$  is global abatement,  $C$  is the cost of global abatement, and  $B$  is global benefit from reduced climate damage. Lower case  $c$  and  $b$  are fixed parameters. These are typical assumptions and the ones used by Nordhaus.

In this world, a single country acting on its own will realize that its own abatement will improve the climate and bring it some climate benefit. But most of the benefit of its efforts will accrue to others. As it turns out, if a country is one-tenth the size of the world, it will abate only 1/10 of what would be optimal, and it will do this by setting a carbon price 1/10 as high as it should. Of course the analogous rule holds for any other size country.

### *A coalition of two equal countries*

In a world with the above cost and benefit formulas, would two identical countries be better off if they formed a coalition and made a common commitment? They will realize that a higher price would make more sense than when they acted alone, because if they raise their joint price, they will benefit from their own extra abatement and the same extra abatement from the other country. As mathematics confirms, they will be better off together, even though they spend more on abatement. And neither will want to leave and have their small coalition fall apart.

### *The coalition size limit for internal enforcement*

Sticking with our simple model, if a large country and a tiny country try to form a coalition, the large country will already have a fairly high price, but the tiny country would have a very low price. In an equal-price coalition, that means the little country would have to work much harder, and of course this extra effort would benefit the large country much more than the small one. So tiny countries will not want to form, or stay in, coalitions with large countries. They will prefer to free ride on the large country.

As it turns out, if the small country is bigger than half the size of the large country, it will benefit from joining in a coalition, but if it is smaller, it will lose. Similarly if three identical countries form a coalition, each will view itself as just half as big as the other two put together and will be indifferent about being in the coalition. So three identical countries make a coalition that is just on the brink of falling apart.

If the three differ in size at all, then the smallest will want to leave and free-ride on a coalition of the other two. This is what Nordhaus terms the “small-coalition paradox.” It shows that internal enforcement is not strong enough to realistically hold more than two countries together, which is an argument for common commitments with external enforcement.

## 7.2. A real-world coalition

Fortunately, the real world may be more cooperative than the world of ultra-rational economics. As noted in Section 1, Ostrom found that penalties holding together successful public-goods arrangements were generally much weaker than what could be gained by cheating: There is now much evidence that weak and strong reciprocal interactions stabilize more cooperation than is generally predicted by standard economics that assumes static interaction (see Section 7.4). So let us consider just one possible outcome of this type that could be quite useful for getting started.

If the EU can continue to act as a single country, the world will have three large countries, China, the US and the EU that account for about half of all emissions. Together, these might be a good nucleus for a Climate Club. China, being the largest, would have a positive incentive to stay in the coalition, and the EU would (according to the “small coalition paradox”) prefer to leave and free-ride on China and the US. However, reciprocity, together with face saving and public pressure, may well push Europe into such a coalition. Indeed, the EU has already demonstrated more altruistic behavior than the rest of the world put together.

Also, if the US or China??? So internal enforcement, though not as strong as we need it to be, just might be strong enough to stabilize a coalition covering half of all emissions.

## 7.3. External Enforcement

Although Nordhaus discusses internal enforcement, his Climate Clubs all rely on external enforcement. In particular he favors trade sanctions that are simple yet powerful. These would be employed by Club members against those outside the club. Although some WTO policies

would need to be changed, he advocates placing a tariff of something like 5% on all goods sold by non-members to those in the Climate Club.

This approach is certainly logical in that failing to price carbon is a much larger problem than is indicated by the relatively small amount of carbon embodied in a country's exports. But we would not like to depend on this legally-complex approach to get started, and we do not believe this is necessary. Later, when climate measures need to be stricter, and climate problems are more obvious, this approach may be needed and may be possible.

In the meantime, as was mentioned previously, a substantial climate fund can be made use of as external enforcement, and it would likely be far more acceptable by developing countries. As noted, it would pay climate funds only to countries that meet the common price commitment. Also "internal enforcement" discussed above will help stabilize the initial coalition.

#### 7.4. Reciprocity and Enforcement

Trust and reciprocity are what Ostrom calls the "necessary central core" of successful collective action. Broadly speaking, positive reciprocity means responding kindly to kind actions and negative reciprocity means responding unkindly to unkind actions. Both responses can act as enforcement.

Economics distinguishes two fundamental types of reciprocity, weak and strong. (Both can be positive or negative.) Strong reciprocity refers to actions that are similar to altruism in that they do not serve narrow self-interest and often serve the common good. Weak reciprocity (more common) is motivated by narrow self-interest to gain better treatment by others. This is, of course, the point of any deliberate system of enforcement. Having explained this, we will discuss them all together and call any combination of them simply "reciprocity."

We have suggested several ways of including reciprocity in the design, such as:

1. Coalition members only commit to a price as high as others
2. Poor countries that join the coalition will be rewarded
3. If a county does not join the coalition it could be subject to trade sanctions

This approach to treaty design should not be surprising, since all disciplines dealing with human cooperation find that reciprocity is the key principle underlying cooperation. It is the most robust pattern of cooperation seen in laboratory, field and theoretical studies of free-rider situations, and is consistently found to stabilize higher cooperation levels. This has been thoroughly explained by scholars across all disciplines dealing with human cooperation.<sup>4</sup> Without reciprocity, a public goods dilemma like climate change, will result in the tragedy of the commons.

#### 7.5. Group reciprocity requires a common commit

With only two parties, it is quite common for reciprocity to be asymmetrical—I will fix your sink if you pay me \$100. With three parties it becomes difficult. You may suggest, I will do x, if Alice does y and Charlie does z. But Charlie may think he should do less, and Alice more, which

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<sup>4</sup> E. Ostrom (1990), *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press; D. Fudenberg and J. Tirole (1991) *Game Theory*, Cambridge, MA: MIT Press; S. Bowles and H. Gintis (2013), *A Cooperative Species: Human Reciprocity and Its Evolution*, Princeton University Press; Kraft-Todd et al. (2015), "Promoting Cooperation in the Field", *Current Opinion in Behavioral Sciences*, 3:96–101; see also the references in chapter 3.10.1.4 of the "Mitigation of Climate Change" volume of the Fifth Assessment Report of the IPCC.

would be OK with Alice if you did more too. So the negotiation quickly becomes more complex as the number of parties increases.

Under pledge-and-review, every pledge will be of a different type and all will need to compare the others' pledges to their own. But in reality, they will not find that worthwhile and will just focus on their own contribution. So there will be little if any reciprocity.

The complexity of many individual commitments makes effective reciprocity impossible without a common commitment. This could, in theory, take many forms but none based on emissions quantities have been found to garner even modestly broad support. However, supporters of cap-and-trade and carbon pricing both agree that carbon prices around the world should be equal. That is the entire point of the "trade" in cap-and-trade. And that is all that is needed for a common price commitment—every country should commit to the same price.

## 7.6. Conclusion

Reciprocity is the key to cooperation, and enforcement is a form of reciprocity. To utilize reciprocity in a group, a common commitment is required. As previously suggested this will need to take the form of a global carbon price. Simply agreeing to this common commitment is a form of reciprocity—"I will implement the global price if you will, and I won't if you won't." Trade sanctions and climate-fund payments are negative and positive forms of reciprocity that can stabilize and enlarge a Climate Club or a coalition of the willing.

But there are many other actions, such as tech transfer or informal support in various international forums that could be used informally to help stabilize and strengthen a climate treaty. The real message of this section is that all countries should stop thinking in terms of altruistic climate aid, and think instead about reciprocal actions of many kinds to encourage and stabilize a strong climate commitment. But none of these will work well until we have a global treaty based on common commitments. This is the most fundamental message shared by all experts contributing to this book.

## 8. The Enormous Risk of Trading

We turn now to one of the most serious, but rarely mentioned, problems of global cap-and-trade. So far, all workable forms of global cap-and-trade require long-term allocations of permits to countries, so these must be based on long-term estimates of future business-as-usual emissions. When these estimates prove wrong, countries can find themselves with surprising windfall gains and losses, which have nothing to do with good climate policy.

Global cap-and-trade requires international trading of carbon permits for two reasons. First, some countries need to be given extra permits to sell as a way of reducing their burden. Second, some countries can abate more cheaply, so countries where abatement is more costly can (and should) take advantage of this efficiency gain by buying permits from them. This is equivalent to paying them to abate.

Sometimes we may want to place only a small burden on a country by giving them all the permits we think they will need. However, by accident, we may give them too few permits, which could force them to spend a lot of money buying permits from foreign countries (or abating excessively, which would cost them even more). We call such unnecessary trading "prediction-error" trading.

To understand the following example of prediction-error trading, it is useful to first understand two concepts, business-as-usual emissions and the usefulness of business-as-

usual targets. Such emissions are simply the emissions that would occur without a climate policy. Suppose this is one gigaton per year of emissions. In that case a business-as-usual target gives the country one gigaton of free carbon permits per year. This means that it can ignore this climate policy and continue to emit one gigaton per year with no consequences, because it has enough permits. But if it's smart, it will realize that it can find some very cheap ways to abate more carbon, and by taking these opportunities, it will find it has left-over permits, which it can sell to other countries at a profit. In this way, giving country a business-as-usual target keeps it safe—it can do nothing and have no cost, and also gives it an opportunity to abate and make some profit selling permits.

### 8.1. Jeffrey Frankel on the Safety of Business-as-Usual Targets

Jeffrey Frankel served on the US President's Council of Economic advisors during the Kyoto negotiations. In July 1998 he wrote, "let us consider a plan under which developing countries commit to their 'business-as-usual' emission paths in 2008-2012." He was, however, unsure that the US government would support such a plan since, at that time, cap-and-trade advocates were favoring stricter targets than business as usual.

Then he wrote about countries like China, "The first thing you should notice is that this system is not going to hurt you," and he explained, exactly what we explained above about a business-as-usual target. However his explanation and ours both apply to targets that actually do match business-as-usual emissions, and this is not what his claim of "not going to hurt you" applies to. He was talking about setting a target in 1998 for the Kyoto compliance period of 2008 – 2012, which is what the Kyoto treaty did. So there is no reason to believe there actually would be a perfect match between the so-called business-as-usual target (the allocations of free permits) and the actual future business-as-usual emissions of various countries.

### 8.2. China Comes up 29 Billion Permits Short

Since Frankel mentions China in this discussion, let us look at how China might have fared. The US Department of Energy's *1999 International Energy Outlook* predicted that China's CO<sub>2</sub> emissions in the target years would total 7.5 billion tons. In reality they turned out to be 36.6 billion tons. So China would have been short 29.1 billion permits. At a permit price of \$30/ton they would have had to spend \$874 billion buying permits, mostly from developed countries, had they not cut emissions.

Of course they would have found some emission that could be cut more cheaply than buying permits, so that might have brought the bill down to, say, \$600 billion, but then again, trying to buy an unexpected 20 billion permits from the market might well have sent the price up above \$30/ton. In any case, the Chinese might have taken issue with Frankel's assurance that "this system is not going to hurt you," especial when they realized their rich trading partners would be selling them permits at the marginal cost of abatement, which is always higher than the average cost. Hence, rich countries would have profited from China's bad luck, quite possibly by more than \$100 billion.

### 8.3. Frankel Proposed a Fix and Then Dropped It

To be fair, a few pages after estimating that "If China were to join, it would capture almost \$4 billion a year" in gains from trade, Frankel does warn that, "One problem is the uncertainty of the business-as-usual path. It is difficult to forecast ten years ahead what a country's emissions would be in the absence of policy change."

He then suggests, "I have a possible response to this problem. It is a suggestion to index the emissions target, to such variables as GDP in the year 2007." This would have helped, but

the GDP prediction for 2007 from back in 1999 was only 26% short of the mark, while the CO<sub>2</sub> prediction was 80% low. So the “hurt” would still have been in the hundreds of billions of dollars.

Frankel also suggested, in 1998, that the business-as-usual path could be determined by “objective experts,” which would seem to correspond to the Department of Energy forecast used above. In 2014, when describing his most recent formulas for determining future free permit allocations for a global cap-and-trade system, he suggests that “BAU is defined as the path ... countries would experience in the absence of an international agreement, preferably as determined by experts’ projections.” So 16 years later he has settled on the method (experts’ projections) that produced the 29-billion-ton under-estimate of the business-as-usual (BAU) target, as still the best estimation method he can come up with.

#### 8.4. Risk under a Global Carbon Price Commitment

Suppose that China had agreed to a global carbon price commitment instead of global cap-and-trade in 1999. And let us add some detail that, while speculative, is in no way implausible. Rather it consists of exactly the sort of assumptions the Chinese should have made, and perhaps did make, when determining whether to accept the type of “binding commitment” they were being asked for. Suppose, to make comparison simple, that the *expected* carbon price under either global cap-and-trade or under a comparable global carbon price commitment would have been \$30/ton. Further assume that, given the surprising increase in China’s business-as-usual emissions, the global carbon price under cap-and-trade would have risen to \$45/ton and that a \$30 carbon price would cause 20% abatement and a \$45 price, 30% abatement.

Under either system—a cap or a price—there would be abatement costs, which are reasonably and traditionally calculated with the following cost of abatement formula:  $C = P \times A/2$ , where  $P$  is the carbon price and  $A$  is the abatement.

With this formula we calculate the cost of abatement as \$247 B under cap-and-trade and \$110 under carbon price commitment. But there would still be 25.6 gigatons of unabated emissions under cap-and-trade, only 7.5 of which China would have permits for. So it would have had to buy permits for 18.1 billion tons of emissions at \$45/ton, for a cost of \$817 B, and a total cost under global cap-and-trade of \$1.1 trillion.

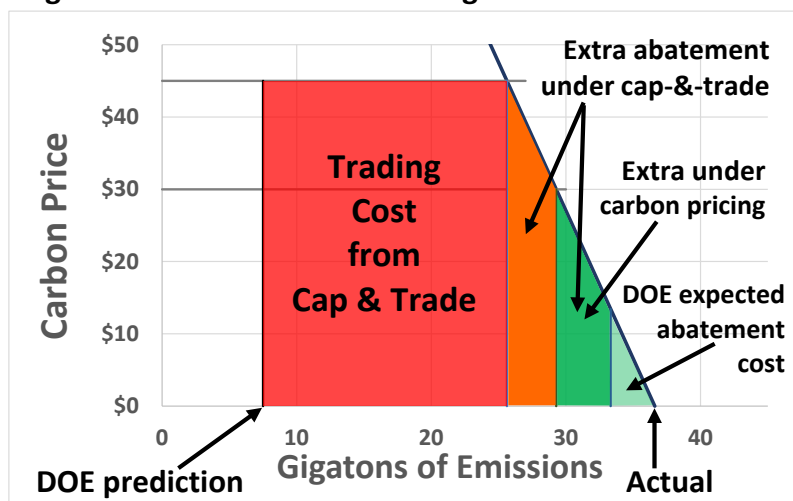
But remember, some abatement cost (\$22 billion) would have been expected under either system if the 1999 emission prediction had been accurate. Under cap-and-trade, the permits for the abated tons could have been sold at a profit of \$44 billion. The net gain (trading cost minus abatement cost under cap-and-trade) would have been \$22 billion. (This is quite close to the gain of “almost \$4 billion a year” for five years mentioned by Frankel and quoted above.) But this is too small to notice given the global cap-and-trade costs of \$1.1 trillion.

The net *unexpected* cost under a carbon price commitment would have been \$110 – \$22 = \$88 billion (unexpected minus expected abatement costs). The final result is that the unexpected cost to China would have been more than 12 times greater under global cap-and-trade than under a matching global carbon price commitment, and it would have been one trillion dollars greater.

It should also be noted that while the unexpected cost of \$88 billion (over 5 years) is still fairly large under a global carbon price commitment, this cost would have gone mainly towards cleaning up their coal industry and solving a major internal pollution problem. The \$817 billion spent on purchasing carbon permits from, say the US and EU, would, on the other hand, have

caused unimaginable domestic political recriminations, had it been carried out. This is illustrated in the following graph.

**Figure 3. Prediction-Error Trading Costs**



In Figure 2, areas represent costs and the sloped line represent the demand-curve for carbon emission. The higher the price of carbon, the lower the emission level. The red rectangle shows the cost to China of purchasing permits after doing extra abatement due to the unexpected \$45/ton cost of permits. China's unexpected abatement cost is the dark-green and orange areas combined. The dark green area is the cost of unexpected abatement under a fixed global carbon price of \$30. The area of the light-green triangle represents the cost of abatement that was expected under either system due to a \$30 carbon price and the DOE-predicted level of emission. (The light green triangle has the right area, but has been moved and reshaped from where its area was calculated—at the DOE prediction.) From China's perspective, abatement costs in the green and orange areas have considerable benefit and hence very low net cost. The trading costs under cap-and-trade are far larger, have no benefit, and carry a considerable political liability.

### 8.5. Conclusion

The above example was not cherry picked. It was picked by a leading advocate of global cap-and-trade, who simply had no idea of what the future would bring. And it should be noted that this is not the only surprising change in business-as-usual emissions we have witnessed. There was also the collapse of the Soviet Bloc and the Fukushima disaster. Global cap-and-trade, is designed so that it turns such unexpected shocks into huge windfall gains or losses, which will inevitably destroy any treaty with an effective carbon price that is based on this approach.

Almost all comparisons of global capping and pricing made by capping advocates have used what is called a "certainty equivalent" model. This ignores all prediction errors as if being right on average was the same as being right all the time. Yet two of the most serious problems with global cap-and-trade are due to price uncertainty and business-as-usual uncertainty. Both of these are rendered invisible by certainty-equivalent models.

In the case of business-as-usual uncertainty, it seems likely that, as Cooper explains, developing countries will all want caps that assume a business-as-usual CO<sub>2</sub> growth rate something like China's just because that might happen and they do not want to be seen as projecting anything less than stellar growth. (Even one US candidate for President is now



projecting 6% annual growth for four-years if elected.) They also do not want to risk having to buy billions of dollars' worth of carbon permits from rich or rival countries. Accepting permit allocations that accommodate such hopes and fears will result in global cap that is far too high to have any significant effect on the climate.

## 9. Does Cap-and-Trade Have a Record of Success?

There are two systems that claim to achieve a fairly uniform carbon price: global cap-and-trade and global carbon pricing. We have already made several comparisons. But one misconception still needs to be addressed. Has global cap-and-trade already been widely implemented and found to work quite well? If so, what is the point analyzing its shortcomings?

The Kyoto Protocol is global cap-and-trade. It allocates international emissions permits (AAUs) and sets up a system for trading them. The argument for trying this was largely that standard cap-and-trade had been tried in the US, and it worked well. In fact it did work well for curbing sulfur emissions. But that argument is without merit. Global cap-and-trade and standard cap-and-trade are fundamentally different.

1. Standard cap-and-trade is run by a government, global cap-and-trade is not.
2. Standard cap-and-trade can subsidize participants by enhancing market power, global cap-and-trade cannot.
3. Standard cap-and-trade prices carbon emissions, global cap-and-trade does not.

The only track record for global cap-and-trade is the dismal record of the Kyoto Protocol.

### 9.1. There's No Government

Under standard cap-and-trade, the government sets and enforces the cap. Under the Kyoto Protocol, since there is no global government, no one even talked about what the cap would be, and no one enforced it. The cap was determined indirectly, not by the Protocol, but by the sum of the AAUs eventually allocated to those who ratified the treaty. This is like having the coal-fired power plants decide among themselves how many sulfur emission permits each would get.

### 9.2. Profits from Permits, but Not for Countries

It is often claimed that global cap-and-trade will be good for hiding transfers from rich to poor, although what is actually meant is that the rich won't notice, but the poor will see exactly what is going on. For example, Gollier and Tirole (chapter 6) say,

*We believe that the transparency issue [the ability to hide transfers] is one of the reasons why many pollution-control programs around the world adopted cap-and-trade and handled the compensation issue through the politically less involved distribution of tradable permits (often in a grandfathered way).*

This is true but could be misleading, because these "pollution-control programs" hide most of their transfers in a way that simply will not work under global cap-and-trade.

Standard cap-and-trade (pollutions-control programs) causes companies to raise their prices (due to the "opportunity cost" of not selling the permits, which we will not explain here). The result is that standard cap-and-trade can actually increase the profits of polluters without any money passing from the government to the polluters. This will not work at all for

international financial transfers. Poor countries cannot profit by raising prices on their own citizens. As Gollier and Tirole point out,

*To be certain, the transfers made under national cap-and-trade programs are different in their economic and political nature from international payments for international permits.*

*... transfers associated with an allocation of free permits are not that hard to compute and one would imagine that politicians (privately or publicly) opposed to an ambitious climate change agreement would quickly publicize the numbers (if unfavorable to the country) so as to turn their domestic public opinion against the agreement.*

In fact, under the Kyoto Protocol, AAU trading became so controversial that Japan had to publicly deny purchasing AAUs from countries previously in the Soviet Bloc (Cramton et al., chapter 8). Obviously, the argument that standard (domestic) cap-and-trade demonstrates that global cap-and-trade can hide transfers from the rich while making them transparent to the poor is highly questionable.

### 9.3. Global Cap-and-Trade Will Not Price Carbon Emissions

Section 4 showed that global cap-and-trade does not *require* countries to price emissions. In reality, under Kyoto, the AAU market was so illiquid and secretive that there was no “market price” and the price of very few transactions was known. So this did not result in any carbon pricing policies at all. The main Kyoto Protocol compliance policies were subsidies and requirements for wind, solar and energy efficiency. These do not put a price on emissions even though the implicit cost of saving carbon ranged as high as 800 euros per ton (Gollier and Tirole chapter 6). *Global* cap-and-trade is unlikely to cause much pricing of carbon emissions, unlike *standard* cap-and-trade that does price carbon emissions.

## 10. Why Global Cap-and-Trade Negotiations Cannot Succeed

The most decisive flaw in global cap-and-trade is that a strong treaty could never be negotiated, and if it could be, it would unravel. There are three main parts to this argument:

1. Trading risk would unravel a strong global cap-and-trade treaty
  - Explained in Section 8
2. Free-style permit negotiations would very likely end in deadlock
  - Even cap-and-trade advocates agree with this
3. No common-commitment formula can be found to replace free-style negotiations
  - A twenty-year search has come up empty handed

Note that we cannot rule out a weak global cap-and-trade agreement—one that has too little impact on the climate to warrant attention. But we ignore this possibility because it is essentially useless and instead focus exclusively on the problems of strong global cap-and-trade agreements.

### 10.1. The risks of Prediction-Error Trading

Section 8 discussed prediction-error trading risk in detail and concluded that unexpected shocks to business-as-usual emissions would lead to defections. This point is not necessary for

the present argument, since we will argue next that a strong treaty could not even be negotiated. But this risk is reason enough not to embark on such an adventure. The cost in time (decades) and effort to put such a system in place should not be squandered on one that would have disintegrated in just ten years had it been built 15 years ago.

We also argued that the knowledge of such individual country risks, would drive the developing countries (and likely others) to demand larger allocations of carbon permits than they will likely need, just to protect against risk (see Cooper 2015). This is a factor, in addition to the ones we are coming to, that will weaken any global cap-and-trade treaty.

## 10.2. Why free-style Negotiations End in Deadlock

As explained by Gollier and Tirole (chapter 6):

*Free-style negotiations among  $n$  countries are exceedingly complex and are very likely to lead to a deadlock ... [concerning] the allocation of free permits among countries under cap-and-trade.<sup>5</sup>*

The extreme complexity they mention is only half the reason deadlock is inevitable, but it is still decisive. Such complexity is obvious from the dozen or so different variables Kyoto negotiators attempted to account for when they tried to invent formulas for allocating permits (Depledge 2000). And many factors were ignored—for example, access to renewable resources.

But Weitzman (2014, chapter 5) and Cramton et al. (2010, 2012) emphasize a different problem with free-style negotiations—free riding. With free-style negotiation of permit allocations, every country's self-interest is to gain more free permits. This dramatically weakens free-style commitments. And as noted, the risks of prediction-error trading will make countries even more aggressive in their demands for free permits.

On top of the free-riding problem of free-style negotiations, we have the extreme complexity noted by Gollier and Tirole, which includes the mixing of climate policy with burden sharing. This will just make it that much easier to find excuses to hide behind when free riding.

But none of these effects leads directly to a deadlock. Instead they seem only to lead to weak national commitments,  $Q_i$ . Since the sum of all such commitments is the global cap  $Q$ , this means there will be a high (weak) global cap.

But Gollier and Tirole make the first step in their negotiation process the selection of  $Q$ , the global cap, and assert that this should be consistent with a 2°C limit. Since the outcome of this negotiation does not commit any country to do anything in particular, all will want to show their “ambition” by agreeing to a very tight cap, probably consistent with the 2°C limit, as has been the case with some previous aspirational agreements.

But with a 2°C cap locked in place, the weak individual-country commitments, which sum to a weak global cap, can now be seen to lead to deadlock. Deciding the global cap by two completely different processes, one that leads to unchecked optimistic aspirations, and one that leads to nearly unchecked self-serving caution, will never produce consistent results. Hence, deadlock is inevitable.

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<sup>5</sup> As they note, this also applies to negotiations over the Climate Fund contributions.

### 10.3. Why a Quantity-Commitment Formula Fails

Successful negotiation requires a common commitment to simplify the process and solve the free-rider problem. But a 20-year of search for a common quantity commitment has turned up no satisfactory proposal. This history of failure is no accident.

The root of the problem is the nature of the quantity approach. Every allocation of free permits plays two contradictory rolls. Permits are money and collectively permits must curb emissions. In “theory” they could do both at once, but that requires the allocation of permits by a world government with perfect foresight.

#### *Kyoto’s Formulas*

The Kyoto negotiations first tried a very simple rule—equal percentage reductions from 1990 emissions levels—and when that failed, they went on to try nine more-complex rules (chapter 8, Depledge 2000). But all of these failed as well, and countries were left to choose their own commitments—a free-style negotiation indeed.

#### *Jeffrey Frankel’s formula*

After Kyoto, it was obvious that no acceptable allocation rule was in sight and that including the developing countries would make finding an acceptable rule far more difficult. It was also obvious from the US Senate’s 95 to 0 vote that without the developing countries the US would not join. Understanding this, Jeffrey Frankel (1998) took up the challenge, and worked on allocation formulas that would be politically acceptable. These evolved over the next 16 years and are quite sophisticated (Bosetti and Frankel 2014). They specify free permit allocations in terms of several parameters, including business as usual emissions, emissions in 1990, and for the initial-year formula, emissions in the year the country signs the cap-and-trade agreement. So far, there does not seem to be much interest in these formulas, which may not be as transparent as required for acceptability.

**Figure 4. The Bosetti-Frankel Cap-and-Trade, Common-Commitment Formulas**

$$(\text{LnTarget}_t - \text{lnBAU}_t) = c - \gamma(\text{ln IPC}_t) + \beta(\text{ln emissions}_t - \text{lnBAU}_t) - \beta\lambda(\text{ln emissions}_t - \text{ln emission}_{1990}) \quad (1)$$

$$(\text{LnTarget}_{t+1} - \text{lnBAU}_{t+1}) = c - \gamma(\text{IPC}_t) + \beta(\text{lnBAU}_{t+1} - \text{ln emissions}_{1990}). \quad (2)$$

#### *Arguments that formulas cannot be agreed on*

In 2006, Stiglitz argued that it would be impossible to find a formula for free permits that the world could come close to agreeing on, and Weitzman (chapter 5) has taken a similar position.

#### *Gollier and Tirole’s common-commitment formula*

Having agreed that free-style negotiations will “very likely lead to deadlock” and that this problem must be addressed with a rule—either simple or more sophisticated—Gollier and Tirole (chapter 8) suggest a simple formula for a common commitment, just as a starting point. It is quite useful however for pointing out a fundamental difficulty with permit-allocation formulas.

Although the purpose of the formula is simplification, the task it simplifies is burden sharing. It performs this task by over-allocating permits to poor countries, and under-allocating permits to rich countries. This allows the poor to sell excess permits to the rich and gain from these sales. But it is well known that that such allocation formulas face a dilemma. If they are used as long-run formulas that run for decades without adjustment, they impose the enormous trading risk examined in Section 8. And if they are adjusted every few years they run into the ratchet effect. “The ratchet effect is what plagued the Soviet economy: firms were

reluctant to meet current quotas because of the expectation that the current quotas would be raised tomorrow as a consequence” (Guesnerie 2008).

However, in the present case, Gollier and Tirole seem to hope to avoid this bind by using a short-run formula to allocate a long-run global cap. In this way, it seems at first that frequent adjustments can prevent long-run prediction risks, while the long-run cap prevents the ratchet from weakening global climate policy over time. However, as will be seen below, the pressures that would otherwise produce a quantity ratchet instead distort the price of permits and result in a loss of control over transfers from rich to poor.

As they point out their formula is very similar to our climate-fund formula in equation (1). Although their compensation formula must specify the allocation of permits (allowances) and not monetary transfers, it is easy to convert to monetary transfers with the formula:

$$G_i = (E_i - Q_i) Pa, \text{ where } Pa = \text{price of allowances.} \quad (2)$$

In other words, a country must buy permits for any emissions,  $E_i$ , that exceed its allocation of free permits,  $Q_i$ , and this cost will flow to countries with extra permits. So, this monetary flow is exactly like a contribution to a climate fund. Using formula (2) we can simplify the Gollier-Tirole formula so that it looks almost identical to our climate-fund formula (1).

$$\text{Climate-fund transfers (1):} \quad G_i = g \times X_i \times Pc, \quad (3)$$

$$\text{Permit-transfer compensation:} \quad G_i = g \times X_i \times Pa, \quad (4)$$

Formula (3) is the same as (1) with  $Pc$  just denoting the price of carbon emissions more explicitly to avoid confusions with  $Pa$ , the price of carbon allowances. Formula (4) is Gollier and Tirole’s formula expressed in terms of money instead of permits. (Recall that  $X_i$  is the excess emissions of country  $i$ .)

Gollier and Tirole say this is an “atemporal approach” taken for the sake of simplicity. Such a timeless approach tends to obscure its most problematic features. There are two possible interpretations of “atemporal” in this context. It could mean a static formula based on perfect foresight, or it could mean a formula that adjusts frequently (perhaps annually) as  $X_i$  changes.

In its original form, it is clear that with  $g = 0$ , countries are allocated permits exactly in proportion to their actual emissions so there is no sharing of the burden on poor countries by rich countries. (And, of course,  $g = 0$  in equation (4) similarly means no transfer payments.) However, with  $g = 1$ , countries are allocated permits in proportion to their population and so there are huge transfers from rich to poor, or so it would seem. As they explain, “So, the ethical approach prevails if  $g$  is close to 1, and the Realpolitik concerns are reflected by a small  $g$  value.”<sup>6</sup>

Somewhat surprisingly this conclusion depends on the meaning of “atemporal.” If it means perfect foresight and an unchanging value of  $X_i$  then their conclusion holds. However as we saw in the section on trading risk, such fixed permit allocation policies are disastrously risky.

It would seem to make more sense to let  $X_i$  adjust annually as is called for in the climate-fund equation (3), but then the generosity parameter in (4) completely fails to do its job, as

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<sup>6</sup> The phrases concerning  $g$  have been adjusted to compensate for that fact that  $g = (1 - \hat{g})$ . The change of notation has no effect other than to give  $g$  the same meaning in equations (3) and (4).

we will now explain. This is the result of global cap-and-trade trying to control climate and compensation policies with one set of parameters. Here's how things go wrong if equation (4) is used with annual adjustments, as would be sensible and as works so well under global carbon pricing.

Consider a purely Realpolitik version of (4) with  $g = 0$ . As noted there would be no compensating (climate-fund) transfers. No country gets extra permits. But if this is to hold year after year, a country that increases its emissions, must be given additional permits to cover the increases. With  $g > 0$ , something similar happens, but fewer free permits are given out to compensate for increased emissions, and with  $g = 1$ , none are given out when emissions increase, because permit allocation is strictly proportional to population.

Unfortunately, giving out permits for increasing emissions makes it cheaper to emit. However, his perverse incentive does not harm the climate because the cap will hold. Instead, a little algebra shows that its effect is to drive the price of permits,  $P_a$ , up above the price of carbon  $P_c$ . In fact the exact result is  $P_a = P_c/g$ . Substituting this into equation (4) we find:

$$\text{Permit transfers:} \quad G_i = 1 \times X_i \times P_c. \quad (5)$$

In other words, when “atemporal” is assumed to mean annual adjustment—a realistic interpretation—the compensation formula devolves into one that always gives the “ethical” level of compensation. In effect,  $g$  always equals one. As Gollier and Tirole point out this is too extreme and will not work.

Compare this to the climate-fund formula (3) when it is used annually. In this case, an increase in excess emissions by country  $i$  leads to an increase in payments ( $G_i$ ) into the climate fund, just as it should. And of course these payments flow to low-emission countries. But if  $g$  is small the increase will be slight and if  $g = 1$  it will rise to the “ethical” level just as Gollier and Tirole hoped for with their formula. And since it tracks actual emission year by year, there is never any risk to those who receive climate-fund payments. There is no chance they will end up like China in Section 8, when they thought they were going to receive green-climate-fund payments. In other words, Gollier and Tirole's formula works just as they would like it to work, while tracking unexpected changes in emissions, if it is used with global carbon pricing.

The main point here is not that a mistake was made—since we do not know how equation (4) was meant to be interpreted. The point is rather that when cap-and-trade attempts to mimic a simple formula that has wonderful incentive properties under global carbon pricing, it ends up stuck between extreme trading risk if it attempts to lock the formula in place, and perverse incentives if it attempts to be reasonably flexible and reduce risks. This is the result of the inherent contradiction of having permit allocations simultaneously serve as wealth transfers and climate ambition.

#### 10.4. Conclusion

The Kyoto negotiators knew they needed a common-commitment formula and invented ten of them. They could not agree on any. After Kyoto, it became clear the problem would become far more difficult because developing countries would need to be included. Realizing this, Frankel began proposing formulas in 1998 that covered all countries. There has not been much interest in these, perhaps because of their complexity, and after 16 years, there seems to be less interest than ever.

In July 2015 Gollier and Tirole proposed a new common commitment formula with one policy parameter that could be set to make anywhere from no transfers to very generous

transfers from rich to poor. They acknowledge that it is too simple, and intend it mainly as an illustration of how global cap-and-trade could solve the problem of free-style negotiations that they agree would lead to deadlock.

Unfortunately, because global cap-and-trade masks subtle economic incentives, this proposal would fail to work as intended. It would either be extremely risky or it would become unrealistically generous by sending permit prices far above the price of emissions. Thus it illustrates the dangers of trying to set climate policy and a fairness agenda with one set of parameters.

The possibility that an easily agreed-upon common-commitment formula for global cap-and-trade will someday be discovered cannot be ruled out with certainty. However, it seems that after twenty years of failure and a general loss of interest, it is time to take global cap-and-trade off the table.

## 11. Problems with Global Carbon Pricing

Although a global carbon price commitment is a more direct and simple approach to carbon pricing than is global cap-and-trade, a strong-enough version of a carbon price commitment will still be difficult to implement. But difficult is better than impossible. Here we examine the points that may need the most attention from negotiators and researchers. The key problem areas are enforcement and climate-fund transfers.

### 11.1. Enforcement

There are always two parts to enforcement, monitoring and incentives. To enforce you must find out if the party is in compliance. That's monitoring. And to get them to comply there must be an incentive to comply. The incentive can be a carrot for compliance or a stick for lack of compliance.

#### *Incentives*

The incentive problem is much the same for any climate commitment. There are social-pressure incentives and there are financial incentives. It is not clear if the former will be strong enough and it is not clear that the latter can be implemented. This is equally true of global cap-and-trade or a global carbon price commitment. But one thing is certain; in either case, the problem is much worse without a common commitment, and as we argued above, such a commitment is almost certainly impossible for global cap-and-trade.

In fact, without a common commitment, strong enforcement is counterproductive. If you think you don't want to drive faster than 70 mph, you might commit to that individually out of a spirit of cooperation with weak enforcement, but with strong enforcement, say a \$10,000 fine, you will certainly not commit to anything under 90 mph, "just in case." So, although enforcement may be hard to arrange, at least with a global carbon price commitment it is of some use and not counterproductive.

#### *Monitoring*

The primary challenge for monitoring price is the possibility that a government will cook its books with regard to revenues collected from carbon charges. For most countries this should not be a problem since they will either provide reasonably reliable public data (most of the Annex I countries under the Kyoto Protocol) or they will be poor countries, that are receiving some climate-fund assistance that can be withdrawn if they do not fully open their books.

For the problematic countries, and there may be a couple of large ones, there are three recourses. First, if they do not open their books to careful auditing, they could be deemed non-compliant regardless of claims concerning carbon revenues. Second, there are four international organizations, the World Bank, the IMF, the IEA, and the WTO, which already conduct similar audits. In fact, such audits would be needed to monitor global cap-and-trade with regard to carbon pricing of exports—one of the most difficult segments of society to monitor. Of course, whichever organization performs this function will need additional funding, but that will be a small burden relative to others.

Finally, the price of most fossil fuels has easily visible public indicators. The price of gasoline is no secret, and that accounts for roughly one third of fossil-fuel use. The price of electricity to residential and commercial users can also be discovered easily, as can the price of heating fuels to these groups. Monitoring will not be perfect, but with a little effort it may well be as good as or better than the monitoring of emissions.

## 11.2. Green Climate Fund Transfers

We have discussed how to allocate responsibility for, and benefits from, a climate fund. But there is a higher-level question that is perhaps just as difficult. How can significant funds be transferred from rich to poor countries without triggering too much political opposition in wealthy countries, especially those on the hook for larger transfers, due to their wealth and high emission levels?

### *Hiding transfers*

One approach is to hide the transfers. This is often cited as a benefit of cap-and-trade, but as explained in Section 9.2 this is largely based on a fallacious analogy between global and national cap-and-trade programs.

However, Frankel suggests that poor countries could be given free permits, and could give them to private companies who would then sell them to private companies in rich countries. In this way the financial transfers would be kept private and less visible than the financial transfers between governments that are generally envisioned for the Green Climate Fund.

This method would not be as surreptitious as it might seem, since companies in the rich country will be required to return the permits to the UN in order to make use of them. And the UN will be required to keep a full accounting. And this will be made public, at which point the press will write stories about how much money went where. It may take a few years before this information is fully utilized by the forces that wish to gain political advantage from stopping the transfers, but that outcome does seem inevitable.

If this ruse is thought to be effective, a similar process could be arranged under a global carbon price commitment. If the US had been allocated a responsibility for \$10 billion of climate fund contributions and the global carbon price was set at \$20/ton, half a billion carbon-price credits could be issued and marked as redeemable in the US only. These could then be distributed to poor countries who would give them to their businesses, who would sell them to US business, who would then not be charged for that many tons of carbon emissions.

One advantage of price-based climate-fund transfers (as opposed to permit transfers under a cap) would be that their value would be far more predictable. For example, with the Gollier-Tirole approach of annual compliance, the carbon price would drop precipitously in the case of a global slowdown. And in this case, permit transfers to poor countries would suddenly become far less valuable and perhaps nearly worthless. On the other hand the global carbon price might spike while a developed country is in recession and it would find itself making



double or triple climate-equity payments at just the wrong time. Such risk would not be present under a global carbon price commitment.

### *Making transfers more appealing*

Jonathan Gruber, an economist who consulted on the design of President Obama's Affordable Care Act, is now famous for explaining that the "Lack of transparency is a huge political advantage" for "getting the bill passed." In the long run—and no policy is longer-run than climate policy—attempting fairly transparent deceptions involving tens of billions of dollars may prove counterproductive. There are better approaches.

The first principle for making equity transfers more palatable is to make sure they are reciprocal. Traditionally this would mean requiring the money be used for some approved "green" project, hopefully, related to climate. Unfortunately, history has shown this leads to corruption—witness the Clean Development Mechanism, the Joint Implementation Mechanism, and even the enormous subsidies for corn ethanol in the United State.

So the basic formula for reciprocity should be that equity transfers are conditional on compliance with either a global cap-and-trade or a global carbon price commitment. This will provide funders with far more assurance that they are getting something worthwhile for their money, and at the same time provide a useful incentive mechanism for enforcing compliance.

There are a number of other standard techniques for making transfers more palatable. One is to require funds be spent in the donor country. This would not be possible with global cap-and-trade. Another way is to earmark tax receipts from the most unpopular domestic polluters to be used for equity transfers.

## 12. Summary and Conclusion

If steady progress was being made with global cap-and-trade, even a promising new approach would seem questionable. But after twenty years of real-world testing and academic theorizing, no obvious progress can be seen. Kyoto has failed and its latest theoretically incarnation, described here by Gollier and Tirole (chapter 6) shows little progress since 1997. It addresses the huge new challenge of including the developed world only by suggesting a stylized formula for a common quantity commitment that ignores all past attempts to devise such a formula. This new attempt still fails to resolve the fundamental contradiction between the risk of long-run targets and the perverse incentives of regularly-updated targets. And it adds to the challenge of negotiating individual targets by requiring that these meet a strict pre-set total cap.

This leaves global cap-and-trade with four decisive failures, all of which are addressed by global carbon pricing.

### *Carbon pricing eliminates huge trading risks*

Global cap-and-trade needs to lock in targets for a decade or two. During this time business-as-usual emissions change unpredictably. As shown in Section 8, this can be extremely risky for participating countries. This leads to demands for more generous targets or even refusal to participate. And if a strong treaty were ever implemented it would lead to defections and unraveling. Global carbon pricing completely eliminates this useless source of risk.

### *Carbon pricing actually does price carbon emissions*

Neither the Kyoto Protocol nor global cap-and-trade, as specified here, require that emitters acquire emission permits. Instead, governments must own permits similar to Kyoto's AAs. In

idealized economic theories, the price of AAUs would be transmitted, with the help of government regulations, to actual carbon emissions. There has been no sign of this under the Kyoto Protocol and there is no reason to believe things would be different under the newly proposed global cap-and-trade policy. In contrast, countries would be required to price carbon emissions in order to meet a global carbon price commitment.

### *Pricing rewards environmental ambition*

A global cap, if it works as intended, will control the total emissions of the participating countries. If one country emits less, that will free up permits so other countries can emit more. And, if one emits more, others will be constrained to emit less.

The consequences are obvious. If any country, province, social group, or individual voluntarily does more than is in their narrow self-interest, it will not benefit the climate at all. All such altruistic efforts will be negated by the market. Ambitious action by some will simply make it cheaper for those who are not ambitious to do less. And, they will do less. And if they do not do enough less to negate all environmental ambition, the market will depress the price of carbon even more and make sure selfish people do even less. The cap will be met.

Global carbon pricing does not discourage ambition at all. Extra abatement does not change the price faced by non-ambitious groups and individuals, so the ambition of others does not encourage them to do any less. The result is that every ton of ambitious abatement reduces global emissions by a full ton.

### *Pricing stops free riding in the negotiations*

Climate change is a problem of managing the collective commons, and the essence of that problem is that countries can free-ride on the use of the atmosphere. Requiring them to pledge some action, even if the action is to join a global cap-and-trade agreement and choose a “target”—an allocation of emission permits—does not prevent free riding. Instead of free riding by just emitting, countries can now free ride by taking a high target and emitting more or by profiting from selling extra permits.

To stop free riding we need to replace individual commitments with a common commitment. For twenty years, Kyoto negotiators and academic economists have tried to find ever more complex formulas to create a common quantity commitment, with no signs of progress. Global carbon pricing provides an obvious solution. All countries should commit to price at the same global price. There is still a problem of negotiating climate-fund transfers, but decoupling these two problems greatly simplifies them, and largely insulates climate policy from disputes over monetary transfers.

### *Conclusion*

Global carbon pricing was designed to facilitate negotiation and cooperation. To many this will seem backwards—it should have been designed “for the climate.” But the real problem is not the climate; the real problem is people—and their lack of cooperation. After 20 years of pretending to do what is right of the climate, and actually doing almost nothing, it is time for a change. We should design the negotiations and our policy goal to maximize cooperation and accept that we cannot do better than the best we can do.

It’s a simple idea. But the change of focus from supposedly scientific round numbers, 1 trillion tonnes, 2.0 degrees, 450 ppm (or some say 350), to a focus on how people cooperate makes all the difference. Elinor Ostrom spent her life studying how people actually solve common-pool resource problems. She found the answer was always “trust and reciprocity,” not numerology. Global carbon pricing is designed to build trust with reciprocity.

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## Chapter 2

# The Case for Pricing Greenhouse Gas Emissions

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### Abstract

*This paper makes the case for negotiating a common international charge on greenhouse gas emissions (“carbon”) as opposed to global cap-and-trade. All countries would be covered in principle, but a much smaller number that covered most of the emissions would suffice. The charge would be internationally adjusted from time to time, and each country would collect and keep the revenue it generated by imposition of national taxes on fossil fuels, cap-and-trade schemes or any combination.*

*The paper first discusses the likely impossibility of negotiating a global cap-and-trade scheme, because the global “caps” would be too high, and because the allocation of permits to domestic agents would invite corruption. It then discusses the advantages of agreeing on a uniform international carbon charge. Finally the question of compliance is considered and the paper concludes that a uniform carbon charge with all revenues kept at home, is far superior to cap-and-trade as a global arrangement for mitigating climate change.*

*Keywords: Climate change, Global warming, Carbon pricing, UN climate negotiations*

## 1. Introduction

This short paper argues for imposing a globally-uniform charge on all emissions of greenhouse gases, insofar as practicable. It will focus for concreteness on carbon dioxide, the most prevalent and long-lasting greenhouse gas. It argues that such a charge would be superior to a system based on quantitative international targets with provisions for trading emission rights, global cap-and-trade for short.

Climate change is a global problem, not a localized one, and to be effective it therefore requires a global approach to reduction of GHG emissions. “Global” does not necessarily mean universal, although that would be desirable. It would be sufficient to engage the 30-40 largest emitting countries, at least for the next decade or two. These countries account for the overwhelming majority of fossil-fuel consumption, and also include countries covering the bulk of changes in land use that result in CO<sub>2</sub> emissions.

But several economies, most notably the European Union, have embarked on a cap-and-trade system. It is worth asking, therefore, whether the two systems can co-exist and comply with a uniform international charge on carbon. The answer is affirmative, provided several conditions are met. These conditions would assure that the combined charges from fossil fuel taxes and carbon permits issued under cap-and-trade equaled the requirements of the uniform international charge (for further discussion, see Cooper (2008)).

The case for a charge on carbon as opposed to a global cap-and-trade scheme is based partly on the negatives associated with cap-and-trade, partly on the positives associated with the carbon charge. Let us take up the negative component first.

## 2. International Cap and Trade

How well would a cap-and-trade system work at the global level? It would require allocating emission targets, covering many years, to states. To be effective, the total targets would have to be tight enough to cut emissions significantly from what they would otherwise be. In my view, it will be impossible to negotiate meaningful national targets. The reason is straightforward. Developing countries understandably place a higher priority on economic development than they do on mitigation of climate change, and they will not agree to binding emission targets that they believe will compromise their development objectives (Stiglitz 2006b and this issue). Moreover, we now have several examples of countries that have grown 8-10 percent for two decades or more, and most developing countries will aspire to achieve such growth rates, even though most of them will fail to do so. But aspirations, not ex post realities, will shape their positions in international negotiations. And with generous targets allotted to the leading developing countries, the rich countries, especially the USA, will not agree to compensate with targets so stiff that they seriously threaten standards of living in those countries. In short, meaningful binding global targets are not feasible.

Even if this (decisive) argument is put to one side, there is another acute problem with a global system based on cap-and-trade. To work, the national targets (aka emission rights) must be allocated to the entities that actually make decisions about what kinds and how much fossil fuels to consume, that is, to electricity-generating firms and energy-intensive industrial firms. The idea of cap-and-trade is that each covered firm would be given an emission target for the coming year, perhaps declining from year to year, and each firm would either have to meet its target or purchase emission rights from other firms that had reduced emissions below their targets. This would require a market in emission permits, of which one has functioned in Europe since 2005. Although there were a number of glitches, Europeans have demonstrated that such a market can work. But the European system covers less than one half of European CO<sub>2</sub> emissions. For compelling practical reasons, Europeans have not yet extended the system to all or even most emissions, particularly those in the transport and heating sectors, and in much of industry.

Unless the permits are auctioned, raising the separate question of how a fair auction is assured, the permits are allocated to the covered firms free of charge. In countries with loose governance (i.e. most countries), this is an invitation to favoritism: the government is allocating permits that have significant financial value, and most governments are likely to do that in a biased way. Put more bluntly, it is an open invitation to corruption. This is a fatal flaw in a global cap-and-trade system, since well-governed democratic countries will be unwilling, and they should be unwilling, to impose burdens on their own citizens in order to enrich political favorites in less well-governed countries through international trade in emission permits. Concretely, no US Senator who understood the process would vote in favor of a treaty with this implication. In other words, the United States would not participate in such a global scheme, even if it had adopted a cap-and-trade system domestically.

Or viewed from a slightly different perspective, what Senator, once s/he understands the full implications of a trading regime, can vote for a procedure which could result in the

unconditional transfer of billions of dollars, even tens of billions, to the government of communist China, or to Castro's Cuba, or to Putin's Russia? That would be politically unacceptable, at least in the United States and probably elsewhere.

This implication of unwholesome international transfers could be avoided if each participating country had its own national cap-and-trade system (EU-wide in the case of the EU). But that would vitiate much of the "trade" part of a cap-and-trade system, since we have reason to believe that emission reductions will be much less costly in many developing countries than they would be in many rich countries. Denying international trade in permits would reduce greatly the efficiency of the cap-and-trade system. High-cost emission reductions would yield to lower-cost reductions only on a national basis, not internationally.

That is the negative case for carbon charges: the main alternative, cap-and-trade, cannot be made to work effectively and efficiently at the global level. Yet a global solution is required.

### 3. Carbon Charges

The affirmative case for carbon charges contains a number of elements. First, it uses the price system, which is the only way to reach the billion plus decision-makers around the world who decide what and how much energy to consume. They will be encouraged either to consume less or to switch to less carbon intensive sources of energy.

Second, the charge can be applied to all fossil fuels at choke-points – oil refineries, main gas pipelines, and principal coal transit points – with high confidence that the charge would affect downstream prices, that is, those faced by businesses and households. Separate provision could be made for the relatively few exceptions, e.g. a power plant located at a coal mine.

Third, the charge can and should (by negotiation) be made uniform (with perhaps a time lag of a few years for some developing countries), thus neutralizing the important issue of competitiveness of national energy-using industries in international markets. For example, the steel industry in all important steel-making countries would pay the same carbon charge, so none could complain that they were being put at a competitive disadvantage by a different GHG regime in other countries. It is noteworthy that many European countries levy much lower electricity charges to business than they do to households, using "competitiveness" as the rationale; and they were disproportionately generous to some industries in the allocation of emission permits to some industries on similar grounds.

Fourth, a carbon charge would for many years generate revenues, badly needed by most governments these days (Norway and Qatar may be exceptions). These revenues could be used as each government saw fit, provided the use did not undermine the purposes of the agreement, viz. to reduce GHG emissions. Some would reduce deficits, some would finance needed expenditures, some (probably including the United States) would reduce other taxes, many would perhaps help adaptation to climate change in poor countries. Properly used, the revenue from the charges could enhance growth. Auctioning permits in a cap-and-trade system would also produce revenues, but if the legislative process in Europe and in the United States provides any guidance, auctions will be resisted strongly in favor of free allocation. The EU has agreed that in principle all permits will be auctioned by 2027 – 22 years after first introduction of its cap-and-trade system, and it remains to be seen whether this agreement will actually be carried out. The carbon charge can be phased in gradually, on a certain timetable, to limit any unwanted macroeconomic effects of a significant new tax.

The impact of a carbon charge on economic growth would be low, and could even be positive if the revenues are used in growth-enhancing ways, e.g. to reduce distortionary taxation or to finance research, development, and dissemination of new knowledge.

It will not be easy to negotiate a uniform charge among the major emitting countries. But “difficult” is much easier than “impossible,” which I believe to be the case for a meaningful global cap-and-trade system. The current international negotiations through the conferences of parties to the Framework Convention on Climate Change cannot, in my view, lead to a meaningful mitigation of climate change (Gollier and Tirole, this issue). There are too many (193) participants, with too diverse interests and objectives, operating under a parliamentary rule of “consensus,” which permits a small number of countries, even countries that are not relevant to GHG mitigation, to block action. And the focus has been on agreeing on binding quantitative restrictions on emissions on only a subset of relevant countries, although the last restriction seems to be easing. To get somewhere, the negotiators need to shift away from quantitative emission targets to meaningful actions (such as a common charge on CO<sub>2</sub> emissions, although others are imaginable) by the relevant emitters, and initially only those emitters need to participate in the negotiations.

Some will object that a charge on carbon will leave the resulting reduction in emissions uncertain, since we do not know ahead of time how responsive businesses and households will be to the charge. That is entirely true. If the response is judged to be too slight, the charge can be raised in future years after an initial trial period of five to ten years. But the cap-and-trade system also has its uncertainties. As we learned from European experience, the permit price can decline to such a low level that conservation and fuel-switching is not encouraged at all, a result produced in part by two recessions that were not anticipated when decisions were announced on the permits to be allocated. Moreover, from basic principles it is preferable to have a stable emissions price than one that varies with macroeconomic conditions or other disturbances to supply or demand for energy (Weitzman, this issue). It is the stock of greenhouse gases in the atmosphere, not the current inflow, that influences the climate. The “externality” of emissions pertains to stock, not to flows, and is the same per tonne of CO<sub>2</sub> whether the flow is low or high. Thus the price on that externality should be relatively stable, not variable. Moreover, while European experience has been with unexpectedly low prices, it is a reasonable presumption that if the price had instead risen sharply to great heights, the political processes in Europe would have taken steps to limit the high price rather than see it generate an overall economic slowdown.

## 4. Compliance

What about compliance? This is an issue for any international agreement that imposes unwelcome costs on the participants. The temptation to “free ride” – to shirk while others are (presumably) carrying out their obligations – is ever-present. That is as true of a global cap-and-trade agreement as of an agreement involving carbon charges. In either case monitoring would be required, made easier by constant improvements in long-distance sensors; but on-the-ground sensors and international inspections should also be introduced. In the case of carbon charges, the national legislation introducing such charges would be relatively easy to track. Harder would be the actual collection of emission charges. But the Fiscal Department of the International Monetary Fund is already familiar with the tax systems of all member countries (only Cuba, North Korea, and Taiwan and the smallest economies are



not members, all except Taiwan being low emitters). It could be charged with monitoring the collection of carbon charges by each participant in the agreement, which could then be compared with the information from the sensors and inspections.

If a country were found to be out of compliance, it could be asked in informal consultations, and ultimately in formal international panel reviews, to explain its position. Systematic cheating could of course be possible on a small scale. It would be more difficult on a large scale, and would have to involve the complicity of many officials, something that is increasingly difficult in the age of the internet and whistle-blowers.

If a country were significantly and persistently out of compliance, its exports could be subject to countervailing duties in importing countries. The conceptual and legal basis for such duties – to offset government subsidies to exports – has existed for many years, and is embodied in the World Trade Organization (Stiglitz, 2006a) as well as in national legislation. The new element is that under the international agreement the agreed charge on carbon emissions would be considered a cost of doing business, such that failure to pay the charge with government complicity would be considered a subsidy, subject to countervailing duty under existing procedures. Non-signatory countries could also be subject to countervailing duties. WTO panels have found that imports can be restricted on a discriminatory basis if the originating country is in violation of an international environmental agreement (Stiglitz, this issue). This possibility would provide a potent incentive for most countries to comply with the agreement, whether or not they were formal signatories. Of course the sanction would apply only to exports, not to domestic sales, within the offending country.

## 5. Summary

In summary, I conclude that a uniform carbon charge in all major emitting countries, revenues to be kept at home, is far superior to cap-and-trade as a global arrangement for mitigating climate change. This is partly because agreement on an effective and efficient global cap-and-trade regime is hard to imagine, both because the global “caps” would be too high and because the allocation of permits to domestic agents would invite corruption in many countries, leading other countries to decline to trade permits with them—for similar views see Nordhaus (2013), Weitzman (this issue), and Cramton et al. (this issue). Agreement on harmonized national carbon charges would not be easy, but at least agreement on common actions would have some chance to succeed if the relevant international community decided there needed to be a serious attempt to mitigate climate change. And it would have several advantages: providing an appropriate universal price signal to reduce consumption of fossil fuels, generating needed revenue, and dealing directly with widespread concerns about international competitiveness and even stimulating growth -- an important point for developing countries.

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# Chapter 3

## Overcoming the Copenhagen Failure with Flexible Commitments

JOSEPH STIGLITZ<sup>a</sup>

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### ABSTRACT

*The fundamental issues presented by climate change are first, that the global environment is a global public good and second, the question of how to share the burden of providing a better climate. Everyone would like to “free ride” on the efforts of others, but there is disagreement over who is free riding. The Kyoto approach, based on dividing up emission rights, has an inherent problem in that such rights could easily reach a monetary value of over a trillion dollars a year. The approach suggested here avoids any attempt at a grand solution to the fair allocation of these rights. A low-carbon economy could be achieved through the imposition of a moderate carbon price, which would raise substantial revenue and allow a reduction in other taxes, thereby keeping the deadweight loss small. Countries should be given flexibility in how they meet their obligations—whether through a carbon tax, a system of cap and trade, or even possibly certain regulatory mechanisms. But a fully voluntary agreement likely cannot include countries that export a significant amount of fossil fuel. A green fund financed by allocating say 20% of carbon revenues collected in developed countries could be used to implement “differentiated responsibilities.”*

**Keywords:** Climate change, Global warming, Carbon pricing, UN climate negotiations

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### ✎ INTRODUCTION ✎

There is by now widespread agreement that climate change represents an existential threat, that only by global action can the accumulation of greenhouse gases in the atmosphere be stymied, and that there has to be some appropriate form of burden sharing (see, in particular, Stiglitz, 2011). There is even broad consensus over the urgency of action; that unless we act soon, there is a serious likelihood of an increase in temperature well above the 2 degrees C that was at the core of the Copenhagen agreement. Yet, in spite of the broad consensus, there has been little progress. There has been some—but the voluntary measures taken by various countries simply don’t add up to what is needed. This paper (like others in this symposium) attempts to explain why that may be the case and point to an alternative framework for negotiations which, I believe, is more promising than that on which the world has embarked since the Rio agreement of 1992.

The fundamental issues are simple to state but hard to resolve: the global environment is a global public good—all benefit from a good environment, and all suffer from climate change (Stiglitz 1995, 2006a, 2006b, 2006c). As in the case of any public good, there is a problem of *undersupply*; everyone would like to “free ride” off the efforts of others in supplying the

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public good. In the case of global warming (climate change) there is an additional problem: some suffer more from the consequences of climate change than others; the adjustments some have to make to avoid climate change are greater for some than others; and the ability of some to take the actions to reduce emissions and to adapt to the consequences are greater for some than others. Indeed, it used to be thought that the countries like the United States that were the largest contributors to climate change would be the ones that would suffer the least from it. As we have become more aware of the multiple effects of climate change (including on weather variability), that view is not held so strongly today: rich countries like the United States are vulnerable to more property damage from events like Hurricane Sandy.<sup>1</sup> Moreover, poor countries are today responsible for an increasing share of carbon emissions.

Still, the central issue in reaching a global agreement entails burden sharing—who should pay the price associated with reducing greenhouse gas emissions? Should it be the large developed countries who have so far contributed most to the increase in greenhouse gases over the past two hundred years? Should poorer developing countries be asked to sacrifice their growth potential, so that the advanced countries can continue in their emissions-intensive life style?

Some suggest that it should be easy to arrive at an agreement. Whenever there are large externalities—and greenhouse gases give rise to a huge externality—there are arrangements that are Pareto superior; where all would be better off rather than carrying on in a “business as usual” manner. But the problem in this case is that these Pareto improvements would entail developing countries making significant sacrifices which they view they can ill afford, so that the developed countries can continue in their profligate patterns—or so that developed countries could be compensated for not continuing in their profligate patterns. This is because those in the developing world, disproportionately located in the tropics, are likely to be hurt most by climate change; though there is increasing evidence that some of the extreme weather events associated with climate change will affect even those living in more moderate climates, that many of these countries will be adversely affected by sea level changes, and that all could be affected by disease vectors.

Perhaps, in the end, when developing countries face the bleak alternative of desertification, droughts, flooding, etc. they will be willing to make the sacrifices, as unfair as they may seem. Perhaps, in the end, citizens in the more developed country will feel a stronger moral obligation to bear their fair share of the burden. This paper, however, is written in the hope that there is scope for arriving at a negotiated solution sooner rather than later.

### ✎ THE FAILURE OF THE CURRENT APPROACH ✎

The Kyoto approach, based on allocating “emission rights” (which could be traded) to different countries, has an inherent problem. It is now widely recognized that emission rights have a monetary value—probably on the order of \$80 to \$100 a ton in an emissions control scheme achieving the 2 degree goal. Giving a country emission rights is equivalent to giving them money. A global agreement has to decide on how to allocate an asset worth some trillion dollars a year. No wonder that it is hard to reach an agreement.

1. “It is readily apparent that the storm surge and associated damage [from Sandy] was considerably influenced by climate change.” From “Attribution of climate extreme events,” K. Trenberth et al., *Nature Climate Change*, Perspective, 22 June 2015. [www.nature.com/nclimate/journal/vaop/ncurrent/pdf/nclimate2657.pdf](http://www.nature.com/nclimate/journal/vaop/ncurrent/pdf/nclimate2657.pdf).

Inevitably, if there is to be an agreement, the world will have to decide on some principles of allocation—a formula. The debate will focus on the terms of the allocation formula.

Kyoto seemed based on a principle that worked imperfectly among developed countries, but will simply not work when developing countries are brought in: countries were asked to make a given percentage reduction relative to their prior levels of emissions. Negotiations focused on adjustments up or down from the base rate, defended on grounds of particular circumstances facing particular countries. But this principle essentially says that those who emitted more in the past have the right to emit more in the future. No developing country would or should agree to this principle.

There are alternative principles that seem more ethically justifiable. One would divide the world's carbon "space" according to population in 1992, when the problem of global warming was globally recognized. Some countries, like the US, have essentially already used up all of their carbon space. Thus, they either need to move to zero net emissions or purchase emission permits from others.

There are of course more "progressive" allocations. Conventional principles would allocate a global asset such as emission rights in a progressive manner, with poorer countries getting a larger allocation. Many would argue that in allocating carbon space, one should go back in time well before 1992; and since the developed countries were responsible for the overwhelming proportion of the increase in carbon concentration over the past two hundred and fifty years, that would imply that they would have to reduce their carbon emissions going forward even more.

The approach suggested here implies avoiding any attempt at a grand solution to the fair allocation of emission rights, but recasting the problem in ways which minimize the redistributive aspects of the negotiations.

### ✂ THE COSTS OF ADJUSTMENT ✂

Fair burden sharing requires some notion of the costs of mitigation—the societal costs of lowering emissions. While there have been extensive calculations on the costs to different societies, there is a simple approach that suggests why those costs will be limited. By most accounts, the adjustments to a low carbon economy could be achieved through the imposition of a moderate carbon tax (or an equivalent cap and trade system). Such a carbon charge, say at the rate of \$80 to \$100 a ton, would, of course, raise substantial revenue and allow a reduction in other taxes. The standard approach for estimating the societal cost of such a carbon charge is the dead weight loss associated with the charge, the sum of the consumer and producer surpluses associated with raising the price of carbon from its current level to \$80 or 100 a ton. (These calculations do not include the societal benefit of the reductions in climate change, just the direct economic cost of the "tax" itself.) These numbers are referred to as Harberger triangles, and are typically relatively small (though perhaps they might not be when emission reductions exceed 80%). But the reduction of the other taxes (say on labor or capital) would have a corresponding benefit, an increase in consumer and producer surplus. Thus the *net* societal cost of reducing emissions is the difference between the Harberger triangles; the difference is a number that is likely to be small for most countries, and in many cases will even be positive; and the difference in the differences can be even smaller.

Thus, it is plausible that most would see their own private gains from the reductions in climate change more than offsetting the costs (possibly negative) that they would bear. Though some might see themselves gaining more than others, most would see the agreement as positive.

But *within* many countries, there would be large losers: in the oil producing countries, for instance, oil producers and owners of oil assets would be worse off. While in principle, again, the winners could more than compensate the losers, such compensation is seldom made. Thus, the fact that the country as a whole might be better off does not necessarily mean that the country's government would actually support the agreement: the losers (the oil industry) may have disproportionate voice in many countries. (That is evidently the case, for instance, in the United States.)

Still, the approach we have outlined has even a political economy advantage: an argument that the country as a whole would be better off, even if particular special interests would be worse off, should carry weight. Arguments from the oil industry against an agreement would be seen for what they are: self-serving.

But there is an approach that would provide even more impetus to a global agreement. If those countries without a large fossil fuel lobby could agree to a common level of a carbon price, none would be viewed as having an unfair advantage over the other. In effect, a country which does not charge the full social cost of carbon is *subsidizing* carbon emitting industries, an unfair trade/competitive advantage, not unlike that of a country which subsidizes labor. These countries could impose trade sanctions—a cross border tax—on those who do not implement the common carbon price (Stiglitz 2006a, Helm 2010). (As I explain in Stiglitz (2006b), such a cross border adjustment would likely be WTO legal.) This would be an effective mechanism for ensuring compliance with a global agreement—and would provide a strong argument for those not adopting a carbon tax or an equivalent mechanism to do so. For any country not doing so would in effect be granting the tax revenue associated with its carbon emission to its trading partners.

### ✎ PARTIAL VS. GENERAL EQUILIBRIUM ✎

At a deeper level, there would be significant distributive consequences—but consequences which would arise no matter what approach was taken to reducing carbon emissions. For the intent of any global agreement is to reduce the demand for fossil fuels, and that *necessarily* must reduce the rents associated with fossil fuels; the recipients of those rents—the owners of the fossil fuels—will be worse off. And that will be the case even taking into account any benefits they directly receive from the reduction in the threat of climate change. That is why one should not expect a fully voluntary global agreement among all countries; in the absence of any sense of a global social responsibility framework, any country which is exporting a significant amount of fossil fuels would likely be worse off (Cramton and Stoft 2012). And even countries which import only a limited amount might not sign on, simply because of the political influence of the fossil industries.

That is why the target should be more limited: an agreement among a “coalition of willing,” countries without a large domestic fossil fuel sector, with cross-border adjustments on all other countries. I suspect the combination of social consciousness and self-interest on the part of the citizens of other countries would expand the membership in this coalition, until most, if not all, countries, joined the coalition.

### ✎ VOLUNTARY VS. ENFORCEABLE AGREEMENTS ✎

The current approach seeks voluntary reductions. Each country would “offer” up actions it would take to reduce carbon emissions. There have been significant reductions on this basis,

and if all countries fulfill their intentions, the results would be impressive; but they would still fall far short of what is needed. Indeed, it would be remarkable if they did not. In no other area has voluntary action succeeded as a solution to the problem of undersupply of a public good. And this is especially so when there are global public goods, the benefits of which are shared by everyone in the world. There is simply insufficient “solidarity” at the global level. Social pressure works to some extent—but only to a limited extent. And that is especially true when there are large groups within our societies for whom the direct cost of taking action (the loss in value of the fossil fuel assets they own) exceeds any direct gain from reduced global warming. It is not a surprise that such groups try to convince others that there is no real danger of climate change.

That is why the *soft* approach advocated in recent years by the US, amongst others, based on voluntary contributions simply will not work. Agreements have to be enforceable. In the absence of a global government able and willing to impose direct fines, the most effective enforcement mechanism are trade sanctions, including the cross-border adjustments described in previous paragraphs.

#### ✎ FLEXIBILITY IN MAKING COMMITMENTS ✎

But countries should be given flexibility in the manner in which they meet their obligations—whether through a carbon tax or through a system of cap and trade (Cooper 2008), which could be complemented with regulatory mechanisms when their results are sufficiently measurable. Systems of auctioned emission rights are equivalent to a carbon tax. In practice, over time there will have to be adjustments in the “caps” and in the price of carbon. The notion that there is less risk to the global environment with a cap and trade is based on the presumption that we have good knowledge of the level of emissions necessary to achieve any objective in terms of changes in temperature.

Some countries seem to believe that the political economy problems posed by climate change can best be solved by compensations provided through the grants of emission rights. Others worry that such systems are themselves subject to unwanted political pressures—and corruption.

Auctioned emission rights or a carbon tax can have large distributive consequences *within* a country, which is why regulatory mechanisms may have some advantages: restrictions on housing, urban design, transportation, and electricity generation can achieve a substantial fraction of what is needed; the requisite changes in carbon prices, with the associated distributive consequences, may be quite large to elicit corresponding changes. It is worth noting that much of the efforts of the international community have been directed at creating such regulatory standards, e.g. in terms of fuel efficiency in cars. But such an approach opens up difficult questions: should an industry that does not pay a carbon charge be viewed as subsidized if it faces a regulatory constraint that forces it to achieve the same level of carbon emissions? It is as if the industry has faced a carbon charge, but with the proceeds reimbursed to those in the industry as a lump sum payment. Clearly, the lump sum payment is a subsidy—even though it is not a carbon subsidy. Firms in countries facing a carbon charge will rightly argue that this is unfair competition. Moreover, there are difficult issues in transparency and comparability: if there were an agreement about a global carbon price of say \$80 a ton, and some country were to combine tight regulations with a \$70 a ton general price, how would we assess whether it was complying with the regulation? It might argue that it should be given

the flexibility of imposing, in effect, a higher carbon price in some industry (for some technologies) and a lower carbon price for others. Put aside for the moment charges of unfair competition to which such differential pricing might give rise (which arguably would be of limited relevance if the goods in question were non-traded goods). In principle, if we had enough information about the demand and supply curves, we could calculate the reduction in emissions and compare that reduction to what would have happened had there been a uniform \$80 a ton carbon price.

### ✎ COMMON AND DIFFERENTIATED RESPONSIBILITIES ✎

The approach delineated above does not, however, adequately differentiate among the circumstances of different countries. Such differentiation was central to earlier approaches to climate change.

It is inefficient, and likely to be viewed as inequitable for producers in developing countries to face a different carbon price from those confronting firms in developed countries, giving rise to charges of unfair competition. At the same time, those from poor countries struggling to develop rightfully feel that *any* extra costs are taking away funds that could otherwise be used for advancing developmental objectives.

This leads to two suggestions: (a) a global green fund, financed by allocating 20% of the funds from the carbon tax (or the equivalent) imposed in developed countries. Since the magnitude of these revenues would be proportional to emissions of those countries, it would arguably be an appropriate basis for raising funds for a global green fund. And this would be particularly so since current emission levels would be highly correlated with past emissions. (This is not the only basis on which one might raise money for a global green fund. One might, alternatively, impose a charge based on *consumption*, on the carbon associated with the goods that individuals in different countries consume. In a competitive equilibrium, of course, charges on production and on consumption are equivalent. In practice, they may not be. There may, however, be more technical difficulties in levying a charge on consumption than production.)

The revenues from a global green fund would be used to help finance expenditures in developing countries on adaptation and on the *incremental* costs associated with mitigation measures reducing carbon emissions. The funds could also be used to help developing countries pursue objectives of carbon sequestration—paying them to maintain forests (which would have additional global benefits in terms of biodiversity) and even *not* to extract hydrocarbons. The contribution to each of the developing countries from the Green Fund should be large enough to compensate them for accepting the global carbon price. (It may, however, be problematic to ask each country what contribution from the Green Fund would induce them to participate; that would give rise to a bargaining problem where some developing countries might claim that they need large compensation. Equity may require establishing a rule based allocation mechanism.)

(b) Improvements in technology are likely to play an important role in meeting the goals of reductions in carbon emissions. Developing countries rightly worry that, should they sign on to an enforceable agreement concerning reductions in carbon emissions, to meet agreed upon reductions would necessitate their paying developed countries large amounts to use their technology. In effect, a global carbon agreement would be an arrangement to transfer large



amounts from developing countries to the developed. Developing countries understandably are reluctant to sign on to an international conventional that would have that as a result.

In the 1992 Rio agreement, there was a provision for compulsory licenses. And yet, the United States (and other developed countries) continue a stance which entails, in effect, a renegotiation of this provision.

The developed countries are in a better position to finance and conduct research leading to technologies which reduce carbon emissions and which lead to carbon storage at affordable costs. They should provide this technology freely to developing countries (perhaps on a sliding scale, with reduced charges for middle income countries). Some of the costs might be met out of the global green fund: research expenditures to reduce carbon emissions are a double global public good—research itself is a global public good; and climate change is itself a global public good.

### ✎ CONCLUDING COMMENTS ✎

It is now more than two decades since the world recognized the threat of climate change. And yet there has been little progress—too little progress—beyond a global agreement that we *should* take actions to limit the increase in temperature to 2 degrees C. We are now set on a course in which we will almost surely miss even this modest goal.

We have explained why the approaches of the past—voluntary caps and actions—will almost surely fail, falling far short of what is needed. We have outlined another approach, based on a global agreement around a common carbon price, with flexibility on how each country implements that agreed upon price. With strong border adjustments, this is more likely to result in an agreement. Perhaps the agreement will initially be only among a large number of countries, a coalition of the willing, in which some recalcitrant countries refuse to join in—most likely those in which fossil fuel industries play an important role in the political economy. But we have explained how over time, even many of these will find it desirable to join the coalition. We have explained too how we can incorporate within this approach the recognized principal of “common but differentiated” responsibility.

It is time to give this alternative approach a chance. Climate change is too important to allow the current impasse to continue.

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## Chapter 4

# Climate Clubs and Carbon Pricing<sup>1</sup>

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September 15, 2015

Much progress has been made by scientists and economists in understanding the science, technologies, and policies involved in climate change and reducing emissions. Notwithstanding this progress, it has up to now proven difficult to induce countries to join in an international agreement with significant reductions in emissions.

The Kyoto Protocol was an ambitious attempt to construct an international climate-change agreement to harmonize the policies of different countries. High-income countries agreed to limit their emissions to 5 percent below 1990 levels for the 2008-2012 budget period. Under the Protocol, important institutional features were established, such as reporting requirements and methods for calculating the relative importance of different greenhouse gases.

But countries did not find the Kyoto Protocol economically attractive. The United States withdrew in 2001. The Protocol did not attract any new participants from middle-income and developing countries. As a result, there was significant attrition in the coverage of emissions under the Protocol. Also, emissions grew more rapidly in non-covered countries, particularly developing countries like China. The Protocol as first designed would have covered 63 percent of global emissions in 1990, but the actual scope in 2012 was barely one-fifth of world emissions. Analyses showed that, even if indefinitely extended, the Kyoto reductions would have a limited impact on future climate change. It died a quiet death, largely unnoticed and mourned by few, on December 31, 2012.

It has been apparent even before its demise that the Kyoto Protocol would not make a substantial contribution to slowing climate change, or indeed that it would meet its limited goals. Nations have struggled through a series of summits and conferences to find a replacement, with the Paris meeting in late 2015 being the latest attempt to reach an agreement that would replace Kyoto with an effective international agreement.

The present article suggests that the Kyoto Protocol ran aground, and that current approaches are unlikely to do better, because of the tendency of countries to free-ride on the efforts of others for global public goods. The article suggests that a “club” model is the most fruitful approach to overcoming free-riding, and describes a Climate Club. The current approaches, starting with the Kyoto Protocol, have little chance of success unless they adopt some of the strategies associated with the club model of international agreements.

But the abstract idea of a club is insufficient; many architectural and practical details of club design need careful analysis. One important aspect is the question of exactly what the international agreement is to agree on. In Kyoto, nations agreed on quantity limits. I suggest here that price agreements – more specifically agreements on an internationally harmonized minimum carbon price – will be the most fruitful way to organize an international club agreement.

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## 1. The Nature of Global Public Goods

Most of economic life involves voluntary exchange of private goods, like bread or blue jeans. These are commodities consumed by one person that directly benefit no one else. However, many activities involve spillovers or externalities among producers or consumers. An extreme case of an externality is a public good. Public goods are commodities where the cost of extending the benefits to an additional person is zero and where it is impossible or expensive to exclude individuals from enjoying.

More precisely, public goods have the two key properties of non-rivalry and non-excludability. Non-rivalry denotes that the consumption of the public good by one person does not reduce the quantity available for consumption by another person. Take global positioning systems as an example. These are used for hiking, missile guidance, and to find a restaurant. These are public goods because people who use them are not reducing the value of signals for others. The second feature of a pure public good is non-excludability. This means that no person can be excluded from benefiting from or being affected by the public good (or can only be excluded at a very high exclusion cost). In the case of smallpox eradication, once smallpox was eradicated, no person could be excluded from the benefits. Herd immunity from vaccines is an important and little-understood public good that is one of the important reasons for mandatory vaccination.

The important economic point about public goods is that private markets do not guarantee efficient production. In this respect, then, production of public goods such as GPS signals or herd immunity differs from production of bread. Efficient production of public goods requires collective action to overcome the inability of private agents to capture the benefits.

The inefficiencies are the greatest for global public goods, whose benefits are spread most widely across space and time. Consider issues as different as greenhouse warming and ozone depletion, terrorism and money laundering, the discovery of antibiotics and nuclear weapons. These are global public goods because their impacts are indivisibly spread around the entire globe. These are not new phenomena. However, they are becoming more important in today's world, because of rapid technological change and of the sharp decline in transportation and communication costs.

## 2. Global Public Goods, Federalism, and the Westphalian Dilemma

While global public goods raise no new analytical issues, they do encounter a unique political hurdle because of the structure of international law. Whenever we encounter a social, economic, or political problem, one of the first questions concerns the level at which the problem should be addressed. We expect households to deal with children's homework assignments and taking out the trash; we expect local or regional governments to organize schools and collect the trash; we expect national governments to defend their borders and manage their currencies.

For the case of global public goods, there exist today no workable market or governmental mechanisms that are appropriate for the problems. There is no way that global citizens can make binding collective decisions to slow global warming, to curb overfishing of the oceans, to efficiently combat Ebola, to form a world army to combat dangerous tyrants, or to rein in dangerous nuclear technologies.

The decision-making difficulties of global public goods raise what might be called the Westphalian dilemma. National governments have the actual power and legal authority to establish laws and institutions within their territories; this includes the right to internalize externalities within their boundaries and provide for national public goods. Under the governing mechanisms of individual countries, whether they are acts of democratic legislatures or despotic decrees, they can take steps to raise taxes or armies and command their citizens to clean their air and water.

By contrast, under international law as it has evolved in the West and then the world, there is no legal mechanism by which disinterested majorities, or supermajorities short of unanimities, can coerce reluctant free-riding countries into mechanisms that provide for global public goods. Participants of the Treaty of Westphalia recognized in 1648 the *Staatensystem*, or system of sovereign states, each of which was a political sovereign with power to govern its territory. As the system of sovereign states evolved, it led to the current system of international law under which international obligations may be imposed on a sovereign state only with its consent.

Because nations, particularly the United States, are deeply attached to their sovereignty, the Westphalian system leads to severe problems for global public goods. The requirement for unanimity is in reality a recipe for inaction. Particularly where there are strong asymmetries in the costs and benefits (as is the case for nuclear non-proliferation or global warming), the requirement of reaching unanimity means that it is extremely difficult to reach universal, binding, and effective international agreements. Whether bargaining can lead to such treaties is examined shortly.

To the extent that global public goods are increasingly important in the decades ahead, one of our major challenges is to devise mechanisms that overcome the bias toward the status quo and the voluntary nature of current international law in life- or civilization-threatening issues. Just as national laws recognize that consumer sovereignty does not apply to children, criminals, and lunatics, international law must come to grips with the fact that nations acting under the Westphalian system cannot deal effectively with critical global public goods.

### 3. Free-riding as the Key Obstacle for Climate-Change Treaties

As we look at climate change, the dilemmas raised by their global nature take a particular form. Slowing climate change requires expensive national investments in reducing CO<sub>2</sub> and other greenhouse gas emissions. But the benefits are diffuse in space and time. Emissions reduced anywhere benefit people everywhere, and indeed most of the benefits come to generations in the future, perhaps distant future.

The concentrated costs and dispersed benefits provide strong incentives for free-riding in current international climate agreements. *Free-riding* occurs when a party receives the benefits of a public good without contributing to the costs. In the case of the international climate-change policy, countries have an incentive to rely on the emissions reductions of others without taking proportionate domestic abatement. The failure of the Kyoto Protocol, and the difficulties of forging effective follow-up regimes, is largely due to free-riding.

As suggested by the earlier discussion, while free-riding is pervasive, it is particularly difficult to overcome for global public goods. Arrangements to secure an international climate treaty are hampered by the lack of ability to induce reluctant nations to join

international agreements. In essence, all international agreements are essentially voluntary (see the Treaty of Vienna, 1969, article 34).

## 4. Clubs as a Mechanism to Overcome Free Riding

In light of the failure of the Kyoto Protocol, it is easy to conclude that international cooperation is doomed to failure. This is the wrong conclusion. In spite of the obstacles of international law, nations have in fact overcome many transnational conflicts and spillovers through international agreements. There are over 200,000 U.N. registered treaties and actions, which are presumptive attempts to improve the participants' welfare. Countries enter into agreements because joint action can take into account the spillover effects among the participants. While global warming is to date a failed club, there are many examples of successes. Important examples are the international trading system, international financial arrangements, military alliances, and the protocols to reduce ozone-depleting chemicals. These achievements are a reminder that patient efforts to improve relations among nations are not a fruitless task. In these and other cases, the tendency toward free-riding associated with the Westphalian system has been overcome through the mechanism of clubs.

So what is a club? While most of us belong to clubs, we seldom consider their structure. A club is a voluntary group deriving mutual benefits from sharing the costs of producing a shared good or service. The gains from a successful club are sufficiently large that members will pay dues and adhere to club rules in order to gain the benefits of membership.

The theory of clubs is a little-known but important corner of the social sciences. The major conditions for a successful club include the following: (1) that there is a public-good-type resource that can be shared (whether the benefits from a military alliance or the enjoyment of a golf course); (2) that the cooperative arrangement, including the dues, is beneficial for each of the members; (3) that non-members can be excluded or penalized at relatively low cost to members; and (4) that the membership is stable in the sense that no one wants to leave.

The basic idea that is suggested here is that we can make progress in international climate agreements if we adopt the club model rather than the current voluntary model. The idea of a Climate Club should be viewed as an idealized solution of the free-riding problem. Like free trade or physics in a vacuum, the climate club described here will never exist in its pure form. Rather, it is a blueprint that can be used to understand the basic forces at work and sketch a system that can overcome free-riding.

## 5. A Sketch of the Climate Club

Here is a brief description of the proposed Climate Club: The club is an agreement by participating countries to undertake harmonized emissions reductions. The agreement envisioned here centers on an "international target carbon price" that is the focal provision of an international agreement. For example, countries might agree that each country will implement policies that produce a minimum domestic carbon price of \$25 per ton of CO<sub>2</sub>. Countries could meet the international target price requirement using whatever mechanism they choose – carbon tax, cap-and-trade, or a hybrid.

A key part of the club mechanism (and the major difference from all current proposals) is that non-participants are penalized. The penalty analyzed here is uniform percentage

tariffs on the imports of non-participants into the club region. Calculations suggest that a relatively low penalty tariff rate will induce widespread participation among countries as long as the target carbon price is in the range up to \$50 per ton.

## 6. Games and International Behavior

An important aspect of the climate club – and a major difference from current proposals – is that it creates a strategic situation in which countries acting in their self-interest will choose to enter the club and undertake high levels of emissions reductions because of the structure of the incentives. To understand the nature of the incentives and strategies, I discuss the application of game theory to international environmental treaties.

There is a large literature on the strategic aspects of international environmental agreements, including those focused on climate change. One important strand is the analytical work on global public goods. The clear message is that without special features the outcome will be a prisoners' dilemma or tragedy of the commons in which there is too little abatement.

This analysis usually takes place in the framework of non-cooperative (NC) game theory. In the NC framework, countries act in their national self-interest. So when a country designs its environmental or macroeconomic or labor-market policies, it considers the impacts on its own citizens and largely ignores the impacts on other countries. While the idea of countries acting in their self-interest may seem narrow-minded or parochial, it is actually the foundation of democratic theory. Most of the world's ills (think particularly of wars) arise because countries, or more often their leaders, do not act in their countries' national self-interest. For national public goods with minimal cross-border spillovers, the world's welfare is appropriately optimized when countries act in their self-interest. The problems we consider here arise for global public goods, where the non-cooperative approach leads to inefficient outcomes.

Analysis of NC agreements (either one-shot or repeated) leads to three major conclusions for climate change. First, the overall level of abatement in the non-cooperative equilibrium will be much lower than in the efficient (cooperative) strategy. A second and less evident point is that countries will have strong incentives to free-ride by not participating in strong climate-change agreements. Finally, the difficulty of escaping from a low-level, non-cooperative equilibrium is amplified by the intertemporal trade-off because the current generation pays for the abatement while future generations are the beneficiaries of lower damages. To a first approximation, international climate policy as of 2015 looks like a non-cooperative equilibrium.

## 7. Elements of treaties

Non-cooperative outcomes assume that countries never bargain to improve the outcomes. Might coalitions of countries form cooperative arrangements or treaties that improve on non-cooperative arrangements? This question has been extensively studied analytically using game theory, through modeling, and by examination of history.

Theoretical and empirical studies indicate that coalitions concerned with global public goods tend to be fragile and unstable. More precisely, these studies find virtually universally

that coalitions tend to be either small or shallow, a result I will call the “small coalition paradox.”

Here is the background. Suppose that countries can form treaties to provide global public goods, whether for climate change or public health or financial regulation or whatever. A successful agreement would require the participation of most countries. However, to be stable, each country must determine that participation –which requires investments with large national costs but diffuse benefits – has a higher payoff than non-participation. The problem is that stable coalitions tend to have few members; therefore, as the number of countries rises, the fraction of global emissions covered by the agreement declines. Studies by Scott Barrett have found, based on a comprehensive review of existing environmental treaties, that there are very few treaties for global public goods that succeed in inducing countries to increase their investments significantly above the non-cooperative levels. Moreover, the ones that do succeed include external penalties.

This point was foreseen more than three centuries ago in a discussion by David Hume on collective action and free riding:

*Two neighbors may agree to drain a meadow, which they possess in common; because 'tis easy for them to know each other's mind; and each must perceive, that the immediate consequence of his failing in his part, is, the abandoning the whole project. But 'tis very difficult, and indeed impossible, that a thousand persons shou'd agree in any such action; it being difficult for them to concert so complicated a design, and still more difficult for them to execute it; while each seeks a pretext to free himself of the trouble and expence, and wou'd lay the whole burden on others. (Hume, A Treatise of Human Nature, Section VII, 1739)*

How can we understand the small coalition paradox? Here is the intuition for climate change: Clearly, two countries can improve their welfare by combining and raising their abatement (or carbon price) to the level that would maximize their joint welfare. Just as with Hume's neighbors, either country is worse off by dropping out. The 2014 agreement between China and the US to join forces in climate policy might be interpreted as an example of a small bottom-up coalition.

Does it follow that, by increasing the number of countries in the treaty, this process would accumulate into a grand coalition of all countries with efficient abatement? That conclusion is generally wrong. The problem arises because, as more countries join, the level of abatement, and its costs, becomes ever higher, and ever further from the NC level. The discrepancy gives incentives for individual countries to defect. When a country defects from an agreement with many countries, the remainder coalition (of many-minus-one countries) would reoptimize its levels of abatement. The revised levels of abatement would still be well above the NC levels for the remainder coalition, while the defector free-rides on the abatement of the remainder coalition. The exact size of the stable coalitions would depend upon the cost and damage structure as well as the number of countries, but for most analyses using realistic number, stable coalitions are small and perform only slightly better than the non-cooperative equilibrium.

As noted above, the syndrome of free-riding along with the international norm of voluntary participation appears to doom international climate agreements like the Kyoto Protocol. The suggestion here is that a club structure – where external sanctions are imposed on non-members – will be necessary to induce effective agreements.



## 8. Sanctions for international agreements about global public goods

While it is easy to design potential international climate agreements, the reality is that it is difficult to construct ones that are *effective and stable*. Effective means abatement that is close to the level that passes a global cost-benefit test. The concept of stability used here is that a coalition is stable if no group (sub-coalition) among the countries can improve its welfare by changing its participation status. The small coalition paradox motivates the current approach. The goal here is to find a structure that is stable and has a large number of participants for a wide variety of country preferences, technologies, and strategies.

Both theory and history suggest that some form of sanction on non-participants is required to induce countries to participate in agreements with high levels of abatement. A sanction is a governmental withdrawal, or threat of withdrawal, of customary trade or financial relationships. A key aspect of the sanctions analyzed here is that they benefit senders and harm receivers. This pattern contrasts with most cases, where sanctions impose costs on senders as well as receivers and thereby raise issues of incentive-compatibility.

The major potential instrument is sanctions on international trade. Two approaches to trade sanctions might be considered. A first approach, and one that has been widely advocated and examined, is called carbon duties and would put tariffs on the imports of non-participants in relation to the carbon content of these imports. For technical reasons, I do not suggest this route. A second approach, called uniform penalty tariffs and discussed here, would apply uniform percentage tariffs to all imports from non-participating countries. Under this approach, participating countries would levy a uniform percentage tariff (perhaps 2 percent) on all imports from non-participants. This mechanism has the advantage of simplicity and transparency, although it does not relate the tariff specifically to the carbon content of the import.

A major feature of tariff-sanctions is that they are incentive-compatible. Many sanctions have the disadvantage that they penalize the penalizer. For example, if Europe puts sanctions on Russian energy companies, this is likely to raise energy prices in Europe, hurt European consumers, and therefore have costs on Europe as well as Russia. The tariff-sanction mechanism analyzed here imposes costs on the non-participating country but benefits participants that levy the penalty tariffs. Moreover, because tariffs apply bilaterally, they can support an efficient equilibrium for global public goods for a large number of countries.

## 9. The Central Role of Carbon Prices

There are many issues in club design. A central question is how to harmonize countries' policies. What exactly are countries negotiating over? In a Kyoto design, and all the linear descendants through Paris, the negotiations are about quantities. This has proven a slippery slope without much to hold on to. A more promising approach is harmonizing carbon prices, and this is the route followed in the proposed Carbon Club.

Start with the positive reasons to use carbon prices: The economics of climate change is straightforward. Virtually every activity directly or indirectly involves combustion of fossil fuels, emitting carbon dioxide into the atmosphere. If there is a single bottom line from economics, it is that we need to correct this market failure by ensuring that everyone, everywhere, and for the indefinite future faces a market price of carbon that reflects the social costs of their activities. Economic participants – thousands of governments, millions of

firms, billions of people, all taking trillions of decisions each year – need to face realistic carbon prices if their decisions about consumption, investment, and innovation are to be appropriate.

The most efficient strategy for slowing or preventing climate change is to impose a universal and internationally harmonized carbon tax levied on the carbon content of fossil fuels. An alternative would be a hybrid cap-and-trade system, but this has many subtle flaws.

Move next to the negative reasons not to use quantitative targets: Quantitative targets in the form of tradable emissions limits have failed in the case of the Kyoto Protocol. They have shown excessive price volatility, lose precious governmental revenues, and have not lived up to their promise of equalizing prices in different regions. They are unattractive bargaining tools because they can be tailored to favor the strong and disadvantage the weak. To the extent that carbon-price targets lead to carbon taxes, the administrative aspects of taxes are better understood around the world than marketable emissions allowances, and they are less prone to corruption.

It will be useful to use an analogy. Assume a country wishes to reduce its gasoline consumption. It could do so by issuing ration coupons (either to consumers or to companies), and then have a market in tradable coupons. This would give a firm idea of the quantity reduction, but the history of rationing shows that it is highly inefficient and tends to become increasingly distorted over time. No country in the modern world takes this approach. A simpler approach would be to tax gasoline. This is administratively simple, raises revenues for governments, can have unfavorable distributional impacts offset through income-tax changes, and is clearly a system that can endure for decade after decade.

Now go a step further and assume that countries desire to harmonize their gasoline policies. Harmonization of gasoline taxes is simple. By contrast, the design of a harmonized rationing system would be challenging and subject to endless games and lawyerly disputes. The same logic applies to negotiating tax treaties or international trade regimes.

## 10. Modeling a Climate Club

In order to understand how a climate club would operate, it is necessary to move beyond description to analytical and numerical modeling of the incentives and behavior of regions with realistic economic and geophysical structures. The challenge of analyzing and modeling the science and policy associated with global warming is particularly difficult because it spans many disciplines and parts of society. An important approach to bringing the different fields together has been the development of integrated assessment models (IAMs). These pull together in a single model a wide variety of geophysical, economic, and political relationships so that projections, analyses, and decisions can consider simultaneously all important endogenous variables at work. IAMs generally do not aspire to have the most detailed and complex representation of each of its components. Rather, they aspire to have at a first level of approximation the most important relationships and ones that can operate simultaneously and with reasonable accuracy.

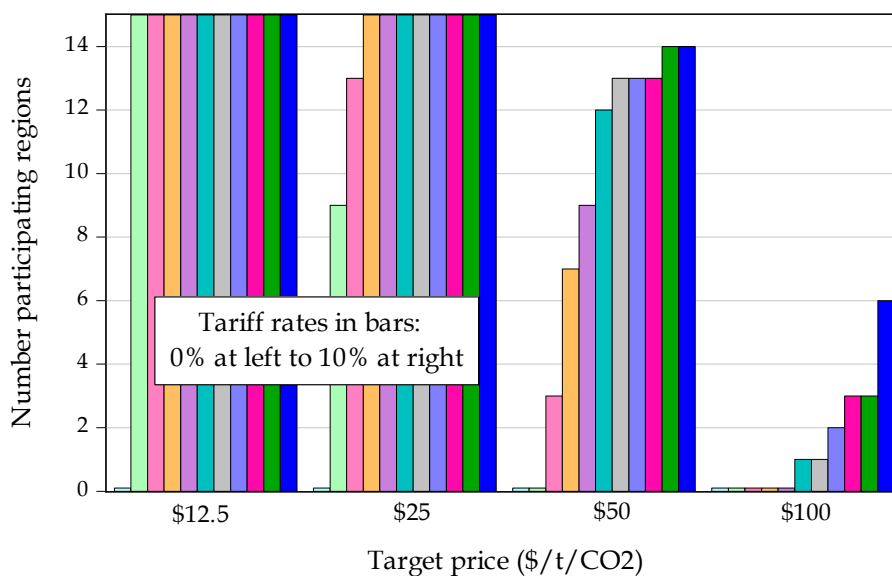
In the major study on which this article is based, I describe an integrated-assessment model (the Coalition-DICE or C-DICE model) of economics, tariffs, and climate change that examines the effects of different potential climate clubs. I will not give a detailed report on the results of those simulations but refer interested readers to the original source for an extended discussion.

The C-DICE model is designed to find whether or not countries join a coalition of high-abatement countries, and to find stable coalitions. It examines 44 different “regimes,” where a regime is defined as an international target carbon price and a penalty tariff rates. The assumed target prices are \$12.5, \$25, \$50, and \$100 per ton CO<sub>2</sub>, and uniform penalty tariffs range from 0% to 10%. For reference purposes, the US government estimates the global social cost of carbon (or the damage imposed by an additional ton of CO<sub>2</sub> emissions) to be around \$35 per ton of CO<sub>2</sub>. In most models, a carbon tax of this magnitude would lead to emissions reduced 15 - 20% relative to a business-as-usual path in the near term. Most economic studies would recommend that the carbon price rise over time to reduce more sharply and even eliminate greenhouse gas emissions over this century.

## 11. Some Illustrative Results

I close by highlighting some of the conclusions of the modeling studies of a climate club. The first major result is to confirm that a regime without trade sanctions will dissipate to the low-abatement, non-cooperative equilibrium. A second surprising result is that, when trade sanctions are imposed, the Climate Club structure generates stable coalitions for virtually all sets of parameters.

A next set of results concerns the impact of different Climate Club parameters on the participation structure. For the lowest target carbon prices (\$12.5 and \$25 per ton of CO<sub>2</sub>), full participation and efficient abatement are achieved with relatively low tariffs (2% or more). However, as the target carbon price rises, it becomes increasingly difficult to achieve full participation. For a \$50 per ton target carbon price, the Club can attain 90+ percent efficiency with a tariff rate of 5% or more. However, for a target carbon price of \$100 per ton, it is difficult to induce more than the non-cooperative level of abatement. Figure 1 illustrates these results.



**Figure 1. Number of participating regions by international target carbon price and tariff rate**

The four sets of bars are the model results for four different international target carbon prices, running from left to right as shown at the bottom. The eleven bars within each set are the penalty tariff rates, running from 0% to 10%. Note that each set has zero participants for a 0% tariff. The vertical scale shows the number of participants. These results are based on the author's C-DICE model. For the source, see Nordhaus, "Climate Clubs" in the references.

What is the pattern of gains and losses? The benefits of a Climate Club are widely distributed among countries. A few regions have losses in some regimes. However, the losses are small relative to gains for other regions. There are no regimes with aggregate losses.

A paradoxical result is that all regions would prefer a climate-club regime with penalties and modest carbon prices to a regime with no penalties. This is the case even for countries that do not participate. The reason is that the gains from strong mitigation measures of participants outweigh the losses from the tariffs for non-participants – as long as the tariff rate is not too high. This powerful result indicates that a regime with sanctions should be attractive to most regions.

The analysis shows how an international climate treaty that combines target carbon pricing and trade sanctions can induce substantial abatement. The modeling results indicate that modest trade penalties on non-participants can induce a coalition that approaches the optimal level of abatement as long as the target carbon prices are not too high. The attractiveness of a Climate Club must be judged relative to the current approaches, where international climate treaties are essentially voluntary and have little prospect of forging agreements that can effectively slow climate change.

## 12. Bibliography and historical notes

The germinal article on public goods is Paul Samuelson, "The Pure Theory of Public Expenditure," *The Review of Economics and Statistics*, Vol. 36, No. 4, Nov. 1954, pp. 387-389. Many of the ideas in this article are drawn from my "Paul Samuelson and Global Public Goods," in Michael Szenberg, Lall Ramrattan, and Aron Gottesman, eds., *Samuelsonian Economics*, Oxford University Press, Oxford, UK, 2006, pp. 88-98. A fine survey of the theory of clubs is in Todd Sandler and John T. Tschirhart, "The Economic Theory of Clubs: An Evaluative Survey," *Journal of Economic Literature*, 1980, 18(4), 1481-1521. The concept of a Climate Club and the modeling results for the C-DICE model are based on my "Climate Clubs: Overcoming Free-riding in International Climate Policy," Presidential Address to the American Economic Association, published in *American Economic Review*, 2015, 05(4): 1339–1370, available at <http://dx.doi.org/10.1257/aer.15000001>. Additional material is drawn from William Nordhaus, *The Climate Casino*, Yale University Press, New Haven, CT, 2013. This article is drawn from my article, "Climate Clubs to Overcome Free-Riding," *Issues in Science at Technology*, Volume XXXI Issue 4, Summer 2015.

William Nordhaus, "Climate Clubs: Overcoming Free-Riding in International Climate Policy," Presidential Address to the American Economic Association, published in *American Economic Review* 5, no. 4 (2015): 1339–1370, available at <http://dx.doi.org/10.1257/aer.15000001>.

# Chapter 5

## Internalizing the Climate Externality: Can a Uniform Price Commitment Help?

MARTIN L. WEITZMAN<sup>a</sup>

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### ABSTRACT

*It is difficult to resolve the global warming free-rider externality problem by negotiating many different quantity targets. By contrast, negotiating a single internationally-binding minimum carbon price (the proceeds from which are domestically retained) counters self-interest by incentivizing agents to internalize the externality. In this contribution I attempt to sketch out, mostly with verbal arguments, the sense in which each agent's extra cost from a higher emissions price is counter-balanced by that agent's extra benefit from inducing all other agents to simultaneously lower their emissions in response to the higher price. Some implications are discussed. While the paper could be centered on a more formal model, here the tone of the discussion resembles more that of an exploratory think piece directed to policy-makers and the general public.*

**Keywords:** Climate change, Global Warming, International public goods, Prices versus quantities, UN climate negotiations

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### ✎ 1. INTRODUCTION: GLOBAL WARMING GRIDLOCK ✎

The world is currently mired in what has aptly been called *global warming gridlock*.<sup>1</sup> The core problem confronting the economics of climate change is an inability to overcome the obstacles associated with free riding on a very important international public good. The ‘international’ part is significant. Even within a nation, it can be difficult to resolve public goods problems. But at least there is a national government, with some governance structure, able to exert some control over externalities within its borders. With climate change there is no overarching international governance mechanism capable of coordinating the actions necessary to overcome the problem of free riding.

Throughout this paper I use the terms “climate change” and “global warming” interchangeably. The term “climate change” is currently in vogue and is a more apt description overall. But the term “global warming” is more evocative of this paper’s main theme. Global warming is a *global* public-goods externality whose resolution requires an unprecedented degree of international cooperation and coordination. This international climate-change externality has frequently been characterized as the most difficult public goods problem that humanity has ever faced. I concentrate in this paper on carbon dioxide emissions, but in principle the discussion could be extended to emissions of all relevant greenhouse gases. Throughout

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1. Global Warming Gridlock is the title of a book by David Victor (2011), who popularized the phrase.

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the paper I blur the distinction between carbon dioxide and carbon, since the two are linearly related.<sup>2</sup>

My point of departure throughout all of what follows is the critical centrality of the international free-rider problem as a cause (really *the* cause) of negotiating difficulties on climate change emissions. Negotiators here are playing a game in which self-interested strategies are a crucial consideration. It turns out that negotiating rules define an important part of the game, and can thereby change self-interest, for better or for worse.

In this paper I try to argue that a uniform global price on carbon emissions can provide a focal point for a common commitment, while quantity targets, which do not as readily present such a single focal point, have a tendency to rely ultimately on individual commitments. As a consequence, negotiating a global price helps to solve the externality problem while individual caps essentially incorporate it. I will try to explain why negotiating a uniform carbon price embodies what I call a “countervailing force” against narrow self-interest by automatically incentivizing all negotiating parties to (approximately) internalize the externality.

## ✎ 2. NEGOTIATING PRICES VS. NEGOTIATING QUANTITIES ✎

At first, for simplicity of exposition I assume that a commitment to a global price of carbon will be implemented as an internationally harmonized, but nationally retained, carbon tax.

An internationally harmonized but nationally retained carbon tax (or price) has already been proposed as a potential solution to the global warming externality, and has been examined on its merits.<sup>3</sup> In what follows I very briefly summarize some of the possible virtues of an internationally-harmonized but nationally-collected carbon tax (or price) that have already been noted in the literature. My foil here is an internationally harmonized cap-and-trade system. This kind of global-design comparison is complicated and full of subjective judgements about what might or might not work better in practice and why or why not. Cap-and-trade systems are perhaps more widely used throughout the world to control pollution, and in that sense are perhaps more visible or more familiar than pollution taxes (although fossil-fuel taxes and subsidies are ubiquitous, if somewhat hidden, almost everywhere). My purpose here is merely to indicate that the perhaps less-familiar uniform carbon tax already has some significant arguments in its favor—as a prelude to some new arguments for negotiating a uniform price on carbon that I will later develop in this paper.

Both quantity-based and price-based controls are inherently uncertain for the period during which they apply (in between times of periodic review), but the uncertainty takes different forms. With cap-and-trade, total emissions are known but the price or (marginal) cost is uncertain. With a carbon tax, the price or (marginal) cost of carbon emissions is known, but total emissions are uncertain. On the basis of economic models of climate change that include uncertainty, carbon taxes outperform tradable permits, both theoretically and in numerical simulations.<sup>4</sup> In the real world, above and beyond theory and numerical simulations, I think that energy price volatility is very poorly tolerated by the general public. Swings in carbon prices, especially in extreme cases, could sour public opinion and discredit for some time thereafter (decades, generations?) the entire idea of a market-based approach to the

2. One ton of carbon equals 3.67 tons of carbon dioxide. My default unit is carbon dioxide (CO<sub>2</sub>).

3. There is actually a fair-sized literature on a carbon-tax (or carbon-price) approach. See, e.g., Metcalf and Weisbach (2009), Cooper (2010), Cramton and Stoft (2012), Nordhaus (2007, 2013), and the many further references cited in these works.

4. See Hoel and Karp (2002), Pizer (1999), and Weitzman (1974).

climate change problem. On the other hand, it is difficult for me to imagine the broad public getting quite so upset because total emissions fluctuate.

It has been argued, I think convincingly, that a carbon tax is more easily administered and is more transparent than a cap-and-trade system. This consideration is especially important in a comprehensive international context that would include all major emitting countries. Under international cap-and-trade, governments will allocate valuable emissions permits to their nation's firms and residents. In some places, under some circumstances, there may be a great temptation for kleptocrats to effectively steal these valuable emissions permits and sell them on the international market.

The collected revenues from an internationally harmonized carbon tax remain within each country, and could be used to offset other taxes or even be redistributed internally as lump sum payments. This, I think, is a desirable property. By contrast the revenues generated from an internationally harmonized cap-and-trade system flow as highly visible external transfer payments across national borders, which might be less easily tolerated by countries required to pay other countries large sums of taxpayer-financed money to buy permits.<sup>5</sup>

This extremely brief, and perhaps somewhat biased, discussion of the advantages of an internationally harmonized carbon tax (compared to cap-and-trade) is not intended to be comprehensive. There are also legitimate arguments in favor of internationally harmonized tradable permits and against a carbon tax.<sup>6</sup>

A point in favor of tradable permits, frequently emphasized by its advocates, is the political appeal of giving free allowance permits to carbon-intensive industry groups (as contrasted with taxing them directly on their carbon emissions). As was pointed out, carbon taxes that are internally-levied and collected by a national government could be used to reduce other, more distortionary, taxes—or they could even be distributed directly to the citizenry as lump-sum payments. But this redistribution aspect of a carbon tax is hidden, behind the scenes as it were. Individual firms will prefer, and typically strongly prefer, what they perceive as the lesser burden of freely allocated permits over the greater perceived burden of pollution taxes. Indeed, studies show that the market value of the free allowances is typically significantly greater than the higher compliance costs of decarbonization that are incurred.<sup>7</sup> Firms and countries in a cap-and-trade regime will therefore struggle hard for a larger share of the total amount of freely distributed emissions allocations. The political appeal of freely distributed tradable permits is a double-edged sword. When negotiating emissions caps, a serious income distortion is introduced because a nation is much more concerned with the revenues from its own free quota allocations than it is concerned with overall international social optimality. Auctioning off the allowances would eliminate this income-effect distortion on the individually desired level of free permit allocations, but then we are effectively back in a tax-like system.

Both approaches (an internationally harmonized but domestically collected carbon price, and freely distributed marketable permits) are subject to immense—sometimes seemingly

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5. Of course, persuading nations to commit to negotiating a uniform price of carbon in the first place might well involve some “green-fund” equity transfers. Because the imposed “carbon tax” is internally retained within each nation, then, at least for small changes, the green-fund transfers needed to offset increased costs of compliance for price changes are deadweight-loss second-order Harberger triangles of the relatively modest form  $(\Delta P \times \Delta Q)/2$ . The corresponding international transfers in a cap-and-trade system (which can be either positive or negative, depending, among other things, on initial cap assignments) are first-order immodest rectangles of the form  $P \times \Delta Q$ .

6. For a critical review of carbon taxes vs. cap-and-trade, see Goulder and Schein (2013) and the many further references they cite.

7. See Goulder et al (2010) and the further cited references therein.



overwhelming—criticisms. In both cases there are innumerable practical details that must be attended to and worked out. In both cases an effective international treaty needs to be binding, which raises uncomfortable issues of enforcement mechanisms and international sanctions. Additionally, there might be mixed hybrid systems. I merely want to establish a level playing field where the idea of an internationally harmonized carbon tax already commands at least as much intellectual respect as an internationally harmonized cap-and-trade system.

The Kyoto approach to global warming was inspired by the ultimate vision of a top-down worldwide treaty limiting the output of each nation's carbon dioxide emissions. It had been wishfully hoped that the highly incomplete Kyoto quantity assignments might have grown over time into a comprehensive binding system of national emissions caps. If these comprehensive caps were freely traded internationally as emissions permits, and if every country had implemented a comprehensive cap-and-trade system internally, it would have caused there to be one uniform worldwide price of carbon emissions, thereby guaranteeing cost effectiveness.

As events played out, Kyoto did not come close to its inspirational vision of an internationally harmonized binding system of emissions caps. By now, the quantity-based Kyoto-type approach has pretty much broken down, leaving the world with a patchwork of sporadic regional volunteerism that does not address centrally how to efficiently correct the critical international externality of global warming.

Throughout this paper I argue that it is very difficult to resolve the global warming externality problem by directly assigning individual quantity targets. A meaningful comprehensive quantity-based treaty involves specifying as many different binding emissions quotas (whether in the form of tradable permits or not) as there are national entities. Each national entity has a self-interested incentive to negotiate for itself a high cap on carbon emissions—much higher than would be socially optimal. The resulting free-rider problem plagues a quantity-based approach. Even if there were a collective commitment to negotiate or vote on a second-stage worldwide total emissions cap, which I will later assume for the sake of argument, disagreements over the first-stage fractional subdivision formula (for disaggregating the negotiated or majority-voted aggregate worldwide quantity cap into individual quantity caps) would make it difficult to enact such a quantity-based approach.<sup>8</sup>

The inspiration for this paper is the perception of a desperate need for some radical rethinking of international climate policy. As a possibly useful conceptual guide for what negotiations might accomplish, I sometimes ask the reader to temporarily suspend disbelief by considering what might happen in a “World Climate Assembly” (WCA) that votes on global carbon emissions via the basic principle of one-person-one-vote majority rule. In this conceptualization, nations would vote along a single dimension for their desired level of emissions stringency on behalf of their citizen constituents, but the votes are weighted by each nation's population.

Right now, anything like a WCA seems hypothetical and futuristic. It presumes a state of mind where the climate change problem has become sufficiently threatening on a grassroots level that world public opinion is ready to consider novel governance structures which involve relinquishing some national sovereignty in favor of the greater good. What might be the justification for a new international organization like the WCA? The ultimate justification is

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8. One could try to argue that binding green-fund equity payments are required to get  $n$  countries to agree in the first place to negotiate a uniform carbon price, also representing an  $n$ -dimensional problem. However, footnotes 5 and 7 suggest that the required green-fund payments may be smaller than the absolute value of the (positive or negative) transfers involved in a cap-and-trade regime that starts off, say, with equal per-capita permit assignments.

that big new problems may require big new solutions. For a world desperately wanting new solutions to the important externality of climate change, perhaps it is at least worth considering establishing a new organization along the lines of the WCA. After all, it is useful to have some concrete fallback decision mechanism behind vague “negotiations” because even with the focus on a one-dimensional harmonized carbon price (or with the focus on a one-dimensional quantity of total emissions), there are bound to be disagreements whose resolution is unclear. I merely assume that it is in the interest of enough nations to forfeit their rights to pollute in favor of a WCA voting solution of the global warming externality. This is truly a heroic assumption at the present time because the WCA does not correspond to any currently-existing international body. Taken less literally, the thought experiment of a hypothetical WCA can still help us to concentrate our thinking and intuition on what negotiations should be trying to accomplish. In other words, I am hoping that the fiction of a WCA might be useful in indicating what might be the outcome of less-formal international negotiations.

It might be objected that a “consensus” voting rule, not a majority voting rule, is employed in negotiations under the United Nations Framework on Climate Change. This “consensus” voting rule has been widely interpreted as requiring near-unanimity. With such a restrictive voting rule, significant progress on resolving the global warming externality is virtually impossible. Surely, a less restrictive voting-like rule, such as majority rule, would render progress more likely, and is at least worth considering.

One aspect should perhaps be emphasized above all others at the outset. The global warming externality problem cannot be resolved without a binding agreement on some overall formula for dividing emissions responsibilities among nations. Volunteer altruism alone will not solve this international public-goods problem. Of necessity there must be some impingement on national sovereignty in the form of an international mechanism for coordinating targets, verifying fulfillment, and punishing non-compliance. The question then becomes: *Which* collective-commitment frameworks and formulas are more promising than which others?

### ✎ 3. THEORY OF NEGOTIATING A UNIFORM CARBON PRICE ✎

In this paper I examine the theoretical properties of a natural one-dimensional focus on negotiating a single binding price on carbon emissions, the proceeds from which are domestically retained. As was previously mentioned, for expositional simplicity, I identify this single binding price on carbon as if it is a harmonized carbon tax. At a theoretical level of abstraction, I blur the distinction between a carbon price and a carbon tax. However, in actuality the important thing is acquiescence by each nation to a binding minimum price on carbon emissions, not the particular mechanism by which this binding minimum price is attained by a particular nation.

A system of uniform national carbon taxes with revenues kept in the taxing country is a relatively simple and transparent way to achieve harmonized carbon prices. But it is not necessary for the conclusions of this paper. Nations or regions could meet the obligation of a minimum price on carbon emissions by whatever internal mechanism they choose—a tax, a cap-and-trade system, a hybrid system, or whatever else results in an observable price of carbon. I elaborate further on this issue in my concluding remarks.

At a theoretical level, I would suggest that the instruments of negotiation for helping to resolve the global warming externality should ideally possess three desirable properties.

1. *Induce cost effectiveness.*
2. Be of *one dimension centered on a “natural” focal point* to facilitate finding an agreement with relatively low transactions costs.
3. *Embody “countervailing force” against narrow self interest by automatically incentivizing all negotiating parties to internalize the externality.*

Using these three desirable theoretical properties as criteria, I now compare and contrast an idealized binding harmonized price with an idealized binding cap-and-trade system.

On the first desirable property, in principle both a carbon price and tradable permits achieve cost effectiveness (provided agreement can be had in the first place).

The second desirable property (low dimensionality) argues in favor of a one-dimensional harmonized carbon price over an  $n$ -dimensional harmonized cap-and-trade system among  $n$  nations. Alas, this argument is elusively difficult to formulate rigorously, or even to articulate coherently. My argument here is necessarily intuitive or behavioral and relies on empirical counter-examples. In this case a primary empirical counter-example is the breakdown of the quantity-based Kyoto approach.

With  $n$  different national entities, a quantity-based treaty involves assigning  $n$  different binding emissions quotas (whether tradable or not). Treaty making can be viewed as a coordination game with  $n$  different players. Such a game can have multiple solutions, often depending delicately on the setup, what is being assumed, and, most relevant here, the choice of negotiating instrument. In the case of Kyoto, the world has in practice arrived at a bad quantity-based solution that has essentially devolved to regional volunteerism.

Thomas Schelling introduced and popularized the notion of a focal point in game theory.<sup>9</sup> Generally speaking, a focal point of an  $n$ -party coordination game is some salient feature that reduces the dimensionality of the problem and simplifies the negotiations by limiting bargaining to some manageable subset, hopefully of one dimension. The basic idea is that by limiting bargaining to a salient focus, there may be more hope of reaching a good outcome. In a somewhat circular definition, a focal point is anything that provides a focus of convergence. The “naturalness” or “salience” of a focal point is an important aspect of Schelling’s argument that is difficult to define rigorously and is ultimately intuitive.

The concept of “transactions cost” is associated with the work of Ronald Coase.<sup>10</sup> The basic idea is that  $n$  parties to a negotiation can be prevented from attaining a socially desirable outcome by the costs of transacting the agreement among themselves. One could try to argue that, other things being equal, transactions costs increase at least proportionally with the number of parties  $n$ .

In the case of international negotiations on climate change, I believe that both Schelling’s concept of a salient focal point and Coase’s concept of transactions costs can be used as informal arguments to support negotiating a single harmonized carbon price whose proceeds are nationally rebated. Put directly, it is easier to negotiate one price than  $n$  quantities—especially when the one price can be interpreted as “fair” in terms of equality of marginal effort. I cannot defend this claim rigorously. At the end of the day, this is more of a plausible conjecture than a rigorous theorem. Whether justly or not, throughout this paper I basically

9. Schelling (1960). See also the special 2006 issue of the Journal of Economic Psychology devoted to Schelling’s psychological decision theory, especially the introduction by Colman (2006). Three of the seven articles in this issue concerned aspects of focal points, testifying to the lasting influence of the concept.

10. Coase himself did not invent or even use the term “transactions cost” but he prominently employed the concept. See Coase (1960). For an application of the transactions cost approach to controlling greenhouse gas emissions, see Libecap (2013).

assume that the essential contrast is between one binding price assignment versus  $n$  binding quantity assignments—and I then proceed to examine the consequences.

The third desirable property is that the instrument or instruments of negotiation should embody a “countervailing force” against narrow free-riding self-interest by incorporating incentives that automatically internalize the externality. I believe this third property is arguably the most important property of all. This “countervailing force” property is inherently built into a price-based harmonized system of emissions charges, but it is absent from a quantity-based international cap-and-trade system, at least as traditionally formulated.

If I am assigned a cap on emissions, then it is in my own narrow free-riding self-interest to want my cap to be as large as possible (whether or not my cap will be tradable as a permit). The self-interested part of me wants maximal leniency for myself. Other than altruism, there is no countervailing force on the other side encouraging me to lower my desired emissions cap because of the externality benefits I will be bestowing on others.

*Within* a nation, the government *assigns* binding caps. But *among* sovereign nations, binding caps must be *negotiated*. I believe that this is a crucial distinction for the success or failure of a cap-and-trade regime. A Kyoto-type quantity-based international system fails because no one has an incentive to internalize the externality and everyone has the self-interested incentive to free ride. What remains is essentially an erratic pattern of altruistic individual volunteerism that is far from a socially optimal resolution of the problem.

An internationally-harmonized domestically-collected carbon price is different. If the price were imposed on me alone, I would wish it to be as low as possible so as to limit my abatement costs. But when the price is uniformly imposed, it embodies a countervailing force that internalizes the externality for me. Counterbalancing my desire for the price to be low (in order to limit my abatement costs) is my desire for the price to be high so that other nations will restrict their emissions, thereby increasing my benefit from worldwide total carbon abatement. A binding uniform price of carbon emissions has a built-in self-enforcing mechanism that countervails free riding.<sup>11</sup>

In previous work, I have tried to model formally the role of this third “countervailing force” property of an internationally-harmonized but nationally-collected carbon price.<sup>12</sup> I constructed a basic model indicating an exact sense in which each agent’s extra cost from a higher international emissions price is counter-balanced by that agent’s extra benefit from inducing all other agents to simultaneously lower their emissions via the higher international price.

With further restrictions, the model showed that population-weighted majority rule for an internationally harmonized carbon price can come as close to an optimal price on emissions as the median per-capita marginal benefit is close to the mean per-capita marginal benefit. The key insight from this way of looking at things is that in voting (or more generally negotiating) a universal carbon price, various nations are, to a greater or lesser degree, internalizing the externality. Loosely speaking, an “average” nation is fully internalizing the exter-

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11. Later I discuss negotiating one worldwide aggregate emissions cap (contingent upon a previous-round subdivision formula for  $n$  fractional targets, set, for example, by a preceding agreement on various target reductions from various baselines). A system based on negotiating aggregate emissions (given a subdivision formula) could, in principle, embody countervailing force against the global warming externality. But, again, I will conclude that negotiating the extra layer of  $n$  first-round Kyoto-like fractional subdivision target reductions will likely founder politically when applied on a worldwide scale.

12. See Weitzman (2014).

nality because its extra cost from a higher emissions price is exactly offset by its extra benefit from inducing all other nations to simultaneously lower their emissions via the higher price.

On the price side, a uniform carbon price automatically has the desirable property that cost effectiveness is guaranteed. I think that the formal voting result of the model might perhaps be interpreted somewhat less formally as indicating that negotiating an internationally harmonized (but nationally collected) carbon price may have an important desirable property on the quantity side as well. If the median marginal benefit (per capita) equals the mean marginal benefit (per capita), then the socially optimal carbon price has the property that, roughly speaking, half of the world's population wants the price to be higher, while the other half of the world's population wants the price to be lower. In this situation, the desirable quantity-side property is that the total worldwide output of all emissions might be "close" to being optimal to the extent that the outcome of negotiations mimics the outcome of majority voting. Although the real world is a far more complicated and nuanced place than the restrictive theoretical model that was constructed, I think this voting result is trying to indicate something positive (even if only at an abstract level) about how a negotiated uniform carbon price might possess some overall potential to counteract via internalization the externality of global warming.

#### ✎ 4. MIGHT A MODIFIED CAP-AND-TRADE WORK AS WELL? ✎

Previously I listed three desirable features that instruments for negotiating climate change should ideally possess: (1) cost effectiveness; (2) a natural one-dimensional focal point; (3) a built-in self-enforcement mechanism that internalizes the externality. I then explained that an internationally-harmonized but nationally-retained carbon price possesses all three properties, whereas an  $n$ -dimensional quantity-based cap-and-trade system at best (if it can be negotiated in the first place) possesses only the first property of cost effectiveness. With  $n$  different nations, there will be difficult bargaining over  $n$  different caps with no force other than altruism countervailing each nation's selfish desire to be a free rider and secure for itself a large cap on emissions.

But maybe I am being unfair to tradable permits. Suppose we imagine trying to convert the  $n$ -dimensional problem of allocating carbon emissions permits into some one-dimensional quantity analogue of a uniform price on carbon emissions. We might imagine a thought experiment where the cap-and-trade negotiators are sitting around a negotiating table and limiting themselves to simple linear formulas for allocating individual emissions caps as a fraction of total world emissions.<sup>13</sup>

Suppose the cap-and-trade negotiators must decide the total amount of emissions  $E$ , given a sub-allocation formula for deciding the fraction of emissions permits allotted to each nation. A standard way of conceptualizing this allocation problem for each country is in terms of an assigned fractional emissions reduction from an assigned baseline level. Here I think it is most instructive to view the essence of such an assignment process in terms of a simple linear reduced form that allots emissions permits  $E_i(E) = a_i + b_i E$  to nation  $i$  (where  $\sum a_i = 0$ ,  $b_i > 0$ , and  $\sum b_i = 1$ ).

If each nation  $i$  would accept as *given* the assigned distributional coefficients  $(a_i, b_i)$  and

13. This approach is spelled out in more mathematical detail in Weitzman (2014).

the above sub-allocation formula  $E_i(E) = a_i + b_i E$ , one might then imagine negotiating over (or even voting for) the total emissions  $E$ . *Contingent* upon the distribution of coefficients being accepted as given, this system would seemingly possess the desirable property of having a one-dimensional locus of negotiations (here the level of total worldwide emissions  $E$ ). And there is also countervailing force against negotiating for a higher value of worldwide total emissions  $E$ . Although each nation  $i$ 's automatic assignment of a higher individual emissions cap  $E_i$  when total emissions  $E$  are higher helps directly by lowering its emissions costs, this domestic effect is counteracted by the benefits that each nation would lose from a higher total worldwide emissions level, because then everyone else would also emit more. It appears that such a cap-and-trade system might in principle have desirable focal-point and countervailing-force properties *if* the assigned distribution coefficients were accepted and bargaining were restricted to negotiating total emissions.

But now follow the thought experiment further by asking: Where do the distributional sub-allocation coefficients  $(a_i, b_i)$  come from in the first place? They are presumably the result of an  $n$ -party negotiating process where there is no countervailing force to the selfish desire of each country to make its own fractional allocation coefficients as high as possible. With  $n$  different nations, there will be the usual difficult bargaining over  $n$  different distributional coefficients, with no externality-internalizing incentive countervailing each nation's desire to secure for itself a high fraction of emissions—again presumably resulting in a Kyoto-like breakdown.

When a cap-and-trade system is used to control pollution *within* a nation, the government of that nation *assigns* the caps (or the fractions of emissions).<sup>14</sup> In this intra-national case there is a natural symmetry between a one-dimensional price  $p$  and a one-dimensional total quantity of emissions  $E$ . But there is no international government that has the unilateral power to assign caps or fractions. These caps or fractions must be *negotiated* among sovereign nations. This breaks the one-dimensional symmetry because now one price  $p$  is contrasted with the asymmetry of  $n$  vested sovereign interests jockeying for the  $n$  initial fractional distributions. There is thus a critical distinction between intra-national and inter-national cap-and-trade systems. In the international case the initial distribution of caps is explicitly distributive, resulting in a war of words about who caused the global-warming problem and who should bear the burden of remedying it, who is rich and who is poor, what is fair and what is unfair, and so forth and so on. There could also be a war of words about the green-fund transfers required to induce participation in a uniform-price treaty, but, for reasons elaborated in footnotes 5 and 8 having to do with the difference between first-order and second-order transfers, I think that an internally-retained price treaty takes a lot of pressure off the green-fund payments.

But perhaps a formulation of this generality is biased against cap-and-trade. We might try to imbue the distribution coefficients with dimensionality-reducing salient qualities by imagining “naturally symmetric” focal allocations of the fractional coefficients. One such seemingly symmetric formula might be that each country is assigned the same fractional reduction of emissions from some agreed-upon baseline year. The Kyoto Protocol of 1997 adopted just a little of the spirit of this idea for developed countries alone, with the hope that some variant of it might later be extended to developing countries. The high-income industrialized countries (Annex I) agreed to “binding” commitments (but without any enforcement

14. Admittedly, this is often done in a way that eases special-interest acceptance, such as being allocated for free or almost for free based on something like a uniform reduction of previous pollution levels.

mechanism!) to reduce greenhouse gas emissions in 2012 by an average of 5% relative to 1990 levels (although allowing some individually-negotiated variations around that 5% average). Developing countries were exempt from any “binding” commitments. Overall, the Kyoto Protocol did not come close to fulfilling its initial aspirations. The U.S. and Australia did not ratify, Canada and Japan eventually dropped out, and individual compliance was at best spotty.<sup>15</sup> Furthermore, and perhaps most distressingly, non-Annex I countries have not formally agreed to any actual future “binding” commitments going forward from 2012. The Kyoto experience is subject to multiple interpretations. For me, it largely testifies to the great difficulty of negotiating binding international quantity caps on the major emitters. In the language that I have employed here, it has been overwhelmingly problematic to assign binding quantity-like distributional coefficients on a worldwide basis.

Other seemingly symmetric quantity formulas might also be examined. For example, one might entertain the idea of assigning the same worldwide emissions level per capita. This is a symmetric formula that embodies a certain concept of worldwide fairness, but a cap-and-trade system based on such an initial distribution of caps would involve massive transfers from the developed to the developing countries, which would likely prove politically unacceptable. Besides, even this formula does not address concerns regarding historical responsibility for the cumulative stock of emissions, which would surely be raised. Alternatively, one might imagine negotiating (or even voting on) an identical percentage reduction from some base case of emissions. In this situation, I think, everyone would first argue about the fairness of the baseline emissions that they were initially assigned.

I abstain from further speculation. My point is that no matter what quantity-like initial allocation mechanism I can imagine, an attempt to modify an international cap-and-trade system by making it one dimensional seems likely to founder for essentially the same reasons that an unmodified international cap-and-trade system founders. In a quantity-based system with  $n$  different sovereign nations I fear there will be intractable negotiations for  $n$  different distributional assignments  $(a_i, b_i)$ , with no force countervailing each nation’s free-riding desire to secure for itself a selfishly lenient emissions fraction of the total emissions  $E$ .<sup>16</sup>

Here is what I think is the essence of the one-price vs.  $n$ -quantities negotiation problem as elaborated in this section. A quantity-type system based on a formula like  $E_i(E) = a_i + b_i E$  involves *two* layers of negotiations. First, the  $n$  parties must agree on the quantity-like distributional coefficients  $(a_i, b_i)$ . Then, second, the parties must agree on the single worldwide aggregate level of emissions  $E$ . By contrast, a price-based system involves only *one* layer of negotiation, focused on agreeing to a single one-dimensional uniform price  $p$ . This latter is not an easy task, but it would seem generally easier to negotiate one price layer than two quantity layers (whose first layer involves assigning  $n$  quantity-like distributional coefficients). Admittedly this argument depends upon a particular way of framing the issue, but it seems to me that, in international negotiations among  $n$  sovereign nations, there may be an irreducible asymmetry between one price instrument vs.  $n$  quantity instruments.

15. The one bright spot might be considered the European Union, whose emissions trading system could perhaps be interpreted as evolving towards an EU-wide cap (declining annually) with member-state shares increasingly being determined by auctioning permits. I am unsure and somewhat skeptical about the extent to which this EU model might be extended to the world as a whole. For a generally favorable assessment of this possibility, see Ellerman (2010).

16. Bosetti and Frankel (2012) propose a constructive and imaginative allocation formula for emissions permits, but it still looks complicated and contentious to me.

Even while acknowledging that it only involves one layer of negotiations (as opposed to two on the quantity side), one could ask on the price side what might induce  $n$  countries to agree to a single harmonized charge for carbon emissions. We have been over this ground before. It all begins with the recognition that any resolution of the global warming free-rider problem requires a collective commitment to some binding restriction on the sovereign right of nations to freely emit as much carbon dioxide as they wish. Why might nations restrict their own sovereignty by collectively committing to a common price regime for resolving the global warming externality? Perhaps because enough of them come to realize (or are made to realize) that the international climate-change public good is sufficiently important to outweigh national rights to pollute the global commons—and that a radical collective problem may call for a radical collective solution. Without such a realization and the will to act upon it, progress on resolving the global warming externality will be limited to voluntary altruism, which seems not nearly enough to overcome the free rider problem.

## ✎ 5. CONCLUDING REMARKS ✎

At the end of the day, there is no airtight logic in favor of a negotiated price over negotiated quantities, only a series of partial arguments. One argument is that the revenues from a carbon price are nationally collected, so that the contentious distributional side is somewhat hidden and there is at least the appearance of fairness as measured by equality of marginal effort. A second desirable feature, I have argued, is the natural salience and relatively low transaction costs of negotiating one price as against negotiating  $n$  quantities, which, while somewhat imprecise, is in my opinion an important distinction. A third argument is the self-enforcement mechanism that constitutes the main theme of this paper, namely the built-in countervailing force of an imposed uniform price of carbon, which tends to internalize the externality and gives national negotiators an incentive to offset their natural impulse to otherwise bargain for a low price.

Of necessity, my argument has been sprinkled with subjective judgements. This, unfortunately, is the nature of the subject. To repeat yet again, this time after examining somewhat more carefully the alternatives, I judge it difficult to escape the conclusion that, in the context of an international treaty that covers all major emitters, it is more politically acceptable and it comes closer to a social optimum to negotiate one binding price than  $n$  binding quantities or quantity-like distributional coefficients.

My argument here is sufficiently abstract that it is open to enormous amounts of criticism on many different levels. There are so many potential complaints that it would be incongruous to list them all and attempt to address them one by one. These many potential criticisms notwithstanding, I believe the argument here is exposing a fundamental countervailing-force argument that deserves to be highlighted.

Because the formulation is at such a high level of abstraction, it has blurred the distinction between a carbon price and a carbon tax. As was previously noted, the important thing is acquiescence by each nation to a *binding minimum price* on carbon emissions, not the particular internal mechanism by which this obligation is met. A system of national carbon taxes with revenues kept in the taxing country is a relatively simple and transparent way to achieve harmonized carbon prices. But it is not necessary for the conclusions of this paper. Nations or regions could meet the obligation of a minimum price on carbon emissions by whatever internal mechanism they choose—a tax, a cap-and-trade system, a hybrid system, or whatever



else results in an observable price of carbon.<sup>17</sup> And any nation or region could choose to impose a carbon price above the international minimum. The hope is that even a low positive initial value of a universal minimum carbon price could be useful for gaining confidence and building trust in this price-based international architecture.

The purpose of this paper is primarily expository and exploratory. *Any* proposal to resolve the global warming externality will face a seemingly overwhelming array of practical administrative obstacles and will need to overcome powerful vested interests. That is the nature of the global warming externality problem. The theory of this paper seems to indicate that negotiating a uniform minimum price on carbon can have several desirable properties, including, especially, helping to internalize the global warming externality. To fully defend the relative “practicality” of what I am proposing would probably require a book, not an article. In any event, *this* article is not primarily about practical considerations of international negotiations. I leave that important task mostly to others.<sup>18</sup> However, I do want to mention just a few real-world considerations that have been left out of my mental model yet seem especially pertinent.

An example of a relatively small practical issue that I am waving aside is just where in the production chain a carbon price should be collected. I think the presumption would be that the carbon price should be collected by the country in which the carbon dioxide is actually released into the atmosphere. One might try to argue that a carbon price should be collected downstream as close as possible to the point where the carbon is burned. But this would involve an impractically large number of collection points. It is much easier to collect the price upstream, at various chokepoints where the carbon is first introduced into the carbon-burning economy.<sup>19</sup>

A truly critical issue is that a binding international agreement on a uniform minimum carbon price requires some serious compliance mechanism. To begin with, the carbon price must be observable. For enforcement, perhaps there is no practical alternative to using the international trading system for applying tariff-based penalties on imports from non-complying nations. Nordhaus (2015) advocates such an approach with uniform border tariffs on imports from non-member countries imposed by a “climate club” of member nations who agree to impose on themselves a harmonized carbon price. Cooper (2010) has argued for an expansive interpretation whereby the internationally agreed charge on carbon emissions would be considered a cost of doing business, such that failure to pay the charge would be treated as a subsidy that is subject to countervailing duties under existing provisions of the World Trade Organization.<sup>20</sup>

An efficient carbon price naturally produces more winners than losers (by the metric of the modified Pareto criterion). In the case of the global warming externality, which has been characterized as the greatest public goods problem of all time, it seems reasonable to suppose that there might be many times more winners than losers from imposing a uniform carbon price. Because countries here get to keep their own carbon-price-generated revenues, then welfare-compensating transfers, to the extent they are made at all, ought, at least for small

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17. A minimum carbon price could be attained in a cap-and-trade system by setting it as a floor, which could be enforced, e.g., by making it a reserve price on the auctioning of permits.

18. See, e.g., Bodansky (2010) or Barrett (2005).

19. This set of issues and its distributional consequences (including references to other literature) is discussed extensively in Asheim (2012).

20. See also the discussion of the legality of such sanctions under WTO provisions in Metcalf and Weisbach (2009).

changes, to be relatively modest second-order deadweight-loss triangles instead of the relatively immodest first-order rectangle transfers associated with tradable permits from, say, an initial assignment of caps that are equal per-capita.<sup>21</sup>

I close by noting again that global warming is an extremely serious as-yet-unresolved international public goods problem. With the failure of a Kyoto-style quantity-based approach, the world has seemingly given up on a comprehensive global design, settling instead for sporadic national, sub-national, and regional measures. These partial measures seem far from constituting a socially efficient response to the global warming externality. Perhaps, as was previously suggested, the Kyoto-style quantity-based focus on negotiating emissions caps embodies a bad design flaw. The arguments of this paper indicate a way in which negotiating a binding internationally-harmonized nationally-collected minimum price on carbon emissions might help to internalize the global warming externality.

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21. Cramton, Ockenfels, and Stoft (2015) make an analogous argument in the form of a numerical example indicating that committing to a price tends to be less risky than quantity targets. Thus, according to this reasoning, equity transfers under cap-and-trade would have to be larger than equity transfers under a uniform price because of the increased risk imposed by caps. In a separate argument, they also indicate that choosing a particular green-fund equity-payment formula to encourage participation in a uniform price regime can itself be reduced from a seemingly n-dimensional problem to a one-dimensional focal problem.

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# Chapter 6

## Negotiating Effective Institutions Against Climate Change

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### ABSTRACT

*In environmental matters, the free riding generated by the lack of collective action is aggravated by concerns about leakages and by the desire to receive compensation in future negotiations. The dominant “pledge and review” approach to mitigation will deliver appealing promises and renewed victory statements, only to prolong the waiting game. The climate change global commons problem will be solved only through coherent carbon pricing. We discuss the roadmap for the negotiation process.*

*Negotiators must return to the fundamentals: the need for uniform carbon pricing across countries, for verification, and for a governance process to which countries would commit. Each country would enjoy subsidiarity in its allocation of efforts within the country. We suggest an enforcement scheme based on financial and trade penalties to induce all countries to participate and comply with the agreement.*

*Finally, the choice among economic approaches, whether a carbon price commitment or a cap-and-trade, is subject to trade-offs, on which alternative reasonable views may co-exist. We discuss monitoring reasons for why we personally favor an international cap-and-trade agreement.*

**Keywords:** Pledge-and-review, carbon price, cap-and-trade, climate change, global warming, COP, international public goods, UN climate negotiations, prices versus quantities

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*We are faced now with the fact that tomorrow is today. Over the bleached bones and jumbled residues of numerous civilizations are written the pathetic words “Too late”.*

Martin Luther King, New York, 4 April 1967

### ✎ 1. CLIMATE CHANGE IS A GLOBAL COMMONS PROBLEM ✎

Before discussing efficient institutions against climate change, let us restate the obvious.

#### 1.1. We must put an end to the waiting game

If no strong collective action is undertaken soon, climate change is expected to dramatically deteriorate the well-being of future generations. Although the precise consequences of our inaction are still hard to quantify, there is no question that a business-as-usual scenario would be catastrophic. The 5th Report of the IPCC (IPCC 2014) estimates that the average temperature would increase by somewhere between 2.5°C and 7.8°C by the end of this century, after having already increased by almost 1°C over the last century. Despite the emergence over the last three decades of solid scientific information about the climate impacts of

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increased CO<sub>2</sub> concentration in the atmosphere, the world's emissions of greenhouse gases (GHGs) have never been larger, rising from 30 GtCO<sub>2</sub>eq/year in 1970 to 49 GtCO<sub>2</sub>eq/year in 2010.

According to the IPCC, about half of the anthropogenic CO<sub>2</sub> emissions between 1750 and 2010 occurred during the last 4 decades, due mainly to economic and population growth and to the dearth of actions to fight climate change. Limiting the increase in temperature to 2°C is thus an immense challenge, with a still increasing world population and, hopefully, more countries accessing western standards of living. It will require radical transformations in the way we use energy, we heat and locate our houses, we transport people, and we produce goods and services.

### 1.2. Two “good” reasons for inaction

Most benefits of mitigation are *global* and *distant*, while costs are local and immediate. The geographic and temporal dimensions of the climate problem account for the current inaction.

Climate change is a global commons problem. In the long run, most countries will benefit from a massive reduction in global emissions of GHGs, but individual incentives to do so are negligible. Most of the benefits of a country's efforts to reduce emissions go to the other countries. In a nutshell, a country bears 100% of the cost of a green policy and receives, say, 1% of the benefits of the policy, if the country has 1% of the population and has an average exposure to climate-related damages. Besides, most of these benefits, however small, do not accrue to current voters, but to future generations. Consequently, countries do not internalize the benefits of their mitigation strategies, emissions are high, and climate changes dramatically. The free-rider problem is well-known to generate the “tragedy of commons” (Hardin 1968), as illustrated by a myriad of case studies in other realms. When herders share a common parcel of land on which their herds graze, overgrazing is a standard outcome, because each herder wants to reap the private benefit of an additional cow without taking account of the fact that what he gains is matched by someone else's loss. Similarly, hunters and fishermen do not internalize the social cost of their catches; overhunting and overfishing led to the extinction of species, from the Dodo of the island of Mauritius to the bears of the Pyrenees and the buffalos of the Great Plains. Diamond (2005) shows how deforestation on Easter Island led to the collapse of an entire civilization. Other illustrations of the tragedy of commons can be found in water and air pollutions, traffic congestion, or international security for example.

Ostrom (1990) showed how small and stable communities are in some circumstances able to manage their local common resource to escape this tragedy, thanks to built-in incentives for responsible use and punishments for overuse. These informal procedures to control the free-rider problem are obviously not applicable to climate change, whose stakeholders include the 7 bn inhabitants currently living on this planet and their unborn descendants. Addressing the global externality problem is complex, as there is no supranational authority that could implement the standard internalization approach suggested by economic theory and often employed at the domestic level.<sup>1</sup>

1. See for example Bosetti et al (2013). According to Nordhaus (2015), the equilibrium average carbon price that would prevail in a simple global non-cooperative game is equal to a fraction  $h$  of the first-best price, where  $h$  is the Herfindahl index of country sizes (the Herfindahl index  $h$  is the sum of the squares of each country's share in global output. For example, if there are ten identical countries,  $h$  equals 10%). He concludes that the equilibrium average carbon price in the absence of a coordination mechanism to solve the free-rider problem will be in the order of one-tenth of the efficient level.

A country or region which would contemplate a unilateral mitigation strategy would be further discouraged by the presence of the so-called “carbon leakages”. Namely, imposing additional costs to high-emission domestic industries makes them non-competitive. This tends to move production to less responsible countries, yielding an international redistribution of production and wealth with negligible ecological benefit. Similarly, the reduction in demand for fossil energy originating from the virtuous countries tends to reduce their international price, thereby increasing the demand and emissions in non-virtuous countries. This other carbon leakage also reduces the net climate benefit of the effort made by any incomplete club of virtuous countries. Its intertemporal version is called the green paradox. It states that a commitment to be green in the future leads oil producers to increase their production today to cater to today’s non-virtuous consumers. Since carbon sequestration is not a mature technology, mitigation is a threat to the oil rent, and its owners should be expected to react to this threat.

### **1.3. We must accept the fact that climate mitigation is costly in the short run**

The good news is that an efficient international climate agreement will generate an important social surplus to be shared among the world’s citizens. The political economy of climate change however is unfavorable. The costs of any such agreement are immediate whereas most benefits will occur in the distant future, mainly to people who are not born yet and a fortiori do not vote. In short, climate mitigation is a long-term investment. Many activists and politicians promote climate mitigation policies as an opportunity to boost “economic growth”. The fact that only a few countries (Sweden is the best example) come close to doing their share should speak volumes here: why would countries sacrifice the consumption of goods and leisure to be environment-unfriendly? The reality is bleaker, especially for economies in crisis and in the developing world. In reality, fighting climate change will imply reducing consumption in the short run to finance green investments that will generate a better environment only in the distant future. It diverts economic growth from consumption to investment, not good news for the wellbeing of the current poor. Carbon pricing, if implemented, will induce households to invest in photovoltaic panels on their roof or to purchase expensive electric cars, actions that yield no obvious increase in their own wellbeing, to the detriment of spending the corresponding income on other goods.

To be certain, countries may perceive some limited “co-benefits” of climate-friendly policies. For example, green choices may also reduce emissions of other pollutants (coal plants produce both CO<sub>2</sub> and SO<sub>2</sub>, a regional pollutant); in a similar spirit, countries may encourage their residents to eat less red meat not so much from a concern about global warming, but because they want to reduce the occurrence of cardiovascular diseases. Substituting dirty lignite by gas and oil as the main source of energy had enormous sanitary and environmental benefits in Western countries after WWII, for example by eliminating smog from London. Therefore some actions are to be expected from countries with an eye on national interest only (not to mention the political benefits of placating domestic and international opinion). But these “zero ambition” actions (to use a phrase coined by Robert Stavins) will be far insufficient to generate what it takes to keep global warming manageable.

Overall, fighting climate change yields short-term collective costs, thereby creating a political problem for benevolent decision-makers who support an ambitious international agreement. To sum up, without a collective incentive mechanism, one’s investment in a responsible mode of living will hardly benefit one’s wellbeing. Rather, and assuming away leakages, it will

benefit distant generations who mostly will live in other countries. It is collectively efficient to act, but individually optimal to do little.

## ✎ 2. A UNIFORM CARBON PRICE IS NECESSARY ✎

### 2.1. Economic approach vs. command-and-control

As we have discussed, the core of the climate externality problem is that economic agents do not internalize the damages that they impose on other economic agents when they emit GHGs. The approach<sup>2</sup> that economists have long proposed to solve the free-rider problem consists in inducing economic agents to internalize the negative externalities that they impose when they emit CO<sub>2</sub> (“*polluter pays principle*”). This is done by pricing it at a level corresponding to the present value of the marginal damage associated to the emission, and by forcing all emitters to pay this price. Because GHGs generate the same marginal damage regardless of the identity of the emitter and of the nature and location of the activity that generated the emissions, all tons of CO<sub>2</sub> should be priced equally. By imposing the same price to all economic agents around the world, one would ensure that all actions to abate emissions that cost less than that price will be implemented. This least-cost approach guarantees that the reduction of emissions that is necessary to attain the global concentration objective will be made at the minimum global cost. In contrast with this economic approach, “command-and-control” approaches (source-specific emissions limits, standards and technological requirements,<sup>3</sup> uniform reductions, subsidies/taxes that are not based on actual pollution, vintage-differentiated regulations, industrial policy. . . .) usually create wide discrepancies in the implicit price of carbon put on different emissions. This has been shown empirically to lead to substantial increases in the cost of environmental policies.

Western countries have made some attempts at reducing GHG emissions, notably through direct subsidization of green technologies: generous feed-in electricity tariffs for solar and wind energy, bonus-malus systems favoring low-emission cars, subsidies to the biofuel industry, etc. For each green policy one can estimate its implicit carbon price, i.e., the social cost of the policy per ton of CO<sub>2</sub> saved. A recent OECD study (OECD 2013) showed that these implicit prices vary widely across countries, and also across sectors within each country. In the electricity sector, OECD estimates range from less than 0 to 800 €. In the road transportation sector, the implicit carbon price can be as large as 1,000 €, in particular for biofuels. Given the amount of these subsidies around the world, it is hard to believe that they could be justified by the value of learning in the green technologies sector. The high heterogeneity of implicit carbon prices in actual policymaking is a clear demonstration of the inefficiency of this command-and-control approach. Similarly, any global agreement that would not include all world

2. A liability system would not solve the problem. Because of the diffuse and intertemporal nature of the pollution, it is impossible to link current individual emissions to future individual damages. Therefore, a liability system cannot fix the problem. Besides, even if such a link could be established, one would need an international agreement to prevent free-riding.

3. Let us emphasize that we are not necessarily opposed to standards. For example, one could use an economic instrument to encourage insulation by embodying the carbon price into the price of heating fuel and gas housing. However, insulation standards may overcome an informational problem (consumers may be very poorly informed about the energy efficiency of their dwelling) and, for owners, do not require a complex computation of intertemporal savings on a carbon price. Our point is that standards are often enacted without a clear analysis of whether the goals could have been achieved more efficiently and a computation of the implicit carbon price involved in their design.

regions in the climate coalition would exhibit the same inefficiency by setting a zero carbon price in non-participating countries.

While economists for good reasons are broadly suspicious of command-and-control policies, they also understand that these policies may occasionally be a second-best solution when measurement or informational problems make direct pricing complex and/or when consumers discount the future too much. This is the classic justification for housing insulation standards for instance. But command-and-control is best avoided when feasible.

## 2.2. Carbon pricing and inequality

Income and wealth inequality at the domestic and international levels is often invoked to dismiss uniform carbon pricing. The problems raised by inequality around the world are ubiquitous in analyses of climate change, as discussed by Posner and Weisbach (2010). On the one hand, if poor people emit proportionally more CO<sub>2</sub>, carbon pricing will worsen inequality starting today (Cremer et al 2003). On the other hand, poor people may also be more vulnerable to climate change, so that reducing emissions will reduce inequalities in the future. However, because international and national credit markets are imperfect, poor people may face large discount rates, making them short-termist and focused on their immediate survival to the detriment of the long-term climate risk. This means that the social cost of carbon will be smaller in these countries, even when accounting for future damages abroad.

International inequality raises the question of the allocation of the climate-mitigation burden. For example, the principle of common but differentiated responsibility is redistributive because wealthier countries are typically also those which contributed more to the accumulation of GHGs in the atmosphere. This is certainly an important issue, but its solution should not be found in a Kyoto-Protocol-like manipulation of the law of a single carbon price. The non-Annex 1 parties of the Kyoto Treaty had no binding obligation and their citizens faced no carbon price. This derailed the ratification of the protocol by the U.S. Senate. The Clean Development Mechanism designed in Kyoto was aimed at alleviating the imperfect coverage problem; it met with limited success and anyway was not a satisfactory approach due to yet another leakage problem. For example, Annex 1 countries' paying to protect a forest in a less developed country increases the price of whatever the deforestation would have allowed to sell (beef, soy, palm or wood) and encourages deforestation elsewhere. The CDM mechanism also created the perverse incentive to build, or maintain in operation longer than planned, polluting plants in order to later claim CO<sub>2</sub> credits for their reduction.<sup>4</sup>

The Kyoto Protocol's attempted solution to the equity problem was to exempt non-Annex 1 countries from carbon pricing. But using price distortions to reduce inequalities is always a second-best solution. Policies around the world that manipulate agricultural prices to support farmers' incomes end up generating surpluses and highly inefficient productions. The same hazard affects climate policies if one lets redistributive considerations influence carbon price signals to economic agents. At the national level, one should instead use the income tax system to redistribute income in a transparent way when this is possible. At the international level, one should organize lump-sum transfers to poor countries. This can be done by using the

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4. The best example is the hydrofluorocarbon-23 (HFC-23), which has a warming effect 11,000 times greater than CO<sub>2</sub>, so that destroying 1 ton of HFC-23 earns 11,000 more CDM certificates than destroying 1 ton of CO<sub>2</sub>. From 2005 to June 2012, 46% of all certificates from the CDM were issued for the destruction of HFC-23. Projects for destroying HFC-23 were so profitable that it is believed that coolant manufacturers may have built new factories to produce the coolant gas. As a consequence, the EU banned the use of HFC-23 certificates in the EU ETS from May 1, 2013.



revenues generated by carbon pricing. Given that we emit today approximately 50 GtCO<sub>2</sub> yearly, a carbon price at 30 \$/tCO<sub>2</sub> would generate a rent of \$ 1,500 bn per year, or approximately 2% of the world GDP.

### 2.3. Computing the right price signal

Most infrastructure and R&D investments to reduce GHG emissions have in common that they are irreversible (sunk) costs and yield a delayed reduction of emissions over an extended time span. Energy retrofit programs for residential building reduce emissions for decades, hydroelectric power plans last for centuries. As a consequence, what triggers an investment in these sectors is not the current price of CO<sub>2</sub>, but the expectation of high prices in the future. The right price signal is thus given by an entire path of carbon prices. Two factors call for a carbon price that is increasing with time. First, if the damage function is convex, our inability to stabilize the concentration of CO<sub>2</sub> within the next 100 years would imply that the marginal climate damages of each ton of CO<sub>2</sub> will rise in the future. Second, if we impose a cap on GHG concentration in the atmosphere that we should never exceed, the determination of the optimal emission path under this maximum quantity constraint is equivalent to the problem of the optimal extraction path of a non-renewable resource. From Hotelling's rule, the carbon price should then increase at the risk free rate (Chakravorty et al 2006). Any climate policy must also address the various commitment and credibility problems associated with the fixation of the long-term carbon price schedule. This challenge is reinforced by the current uncertainties affecting the marginal damage function, the optimal GHG concentration target, and the speed at which green R&D will produce mature low-carbon energy technologies. This question is addressed in sections 5.3 and 5.4.

Over the last two decades, governments have commissioned estimates of the social cost of carbon (SCC). In France, the Commission Quinet (Quinet 2009) used a real discount rate of 4%, and recommended a price of carbon (/tCO<sub>2</sub>) at 32 € in 2010, rising to 100 € in 2030 and between 150 € and 350 € in 2050. In the United States, the US Interagency Working Group (2013) proposed three different discount rates (2.5%, 3% and 5%) to estimate the SCC. Using a 3% real discount rate, their estimation of the SCC is \$32 in 2010, rising to \$52 and \$71 respectively in 2030 and 2050.

### 2.4. Two economic instruments for price coherence

Two prominent strategies for organizing an efficient, uniform pricing of CO<sub>2</sub> emissions involve a carbon price and a cap-and-trade mechanism, respectively.<sup>5</sup> Both proposals allow subsidiarity, and neither directly concerns national taxes or national cap-and-trade. Both rely on an international agreement that is reasonably encompassing and therefore on an "I will if you will" approach. They both require some strategy for enforcement; in particular, the implementation of credible and transparent mechanisms to measure emissions is a prerequisite to any efficient approach to climate change mitigation, or for that matter to any policy.

5. There are many other variants using an economic instrument. For example, countries could agree on a universal carbon tax (as opposed to a carbon price), leaving no scope for subsidiarity. To do so, a possible strategy would be to set up an international carbon tax collection entity. This however is not discussed in existing proposals, probably because it could be perceived as too large an infringement on sovereignty, or because there are returns to scope in tax collection. Thus, the implementation of the carbon tax would likely be left to individual countries, and the proceeds from the carbon tax would go to the country itself. We will here focus on the two commonly advocated strategies.

*a) Carbon price*

Under the first strategy, a minimum average price by country on all emissions around the world would be agreed upon and collected by individual countries. All countries would all be using the same price for GHG emissions.<sup>6</sup> The carbon price of a country would be computed as the carbon revenue divided by the country's emissions; the price could correspond to a carbon tax<sup>7</sup> in the special case of a taxation approach; but quite generally it could emerge from a variety of policies (tax, cap and trade, standards etc). Indeed, not all emissions in practice are subject to a carbon tax or ETS price: As Cooper (2015) notes, less than half of the European emissions are subject to EU ETS trading.

An international negotiation on a global carbon price has the advantage of linking each region's mitigation effort to the efforts of the other regions. As explained in Cramton, Ockenfels and Stoft (2015) and Weitzman (2015) for example, each country will internalize in its vote for the level of a uniform price the positive impact of a larger equilibrium price on the global reduction of emissions, thereby raising the potential ambition of the international agreement. Under this scheme, a supra-national supervision of the national carbon-pricing requirement at the internationally agreed level is thus necessary, as we will discuss in Section 5. The compensation issue would be dealt with through a Green Fund.

*b) Cap and trade*

Under the alternative, cap-and-trade strategy, the agreement would specify a worldwide, predetermined number (the cap) of tradable emission permits. The tradability of these permits would ensure that countries face the same carbon price, emerging from mutually advantageous trades on the market for permits; the cross-country price here would not result from an agreed upon price of carbon, but rather from clearing in this market. To address compensation, permits would be initially allocated to the different countries or regions, with an eye on getting all countries on board (redistribution).

## 2.5. Failed or unsatisfactory attempts at pushing the economic approach

The cap-and-trade system was adopted, albeit with a failed design, by the Kyoto Protocol. The Kyoto Protocol of 1997 extended the 1992 UNFCCC that committed participating countries to reduce their emissions of GHG. The Treaty entered into effect on February 16, 2005. The Annex-B parties committed to reduce their emissions in 2012 by 5% compared to 1990, and to use a cap-and-trade system. Kyoto participants initially covered more than 65% of global emissions in 1992. But the non-ratification by the US and the withdrawal of Canada, Russia and Japan, combined with the boost of emerging countries emissions reduced the coverage to less than 15% in 2012. The main real attempt to implement a carbon pricing

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6. This is naturally the same *absolute* level of a carbon price; adding a common carbon price onto the one already in place in each country would not only be inefficient (carbon prices would differ across the world) but also very unfair to a country like Sweden which has been virtuous prior to the agreement and whose extra contribution relative to other countries would thereby be made perennial.

7. Since Weitzman (1974)'s seminal paper, a sizeable literature has compared the relative merits of the tax and cap approaches, focusing on the economic aspects and often leaving enforcement and political economy aspects aside (the two systems have different implications along these dimensions, as we will discuss in sections 5.2 and 5.3). When the various parameters of the climate change equation (climate science, abatement technologies, demand) are known, a carbon tax and a cap-and-trade system are equivalent because, for a given price target, it is always possible to determine the supply of permits that will support this equilibrium price, and conversely. Not so under uncertainty.

mechanism within the Kyoto agreement emerged in Europe, with the EU Emission Trading Scheme (ETS). In its first trading period of 2005–2007 (“phase 1”), the system was established with a number of allowances (the so-called Assigned Amount Units, AAUs) based on the estimated needs; its design was flawed in many respects, and in any case far inferior to that which had been adopted in the US in 1990 to reduce SO<sub>2</sub> emissions by half. In the second trading period of 2008–2012, the number of allowances was reduced by 12% in order to reduce the emissions of the industrial and electricity sectors of the Union. This crackdown was offset by the possibility given to the capped entities to use Kyoto offsets (mostly from the Clean Development Mechanism described in 2.2) for their compliance. In addition, the deep economic crisis that hit the region during the period reduced the demand for permits. Moreover, large subsidies in the renewable energy sector implemented independently in most countries of the Union reduced further the demand for permits. In the absence of any countervailing reaction on the supply of permits, the carbon price went down from a peak of 30 €/tCO<sub>2</sub> to around 5–7€/tCO<sub>2</sub> today. This recent price level is without any doubt way below the social cost of carbon. It therefore has a limited impact on emissions. It even let electricity producers substitute gas by coal, which emits 100% more carbon (not counting dirty micro particles) per kWh. An additional problem came from the fact that the ETS scheme covered only a fraction of the emissions of the region. Many specific emitters, e.g. the transport and building sectors, faced a zero carbon price. During the third trading period (2013–2020), the EU-wide cap on emissions is reduced by 1.74% each year, and a progressive shift towards auctioning of allowances in substitution of cost-free allocation is implemented.

Over the last three decades, Europeans have sometimes believed that their (limited) commitment to reduce their emissions would motivate other countries to imitate their proactive behavior. That hope never materialized. Canada for example, facing the prospect of the oil sands dividend, quickly realized that their failure to fulfill their commitment would expose them to the need to buy permits,<sup>8</sup> and preferred to withdraw before having to pay them. The US Senate imposed a no-free-rider condition as a prerequisite for ratification, although the motivation for this otherwise reasonable stance may well have been a desire for inaction in view of a somewhat skeptical public opinion. Sadly enough, the Kyoto Protocol was a failure. Its architecture made it doomed to fail. Non-participating countries benefited from the efforts made by the participating ones, both in terms of reduced climate damages (free-rider problem), and in terms of improved competitiveness of their carbon-intensive industries (carbon leakage). The instability of the Kyoto coalition is one plausible explanation for why the EU did not attempt to push the price of permits up on the ETS market after the failure of the Copenhagen Conference in December 2009.

Other cap-and-trade mechanisms have been implemented since Kyoto. A mixture of collateral damages (we mentioned the emissions by coal plants of SO<sub>2</sub>, a local pollutant, jointly with that of CO<sub>2</sub>), the direct self-impact of CO<sub>2</sub> emissions for large countries like China (which has 20% of the world population and is exposed to serious climate change risk), and the desire to placate domestic opinion and avoid international pressure all lead to *some* carbon control. Outside the Kyoto Protocol, the US, Canada and China established some regional cap-and-trade mechanisms. In the US, where per capita GHG emissions are 2.5 times larger than in Europe and in China, two initiatives are worth mentioning. In the Regional Greenhouse Gas Initiative (RGGI), 9 Northeast and Mid-Atlantic US states created a common cap-

8. Under some estimation, it would have cost Canada \$14 billion to buy enough carbon credits to make its target.

and-trade market to limit the emissions of their electricity sector. Here also, the current carbon price is way too low at around \$5 /tCO<sub>2</sub> (up from the price floor level of \$2 /tCO<sub>2</sub> during the period 2010–2012). Over the period 2015–2020, the CO<sub>2</sub> cap will be reduced by 2.5% every year. The system will release extra carbon allowances if the carbon price on the market exceeds \$6 /tCO<sub>2</sub>. A similar system exists in California to cover the electricity sector, large industrial plants and more recently fuel distributors, thereby covering more than 85% of the State's emissions of GHGs.<sup>9</sup> In 2014, China has established 7 regional cap-and-trade pilots, officially to prepare for the implementation of a national ETS scheme. The fragmented cap-and-trade systems described above cover almost 10% of worldwide emissions, and observed price levels are low. This is another illustration of the tragedy of commons. These regional or national ETS could be used in the future under any international commitment regime, either a universal carbon price or a cap-and-trade mechanism.

Some countries have implemented a carbon tax. The most aggressive country is Sweden, in which a carbon tax of approximately 100 €/tCO<sub>2</sub> has been implemented in 1991, although with a number of exemptions. France has fixed its own carbon tax at 14.5 €/tCO<sub>2</sub>, with exemptions for some categories of users. Both of these taxes are used for various purposes, such as raising revenue (the demand being relatively inelastic) or addressing congestion externalities and road safety. They also now can be used to comply with an international commitment to cap-and-trade or to a carbon price. Outside Europe, some modest carbon taxes exist in Japan and Mexico for example. Except for the Swedish case, these attempts put a carbon price that is far too low compared to the SCC.

### ❧ 3. PLEDGE AND REVIEW: THE WAITING GAME IN THE CURRENT INTERNATIONAL NEGOTIATION ❧

The Copenhagen conference in December 2009 was expected to deliver a new Kyoto Protocol with more participating countries. In reality, the conference delivered a completely different project. The central idea of a unique carbon price induced by international cap-and-trade was completely abandoned, and the secretariat of the UNFCCC became a chamber of registration of non-committal pledges by individual countries. This change of vision was upheld at the Cancun Conference in 2010 and more recently at the COP 20 in Lima in 2014. The new “pledge-and-review” mechanism is likely to be confirmed at the Paris COP 21 conference in December 2015. Voluntary climate actions (or “*intended nationally determined contributions*”) will be registered without any coordination in the method and in the metric of measurement of the ambition of these actions. Although they are crucial to the credibility of the system, the reporting on, and verification of the pledges are not being discussed either.

The pledge-and-review strategy has four main deficiencies, and definitely is an inadequate response to climate change. First, if implemented, the agreement that will come out of this bottom-up process is expected to yield an inefficient allocation of efforts by inducing some economic agents to implement high-cost mitigation actions while others will emit GHGs that would be much cheaper to eliminate. Because the marginal costs of emission reduction are likely to be highly heterogeneous within and across countries, it will be almost impossible to

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9. Since early 2014, this market is linked to a similar one established by the Province of Québec. The current price of permits in California is \$12/tCO<sub>2</sub>, at the minimum legal price. This fragmented scheme illustrates the strange economics of climate change in the US, where the minimum carbon price in California is larger than the maximum carbon price in RGGI.

measure the ambition of each country's pledge. In fact, individual countries will have a strong incentive to "green wash" their actions by making them complex to measure and to price.

Second, the pledge-and-review promises, even if they were credible, are voluntary; so free-riding is bound to prevail. These pledges are expected to deliver much less effort than what would be collectively desirable. Following Buhr et al (2014), "*pledge-and-review means that climate change is dealt with the lowest possible level of decision making*". As Stiglitz (2015) notes, "in no other area has voluntary action succeeded as a solution to the problem of undersupply of a public good". In a sense, the pledge-and-review process is similar to an income tax system in which each household would be allowed to freely determine its fiscal contribution.

Third, even if the pledges were large enough to put the global emission trajectory back on track, the absence of commitment to the pledges would limit their long-term credibility. This fragility makes it very tempting for countries to deviate from their pledges. The absence of credibility of long-term pledges will reduce the innovators' incentive to perform green R&D, and to implement mature technologies yielding reductions of emissions for a long period of time.

Fourth, the pledge-and-review regime can be analyzed as a waiting game, in which the global negotiation on formal commitments is postponed. Beccherle and Tirole (2011) show that the free riding in this waiting game is magnified by the incentive to achieve a better deal at the bargaining table in the future. Building on both theory and past experiences, countries will realize that staying carbon-intensive will put them in a strong position to demand compensation to join an agreement later: the carbon-intensity of their economy making them less eager to join an agreement, the international community will award them higher transfers (either monetary or in terms of free pollution allowances) so as to bring them on board. Moreover, when the damage function is convex, a country committing to a high emission level before this negotiation raises the marginal damages of all other countries and therefore induces them to reduce their emissions more heavily. All in all, these strategic considerations increase the cost of delay beyond what would be obtained in the traditional free-riding model with no expectation about a future negotiation.

Indeed there has been concern that the current pledges are at a "zero ambition" level, or perhaps even below that level, where "zero ambition" refers to the level that the country would choose simply because of co-damages (local pollutants) and of the direct impact of GHG on the country itself, that is in the absence of any international agreement.<sup>10</sup>

To conclude this section on a more positive note, the pledge-and-review process might be useful in the second half of this year, provided that a) ambitions turned out to be strong enough (a big "if" at this stage) and b) one were to call the countries' bluff and transform or modify their pledges into real commitments. Suppose indeed that the various pledges are in line with a reasonable trajectory for GHG emissions (asserting this requires being able to aggregate/compare the various pledges, as some concern mitigation and others adaptation, and current pledges have rather different time horizons . . .). One could then transform the predicted global trajectory of emissions into an equivalent number of permits; in a second stage, one could allocate permits under the requirement that countries receive the same welfare as they would if their pledge were implemented. A key point is that countries that are sincere about their pledge could only gain from having all countries committed.

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10. See the discussion of China's pledge at <http://climateparis.org/china-emissions-pledge>.

#### ✎ 4. NEGOTIATING A PRICE/QUANTITY AND NEGOTIATING TRANSFERS ✎

Let us now turn to the more satisfactory approach of picking an economic instrument together with a measurement and enforcement strategies.

##### **4.1 The one-dimensional negotiation: uniform carbon price or a global emission target**

We can imagine two negotiation processes “I will if you will” with only one decision variable. Negotiators could try to agree either on a universal carbon price, or on a global emission target. For the sake of the argument, suppose first that all countries were similar in terms of their exposure to climate change, their degree of development, their endowment in natural resources, their tastes, etc. The free-rider problem inherent to the international negotiation on climate change could then be resolved by negotiating a uniform carbon price.<sup>11</sup> Under this negotiation framework, a “world climate assembly” would vote for a uniform carbon price whose implementation would be left to its individual members. The claimed virtue of this framework is to align the constituents’ private interests. Let us illustrate this claim with an example inspired from Cramton, Ockenfels and Stoft (2015). Suppose that the world is composed of 100 countries with the same characteristics (population, economic prosperity, growth expectations, industrial structure . . .). Each ton of CO<sub>2</sub> in the atmosphere generates \$1 of damage in each country. The business-as-usual scenario yields a uniform emission of 10 tCO<sub>2</sub> per capita. Suppose also that 80% of each country’s emission can be eliminated at a unit abatement cost of 50 \$/tCO<sub>2</sub>. The abatement cost of the remaining 20% is 200 \$/tCO<sub>2</sub>. In this context, it is desirable that each country abates its emissions by 80%, since the global damages of 100 \$/tCO<sub>2</sub> exceeds the cheaper marginal abatement cost of 50 \$/tCO<sub>2</sub>. But the tragedy of commons would prevail in the absence of a binding international agreement, because the marginal abatement cost is fifty times larger than the local marginal damages. Suppose that the 100 countries accept to join an international coalition in which they cooperate to enforce the domestic imposition of an internationally harmonized carbon price that is voted by a majority rule. Participants are required to impose the common price as long as all signatories do too. The domestic revenues of the scheme are recycled internally. In this framework, all countries will be in favor of a carbon price of, say, 100 \$/tCO<sub>2</sub>, which will induce them to abate their emissions by 80%. This dominant strategy yields the first-best solution and makes all countries better off.

As Cramton and Stoft (2012) point out, an equivalent negotiation process exists that is based on quantities. Suppose that all countries in the coalition accept to negotiate a uniform emission per capita that is voted upon by a majority rule. The same subsidiarity rule applies for which green policy should be implemented to attain the national target, and countries are allowed to trade their emissions with others. In this alternative framework, all countries will understand the benefit of imposing an ambitious target for themselves as long as the other countries do the same. It is an optimal for each country to vote for an 80% reduction of emissions. In this example, the two negotiation mechanisms yield the same efficient solution,

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11. See Cramton and Stoft (2012), Cramton, Ockenfels and Stoft (2015), Weitzman (2013, 2015), and the papers in this symposium. Cramton et al. (2013, 2015) suggest defining a country’s carbon price as its carbon revenue divided by its carbon emissions. Others recommend a uniform carbon tax. Still others advocate a global cap and trade system leading to a uniform carbon price. At this stage, there is no need to distinguish between the various approaches.

and have the same simple structure of a one-dimensional negotiation, either on a uniform price or on a uniform per-capita quantity.

Alas, the real world does not look at all like the description above. Indeed, countries differ markedly by their exposure to climate change, their abatement costs, their economic dependence to fossil fuels, their willingness to invest in the future, their emission per capita, and so on. These sources of heterogeneity of costs and benefits make the negotiation dramatically more complex.

Consider for example the case in which only 10 of the 100 countries are responsible for all emissions. The other countries emit nothing. Under the uniform price mechanism as under the quantity mechanism, conditional on all countries ratifying the treaty, the median voter will be in favor of respectively a 200 \$/tCO<sub>2</sub> and a zero-emission target for all countries. This example illustrates two difficulties with the two simple negotiation mechanisms examined in this section. First, in line with Weitzman's result (this issue), there is too much abatement at equilibrium, so that these mechanisms do not guarantee a first-best solution.<sup>12</sup> Second, the 10 high-emission countries are likely to quit the coalition because they bear all the cost of mitigation and receive a tiny fraction of the benefits. In economics parlance, their participation constraint is binding. This is why the economists supporting a price negotiation recognize that due to the heterogeneity among countries, the system is feasible only if some mechanism for side transfers (such as a Green Fund or an allocation of permits) is designed so as to bring on board the reluctant countries. We concur. Observe that the sizes of the transfers from the 90 green countries to the 10 others that would induce the latter to participate are exactly the same for the two negotiation mechanisms. Of course this is an artifact of a static model in which perfect foresight is automatic.

Unfortunately, but unavoidably, the Green Fund (under a carbon price) or the unequal allocation of permits (under cap and trade) destroys the simplicity of a single-dimensional negotiation. The Green Fund must set the net (positive or negative) transfer to the fund for each country and therefore involves dimensionality  $n + 1$  (the number of countries,  $n$ , plus 1, the carbon price). In the cap-and-trade mechanism, an unconstrained allocation of permits yields the same dimensionality ( $n$  allowances, plus the carbon price). This sharp increase in dimensionality can be avoided by adopting a common formula as the Kyoto negotiators attempted to do. Cramton and Stoft (2010, 2012) propose doing this and argue that by making this the first stage of a two-stage negotiation, countries would find it easier to agree (more on this below).

Summing up, whether the international architecture adopts a uniform carbon price or a cap-and-trade mechanism, cross-country transfers will thus be needed so as to bring reluctant countries on board. As we just discussed, under the carbon pricing approach, the proposed transfer mechanism is to use a fraction of the collected revenue to help developing countries to adopt low-carbon technologies and to adapt to climate change. This is illustrated by the Green Fund which was created at the COP-15 of Copenhagen in 2009. Under a cap-and-trade protocol, transfers operate through the distribution of free permits.

Either way, the design of compensation poses a complex problem: each country will want to pay the smallest possible contribution to the Green Fund or receive the maximum number

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12. Weitzman (2015) derives an analytical solution for this majority voting scheme on the carbon price when the damage function and the marginal abatement cost function are linear. In that case, the equilibrium price is efficient if and only if the mean and the median of the distribution of the country-specific marginal damages are the same.

of permits.<sup>13</sup> This negotiation is complex and of course a major impediment to reaching an agreement on a carbon tax or a cap-and-trade. On the other hand, it must be realized that most international negotiations involve give-and-take. And there have been successful negotiations in the past. A case in point is the 1990 Clean Air Act Amendment in 1990. This arrangement was not imposed by a centralized authority, but rather was the outcome of a protracted negotiation, in which the mid-west states, high emitters of SO<sub>2</sub> and NO<sub>x</sub>, delayed jumping on board until they received sufficient compensation (in the form of free permits in that case).<sup>14</sup>

#### 4.2. Simplifying the compensation n-dimensional negotiation (Green Fund or allocation of permits)

##### a) Transparency considerations

A Green Fund may be too transparent to be politically acceptable. The transparency argument requires further thought, but experience here suggests a serious concern; the Green Climate Fund established at COP-16 aims at a *flow* transfer of \$100 bn per year by 2020, and four years later had received promises of less than \$10 bn in *stock*.<sup>15</sup> As is known from other realms (like humanitarian relief after a natural disaster or LDC health programs), parliaments are known to be reluctant to appropriate vast amounts of money to causes that benefit foreigners. Even successful programs such as the Vaccine Alliance GAVI - which involves a much smaller amount of money - took off only when the Bill & Melinda Gates Foundation brought a substantial financial commitment. Politicians often pledge money at international meetings, only to downsize or renege on their pledge. Substantial free-riding is expected to continue, jeopardizing the build-up of the Green Fund.

We believe that the transparency issue is one of the reasons why many pollution-control programs around the world adopted cap-and-trade and handled the compensation issue through the politically less involved distribution of tradable permits (often in a grandfathered way). The large transfers to the Mid-West implied by the 1990 Clean Air Act Amendment never really made the headlines. To be certain, the transfers made under national cap-and-trade programs are different in their economic and political nature from international payments for international permits; however, in the EU ETS scheme, billions of euros could have been potentially transferred to Eastern European and former Soviet Union countries (“Hot Air”) through the allocation of permits in order to convince them to sign the Kyoto Protocol.<sup>16</sup>

The strength of the opaqueness argument in favor of the allocation of permits remains to be tested, and no-one has the answer as to whether it would work for climate change. On the one hand, transfers associated with an allocation of free permits are not that hard to compute and one would imagine that politicians (privately or publicly) opposed to an ambitious climate change agreement would quickly publicize the numbers (if unfavorable to the country) so as to turn their domestic public opinion against the agreement. In fact, the public uproar over

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13. In either case, there is also an issue regarding whether the governments will not steal or make use of the transfers for their own wellbeing: they may cash in the Green Fund receipts (or for that matter the carbon tax) or sell permits in the international market to the same effect. This difficulty is inherent to the respect of sovereignty and is not specific to climate policies.

14. See Ellerman et al (2000) for an extensive analysis of these negotiations.

15. However, Cramton and Stoft (2012) claim that a far smaller amount would be needed to support a carbon price of \$30/ton, and that donor countries would receive much more for their money than with the current Green Fund.

16. This a priori gave Eastern European countries the choice between making money by selling permits and not exerting any abatement effort; other countries became reluctant to buy the permits and the second option became the leading one.



the sale of Hot-Air AAUs was such that the UN was forced to restrict their sale. On the other hand, some of the cap-and-trade transfers failed to make the headlines in the past. The jury is still out on this question.

Finally, it should be noted that countries routinely transfer sizeable fraction of their GDP to foreign investors in reimbursement of their sovereign debt. It would be useful to have estimates of likely shortfalls/surpluses of permits (which of course depend on the initial distribution) so as to have a better assessment of the sums involved.

*b) Reducing the dimensionality of the compensation negotiation*

Rich and poor have always had opposite views as to who should compensate the other. Developing countries correctly emphasize ethics and their desire to develop while rich countries were in the past allowed to develop without being hindered by environmental concerns; they demand equal rights per capita or a variant of it. Rich countries invoke Realpolitik and explain that they will not get on board unless permits are grandfathered (like they were in many other instances); or they will contribute only modestly to the Green Fund. The developing countries' being morally right does not mean that they should overstress the equity concern, for their own sake; inducing the rich countries to refuse to get on board will make poor countries much worse off. The politics of negotiations are not always aligned with the ethical view, unfortunately; in the driver's seat lay the countries with a high-projected GDP (they will be the high polluters), those with a high abatement cost, and finally those which will suffer the least -or even slightly gain from- global warming. These countries have low incentives to get on board.

The Green Fund allocation or the formula for the allocation of free permits in the cap-and-trade approach must be acceptable by all.<sup>17</sup> The expectations must also be convergent and unrealistic demands are to be avoided. Rich countries must be much less selfish and accept to bear a large share of the burden (in reality and not through cheap pledges as they sometimes do). Conversely, a common per-capita emission is a complete non-starter for the developed world. This would involve massive wealth transfers to the less-developed world. As Cramton et al. (2013, 2015) stress, it is further unclear on what basis could such transfers be determined; developed countries will argue that while they are responsible for anthropogenic global warming so far, they also have developed numerous technologies (medical, agricultural, communications, etc.) that are benefiting the less-developed countries. Such an acrimonious debate is unlikely to foster a decent solution to climate change. Moreover, the inconsistent expectations that we observe today are, needless to say, very dangerous. Like in the case of an impending war, we hope that the various sides will become more reasonable and come to terms with the huge collective gains from reaching an ambitious agreement.

We agree with the authors of the other papers published in this symposium that free-style negotiations among  $n$  countries are exceedingly complex and are very likely to lead to a deadlock, whether the countries negotiate about who will be a contributor or a recipient (and by how much) of the Green Fund or the allocation of free permits among countries under cap and trade. There is here a complex trade-off between a simple rule, which prevents individual countries from demanding a special treatment, and a more complex rule, that better

17. Cramton, Ockenfels and Stoft (2015) make a similar point for the cap-and-trade initial negotiating approach attempted by Kyoto negotiators, who tried to agree on a uniform reduction of  $x\%$  relative to 1990 emissions; no such  $x$  could be found.

accounts for individual willingnesses to get on board, but also make the negotiation captive of specific demands.

To illustrate this, consider the following (simple) rule, which reflects the trade-off described above between ethics and Realpolitik in the case of a common carbon price approach. The transfer scheme in this approach is based on a Green Fund. Cramton, Ockenfels and Stoft (2015), Weitzman (2015) and De Perthuis and Jouvet (2015) propose to finance the Green Fund on the basis of a one-dimensional bonus-malus system where countries whose per-capita emissions lie above a predetermined threshold would transfer funds to countries whose emission is below the threshold. More specifically, let  $p_i$  and  $P$  denote country  $i$ 's and the world's populations, and  $x_i$  and  $X = \sum_{i=1}^n x_i$  denote the current emissions of country  $i$  and the world. The contribution  $C_i$  to the Green Fund by country  $i$  would then be determined as follows

$$C_i = g \left( x_i - p_i \frac{X}{P} \right), \quad [1]$$

where  $g$  is a generosity parameter, i.e., how many dollars are transferred per ton of excess emission. Note that the sum of these contributions is equal to 0, as it should.

In a cap-and-trade approach, the transfer is implicit in the allocation of free permits. For conciseness, we state it in terms of intertemporal (total) pollutions. Let  $q_i$  denote country  $i$ 's number of free permits and  $Q = \sum_{i=1}^n q_i$  denote the total number of permits (as discussed above,  $Q$  would be computed so as to contain the temperature increase to 2°C). With grandfathering coefficient  $\hat{g}$  in  $[0, 1]$ , the free permits would be allocated according to formula

$$\frac{q_i}{Q} = \hat{g} \frac{x_i}{X} + (1 - \hat{g}) \frac{p_i}{P}. \quad [2]$$

So, the ethical approach prevails if  $\hat{g}$  is close to 0, and the Realpolitik concerns are reflected by a large  $\hat{g}$  value.

There are many potential criticisms to, and improvements on such formulae. For instance, the formulae need not hold in each year, but only overall. Under cap-and-trade, developing countries' endowment might be backloaded, so as to avoid a situation in which initially they are in expectation big net suppliers of permits in the market for allowances.

But the point we want to make here is that such rules may be a bit too simple. Realpolitik suggests accounting at least somewhat for the exposure to climate change, even if this may be rather unfair. Countries like Canada and Russia may not get on board under formula [1] or [2] while other high-income, high pollution countries would, provided that the generosity coefficient  $g$  is not too high or the grandfathering coefficient  $\hat{g}$  not too low.

## ✂ 5. PRICE VS. QUANTITY ✂

Given our concern that the pledge and review approach currently favored by policymakers might prevail at the COP 21, it may be premature to enter the intricacies of “prices vs. quantities” (to use Weitzman’s 1974 terminology) or “carbon price vs. cap-and-trade” (by cap-and-trade, we mean the setting of a global volume of emissions, not of individual countries’ targets, which would be highly inefficient). We feel that either approach clearly dominates the current alternative. Besides, the question is far from being settled among economists. However,

since post-COP 21 negotiations need to be engaged quickly, it is important to discuss these second-stage issues right away.

The choice of instruments has two dimensions: the purely economic question of which system best accommodates scientific and demand uncertainty, a complex question that was treated at a theoretical level in Weitzman's article but on which limited empirical evidence is available;<sup>18</sup> and a political economy dimension on which we now focus.<sup>19</sup>

On the political economy front, of which we developed one dimension (the transparency of transfers) in Section 4.2.a, we would like to make two points. First, like for any other public policy, international commitments must be feasible; that is, its implementation must not be prevented by the lack of information.

Second, and perhaps more controversially,<sup>20</sup> one may want to leave scope for national policies, even though we know that these policies may then deviate from least-cost abatement. Imagine for instance, that some countries with limited tax-collection-and-redistribution capabilities would want to opt for a low carbon price on cement to make housing affordable to the poorest; then they would want to deviate from the single-price rule; to be certain, governments may be weak and grant excessively low carbon prices to some lobbies, but this is by and large a matter of domestic politics (unless the practice is so widespread that it becomes unlikely that the country will abide by its overall commitment, whatever the agreement is). The rationale for subsidiarity is two-fold. First, it gives leeway for governments to convince their domestic opinion (or themselves); second, other countries care only about how much CO<sub>2</sub> is emitted by the country, not how the number came about.

## 5.1 The enforceability problem

### *a) Enforcement under a carbon price commitment*

*Lax enforcement.* Carbon-pricing proposals allow a large array of regulatory mechanisms that get carbon-pricing credit. In order to fulfill their price commitment, countries could levy a carbon tax or set a cap-and-trade system and value carbon permits at their market price. Some countries' carbon price will also reflect their green standards (with an implicit carbon value) or count their public investments that have an impact on emissions. Under the principle of subsidiarity, we believe that all these actions should indeed be accounted for in

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18. Besides, the Weitzman framework does not allow for more complex, but reasonable mechanisms, like dynamic adjustment mechanisms to cope with uncertainty. For instance, the European Commission has recently proposed to create a market stability reserve starting in 2021. The reserve would cope with the current surplus of emission allowances and improve the system's resilience to shocks by adjusting the supply of allowances to be auctioned. It would operate according to pre-defined rules which would leave no discretion to the Commission or Member States.

An economic debate also exists regarding whether price or quantity schemes best insulate countries against uncertainty about climate risk or technology. In theory, hedging instruments should provide an efficient allocation of risk worldwide, but little is known as to the extent to which markets would actually deliver this.

19. We here will not expand on another political economy dimension. Another issue with a carbon tax is the legal process. This obstacle is certainly not insurmountable, but requires specific attention. First, taxes are usually set every year. What is needed for climate change control is a long-term commitment (think about the SO<sub>2</sub> tradable permits in the US, which are issued 30 years ahead). Second, taxes are generally the prerogative of parliaments. For example, in Europe, setting up the ETS cap-and-trade scheme required only a majority vote, while tax harmonization is subject to the unanimity rule, and therefore a carbon tax would have been almost impossible to achieve. So an exception needs to be made to prevent individual parliaments from undoing the international agreement

20. Cramton et al. (2013, 2015) also argue in favor of subsidiarity, although on slightly different grounds.

order to determine the national carbon price, which is the ratio of the carbon revenue over the carbon emission.<sup>21</sup> The net effect is to generate efforts to curb national emissions.

Because most of the climate benefits of this policy accrue abroad, countries currently have no incentive to impose strict carbon usage constraints on their citizens, firms, and administrations; and by and large, except for Sweden, they do not. This will also be the case under any international agreement. Thus, even if enforcement were costless, authorities would still turn a blind eye on certain polluters or underestimate their pollution, thereby economizing on the cost of green policies. This form of moral hazard is particularly hard to avoid in countries which are on the spending side of the compensation scheme (say the Green Fund); but it applies also to countries on the receiving side, which could be threatened by a withholding of transfers in case of non-compliance. To envision the difficulties faced by monitoring of compliance, one can refer to the current debate on poor tax collection in Greece.<sup>22</sup> To sum up, the imposition of a common carbon price faces the standard free-rider problem, with local costs and global benefits. Its management requires a strong international monitoring system.

*Undoing.* Second, another form of moral hazard consists in undoing the carbon tax through compensating transfers; presumably the countries would do this in an opaque way so as not to attract the attention of the international community.

*Multiple grounds for taxation: The case of fossil fuels.* Burning fossil fuels generates various local externalities such as the emission of nanoparticles (cardiovascular diseases, asthma . . .), and, in the case of gasoline, road congestion and the deterioration of road infrastructure. This justifies specific Pigovian taxes whose level depends upon the density of population, the value of life, the burning technology or the average atmospheric conditions for example. Countries also take advantage of the relative inelasticity of demand to raise revenue. Proponents of the carbon price approach propose a “zero baseline” in defining the carbon price. That is, they define the carbon price to include all taxes and subsidies on each fossil fuel on each market, implicitly ignoring all other externalities or more generally other motivations for taxing fossil fuels. One problem with this pragmatic strategy is that these other Pigovian prices differ much around the world. Take again gasoline taxation: the distribution of the price of the liter of gasoline at the pump around the world has huge variance: 2 cents in Venezuela, 97 cents in the US and 209 cents in Belgium.<sup>23</sup> Under the above-mentioned definition, imposing the

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21. We have not studied and therefore will not discuss the question of aggregation of the various efforts along different dimensions. The choice of weights and their relationship to technological progress has been discussed in the literature on price indices (e.g. Diewert 1993); relevant here is also the very embryonic literature on price caps (here floor): Armstrong-Vickers (2000) and Laffont-Tirole (1999). The optimal response of a country, even in the absence of political economy/favoritism considerations, will not satisfy the law of one price, both within the country (the country-optimal tax depends on good-specific cost and local pollution characteristics) and across countries. We however do not have an educated guess as to whether these deviations from price coherence impose sizable costs; and in comparison with the distortions attached with current pledge-and-review approach, this is without doubt a second-order issue.

22. All symposium authors agree that enforcement should work in two steps (1) monitor, (2) impose trade sanctions if necessary. This of course is not straightforward.

In the last few years, and despite the existence of a program and the presence of the Troika in the country, Greece made very little progress in curbing tax evasion. It is just very difficult for foreigners to impose a tax when the government is reluctant to strengthen it. While in both cases (sovereign debt and climate agreements), the foreigners have a strong vested interest in domestic tax collection, one could even argue that the problem is even more complex in the climate context and that there is no reason to believe that the international community would be much more successful in obtaining compliance of the carbon tax agreement. Indeed some compliance-prone factors are not even present in the case of climate change: there is no troika in each country threatening to cut the flow of lending; countries are not under a program (and therefore carefully monitored); they also derive some benefits from compliance (prospect of no longer being under a program, of not facing international sanctions in case of default), while for most countries almost 100% of the benefits of good behavior are enjoyed by foreigners.

23. <http://data.worldbank.org/indicator/EP.PMP.SGAS.CD/countries/1>.

same “carbon price” at the world level forces all countries to price local externalities and embody revenue concerns equally, a contradiction with the basic idea of subsidiarity. Monitoring this by the international community is a serious challenge.

*Non-price policies.* Third, the carbon-price approach requires finding conversion rates for various policies that impact climate change, but are not subject to an explicit price, such as road and housing construction standards, no-till farming or afforestation and reforestation. These conversion rates may need to be country specific: a construction standard will impact GHG emissions differently depending on the country’s climate; similarly, afforestation may increase rather than decrease emissions in high latitude areas, in which trees may cover (high-albedo) snow.

### *b) Enforcement under a cap-and-trade mechanism*

Enforcing an international quantity mechanism is relatively straightforward when countries, rather than economic agents, are liable for their national emissions. The anthropogenic emissions of CO<sub>2</sub> by a nation can be derived from a simple carbon accounting by adding extraction and imports and by subtracting exports and the variation of stocks. Carbon sinks from forests and the agricultural sector can already be observable by satellite. Experimental projects from NASA and ESA to measure the global emission of CO<sub>2</sub> at the country level are promising in the long run.<sup>24</sup> We believe that monitoring the country’s CO<sub>2</sub> emissions is easier than monitoring emissions at the point source, and, like for existing cap-and-trade mechanisms, agents (here countries) with a shortage of permits at the end of the year would have to buy extra permits, while those with a surplus would sell or bank them.

There is one concern about permit trading among nations: some countries (one has in mind China and the US here) may well enjoy market power due to their share of world emissions. This is a potentially serious issue, which requires oversight and offers some similarity to the control of market power in electricity production or in financial rights over transmission on a power grid.<sup>25</sup> In particular, one would want countries to be as close as possible to zero net supply so as to reduce their incentive to affect the world price for permits by restraining the demand or supply.

## **5.2 Price volatility under a carbon price and under cap-and-trade**

Attention should be paid to the question of how to *accommodate uncertainty*. A cap-and-trade approach would compute and issue a worldwide number of permits consistent with the 2°C target. However, there is scientific uncertainty about the link from emissions to global warming. There is also uncertainty about the abatement technology, consumer demand and so forth. So the number of permits will probably have to be adjusted over time. The market price of permits will be volatile (although presumably less so than under the flawed and unstable attempts at pricing CO<sub>2</sub> so far).<sup>26</sup>

24. For example, the NASA Orbiting Carbon Observatory-2, or OCO-2, is already orbiting the planet. The ESA CarbonSat project is also promising.

25. See e.g. Green-Newbery (1992) and Joskow-Tirole (2000).

26. Even in a well-designed, long-term oriented system such as the acid rain program in the US, SO<sub>2</sub> prices have been volatile. They were stable in the first ten years, but then exhibited substantial volatility from 2005 through 2009 for instance.

The same concern holds for a carbon price. Due to the same sources of uncertainty, there is no guarantee that the price will initially be set at the “right level”, consistent with the overall global warming target. Thus, the tax will need to be adjusted over time as well.

More generally still, any proposal must confront the volatility question, as price volatility is likely to be unpopular. One possibility, which a priori does not require public intervention, is to transfer risk through hedging instruments to those who can bear that risk more easily. Another, complementary approach is to intervene in markets to stabilize prices. For example, the European Commission in 2014 has proposed a “Market Stability Reserve”, in which the auction volumes will be adjusted in phase 4 of the EU ETS starting in 2021, so as to create a soft target corridor for banking of EU Allowance units (EUAs). The mechanism will reduce the amount of EUAs that are auctioned if an upper threshold of EUAs in circulation is exceeded and releases them if the EUAs in circulation fall short of a lower threshold. This scheme is meant to be automatic, but its efficiency can be questioned.<sup>27</sup> In particular, one can wonder how it can be made responsive to news in a way that guarantees that the 2°C target is reached. This brings us to the question of the trade-off between flexibility and commitment.

### 5.3 The potential time inconsistency of carbon price and cap-and-trade policies

Whether one opts for a carbon price or for cap-and-trade, one should be concerned by the possibility that, conditional on the accruing news about the climate change process, technology or demand, the ex-post adjustment be too lax (too low a carbon price, too high a number of tradable permits). To understand why, note that the carbon price or tradable rights path is designed so as to incentivize long-term investments: in carbon-light housing, transportation infrastructures or power plants and in green R&D. Ex post the price incentive has served its purpose and now imposes undue sacrifices; put differently, optimal environmental policies are not time-consistent. Furthermore, the possibility of administration turnover or news about other aspects (say, public deficit or indebtedness, economic opportunities) may transform climate policy into an adjustment variable, adding to the overall time inconsistency.

This time inconsistency is studied in Laffont-Tirole (1996 a, b), who look at the optimal mechanism designed by a centralized authority (the world’s nations here) when news will accrue that may vindicate a change of course of action. The optimal mechanism must trade off commitment and adaptation. It can for example be implemented through a generalized cap-and-trade mechanism. This mechanism consists in providing authorities with flexibility, provided that the latter commit to compensate permit owners (in cash or Treasury securities). More precisely, authorities must issue a menu of permits with different redeeming values that limit the authority’s ability to expropriate their owners by flooding the market with pollution permits. For example, if news led the authority to lower the price of permits (or the carbon tax) from \$ 50 to \$ 40, some \$ 50 and \$ 45- strike price put options on the Treasuries (with agreed upon country keys) would become in the money; at \$ 35, some other options (with a \$ 40 strike price) would also be in the money, and so forth. This approach creates flexibility but constrains it by forcing the authority to partly compensate permit owners. It obviously

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27. The precise implementation of this mechanism has been criticized for being asymmetric and failing to have the desired dampening effect (Trotignon et al 2015).

requires a governance mechanism, whose existence is inescapable anyway in any international agreement.

Cap-and-trade mechanisms can obviously accommodate various automatic mechanisms that react to news accrual. We have not studied when the Market Stability Reserve mentioned above or a variant thereof can approximate the optimal adjustment mechanism described in Laffont-Tirole,<sup>28</sup> and we think that economists have not paid enough attention to this aspect, whether they favor carbon pricing or cap-and-trade.

## ✎ 6. ENFORCING A STABLE INTERNATIONAL AGREEMENT: THE CARROT-AND-STICK APPROACH TO PROMOTE INTERNATIONAL COOPERATION ✎

An efficient international agreement should create a grand coalition in which all countries and regions will be induced to set the same carbon price in their jurisdiction. Under the principle of subsidiarity, each country or region would be free to determine its own carbon policy, for instance through a tax, a cap-and-trade, or a hybrid. The free-rider problem raises the question of the stability of this grand coalition.<sup>29</sup> An analogy is sovereign borrowing. Sanctions for defaulting are limited (fortunately gunboat diplomacy has waned!), which raises concerns about countries' commitment to repay creditors. The same applies to climate change. Even if a good agreement is reached, it must still be enforced with limited means. The La La Land of international climate negotiations most often ignores this central question.

Naming and shaming is an approach and should be used; but as we have seen with the Kyoto "commitments", it has limited effects. Countries always find a multitude of excuses (choice of other actions such as R&D, recession, insufficient effort by others, commitment made by a previous government, etc. . . .) not to abide by their pledge.

There is no bullet-proof solution to the enforcement problem, but we think that at a minimum two instruments should be employed. First, countries care about gains from trade; the WTO should view non-compliance with an international agreement as a form of dumping, leading to sanctions. Needless to say, the nature of these sanctions should not be decided by individual countries, as the latter would then gladly take this opportunity to implement protectionist policies.

In the same spirit, one could penalize non-participants through punitive border taxes. This policy would incentivize reluctant countries to jump on board and be conducive to the formation of a stable world climate coalition. Nordhaus (2015) examines the formation of stable climate coalitions when coalitions are able to impose internally a uniform carbon price together with uniform trade sanctions against non-participants. For a carbon price around \$25 per ton of CO<sub>2</sub>, a worldwide climate coalition is stable if a uniform tax of 2% is imposed by the coalition for any good or service imported from a non-participating country.

Second, non-compliance with a climate agreement should be treated as committing future administrations and treated as sovereign debt. This policy would involve the IMF as well. For example, in the case of a cap-and-trade approach, a shortfall of permits at the end of the year would add to the public debt; the conversion rate would be the current market price.

28. For instance, suppose that scientists demonstrate that the climate is deteriorating faster than had been thought. Then permits must be withdrawn. The Market Stability Reserve mechanism reacts to an intertemporal use of permits ("is permit use more frontloaded or backloaded than expected?") rather than to the overall target. So it is likely to miss some desirable adjustments.

29. In an asymmetric information framework, Martimort and Sand-Zantman (2015) describe the optimal mechanism for an international climate agreement when states face some local co-benefits and participation is voluntary.

Of course, we are aware of the potential collateral damages associated with such linkages with other successful international institutions. But the real question is that of the alternative. Proponents of non-binding agreements hope that the countries' good will suffice to control GHG emissions. If they are correct, then the incentives provided through institutional linkages will also suffice a fortiori, without any collateral damage on these institutions.

## ✎ 7. PUTTING THE NEGOTIATION BACK ON TRACK ✎

In spite of the mounting evidence about global warming, the international mobilization has been most disappointing. The Kyoto protocol failed to build an international coalition supporting a carbon price in line with its social cost and illustrates the intrinsic instability of any international agreement that does not seriously address the free-rider problem. An international agreement must satisfy three properties: economic efficiency, incentive compatibility, and fairness. Efficiency can be attained only if all countries face the same carbon price. Incentive compatibility can be attained by penalizing free-riders. Fairness, a concept whose definition differs across stakeholders in the absence of a veil of ignorance, can potentially be reached through lump-sum transfers.

There is currently some enthusiasm for the process of letting each country pledge emission reduction efforts in preparation of the Paris COP 21 in December 2015. We believe that this strategy is doomed to fail. It does not address the fundamental free-rider problem of climate change. The pledge-and-review process is another illustration of the waiting game played by key countries, which are postponing their real commitment to reduce emissions. Countries will make sure that their pledge is hard to compare with other pledges, and that it is non-verifiable and non-enforceable. The predicted outcome of this waiting game in terms of emissions of GHGs is potentially worse than the business-as-usual, zero-ambition outcome. We should tackle the climate challenge more seriously.

All contributors to this symposium consider the efficiency objective of a universal carbon price the top priority in the current negotiation process. But this objective can be achieved in many different ways whose relative merits are mostly untested. Several leave scope for subsidiarity of national climate policies, which has drawbacks but nonetheless has our preference.

Given how delayed and confused current negotiations are,<sup>30</sup> there is little hope to come up in Paris with the architecture we propose, or for that matter with any reasonable architecture. So what shall we do?

We should both get the fundamentals right and face the thorny issue of equity. The latter issue is daunting, but any negotiation will have to confront it, and discussing many other topics simultaneously does not facilitate the task. So the roadmap for the COP 21 in Paris would be:

- Agree on a single-carbon-price principle and on the need for the measurement infrastructure to allow for an independent monitoring of countries' overall pollution.
- Agree on a governance and enforcement mechanism (we have proposed that non-participating countries be imposed penalties through punitive border taxes administered by

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30. Incidentally, we are not convinced that the Onusian framework is optimal either, as bargaining among 200 nations is incredibly complex. A coalition of the current and future high emitters (say the G20) might prove more effective, both to negotiate and then put pressure on other countries, including through the WTO.



the WTO and that participating countries recognize a “climate debt” accounting for the uncovered emissions of the non-abiding countries and administered by the IMF).

If the choice for a single-price policy is carbon-pricing:

- Find a price that is agreeable to the international community and limits global warming to the 2 °C objective.
- Put in place the monitoring environment, as well as the general principles for conversion of non-price policies into the price realm; and define criteria that limit undoing.

If the choice for a single-price policy is cap and trade (option we favor because we believe that it is easier to monitor):

- Fix a trajectory of emissions that scientists deem consistent with the 2°C objective, and agree on the principle of this worldwide cap trajectory.
- Agree that permits will be allocated to participating countries in line with the aggregate cap.
- Agree on a trading mechanism in which countries will have to match pollution and permits at the end of the year to avoid creating unfulfilled climatic debt.

Under the current circumstances, the implementation of any of these two approaches would constitute a formidable achievement.

#### ✎ ACKNOWLEDGMENTS ✎

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## Chapter 7

# Climate action beyond the Paris Accord

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### Introduction: the Paris paradox

After the release of China's "Intended Nationally Determined Contribution" (INDC) at the end of June and the final ruling of the EPA on the US climate action plan in early August, negotiation positions on the road to the COP 21 are now stabilized.

They point to a foreseeable paradoxical outcome of the Paris Conference: an unprecedented universal climate agreement that will not solve our climate crisis.

However, this paradox can be solved, in large part, by introducing, into these climate negotiations, the goal to develop a robust global carbon pricing system.

Our arguments and proposal for a global carbon price are totally in line with our own work on that topic and with most papers of the Symposium on 'International Climate Negotiations'. The thoughts outlined in this article, however, distinguishes itself in that it takes into account the commitments already made by the international community within the framework of current negotiations. As set out in our text, it should be considered that:

- the objective is to limit global warming to below– or around – two degrees Celsius above pre-industrial levels; a global carbon price must therefore aim to meet that objective;
- whatever one's opinion on the debate regarding the best way to levy a carbon price – tax or emissions trading – various countries have already picked their own path and trying to get them to fit the same mold would be unrealistic;
- several countries have pledged to meet quantitative reduction targets (pledge-and-review strategy); so rather than asking these countries to abandon those targets in favour of a global carbon price, it would be better to show them that negotiating such a price would be a powerful means to meet – or even exceed – their targets;
- because the internationally agreed principle of "Common but Differentiated Responsibilities" would make it very difficult to set a single price immediately, it would be more realistic to consider a price convergence-based process stretching over a number of years, as proposed by such international bodies as the International Energy Agency;
- since the developed countries have pledged to provide one hundred billion dollars yearly to help the most vulnerable countries deal with climate change, global carbon price negotiations cannot be used to cancel that commitment: on the contrary, they are a good means to meet – or even surpass – the commitment.

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Let us now review those points in more detail, pondering the reasons why the current climate negotiation system is fundamentally flawed.

## 1 COP 21: missing the wrong targets softly?

### 1.1 The prospect of a legally weak agreement

The key factor in achieving an appearance of success at the Paris Conference will be the way expectations are managed beforehand. That was the major failure of the 2009 Copenhagen Conference, where negotiators promised a global, legally binding agreement but could not deliver it in the end, causing a huge disappointment. This is why Paris negotiators have adopted a flexible position on the legal form of the final text that is likely to be “politically”, but not “legally” binding. Contrary to the Kyoto Protocol, the Paris text will thus probably be an ‘accord’ instead of a ‘treaty’, meaning that its legal power will be even weaker. As is well known in diplomatic circles, it is rarely a good sign when an international text is being labelled an “accord”.

This can indeed be seen as a victory for the US negotiators, who have insisted that a legally binding text, requiring the Republican controlled Senate’s approval, has no chance of being adopted. While the Obama administration is trying to convince other parties that it can act on the basis of executive force (the rationale behind the final ruling of the EPA on cutting emissions from coal fired plants released in early August 2015), it is very hard not to consider climate policy in the US as conditional, the conditionality being that the legal challenges of the States are overturned by the Supreme Court. The US political polarization, not unrelated to the damaging effect of income inequality, is thus a drag on global climate policy.

This possible outcome is contested by the EU and its Member States, which, in their Intended Nationally Determined Contribution released on March 6, have called for “adopting a global legally binding agreement applicable to all Parties” ([URL](#)). China is also calling for a “legally binding agreement” in a clear challenge to the US position ([URL](#)).

But as things stand, the US position is likely to prevail, meaning that the Paris text will be legally weaker than the Kyoto Protocol, itself deprived of any sanction for non-abiding parties.

### 1.2 The stubborn ambition-science gap

At the 2011 Durban Conference (COP 17), the parties acknowledged the gap between their commitments and achieving the two-degree Celsius objective. In the preamble of their joint statement, they expressed “grave concern” and promised to “raise the level of ambition” to bridge this gap. At the Lima Conference (COP 20) in December 2014, the parties reiterated the same “grave concern” about “the significant gap between the aggregate effect of Parties’ mitigation pledges” and the goal of holding the increase in global average temperature below the two-degree Celsius limit. But the ambition-science gap has so far survived all virtuous proclamations.

Climate negotiations have revolved crucially around volumes of carbon emitted: climate performance in the Kyoto Protocol is assessed in terms of emission reduction targets compared to their 1990 levels and climate commitments are being framed in terms of emission reductions up to 2030 or 2050.

There are two reasons why this volume-based approach can be insufficient: it does not specify the instruments that are supposed to be used to match the volume targets (see next point);

and it does not take into account carbon flows, that are emissions resulting not only from national production, but also from national consumption. The gap between the two can be quite large: the EU has reduced its GHG emissions by close to 20% in terms of production since 1990, but by only 5% when consumption emissions are considered. A country like France sees its climate performance since 1990 completely turned upside down when consumption emissions are considered instead of production emissions.

But even if one withholds judgement on the potential efficiency of the volume approach, it appears to fall short on its own ambitions: Climate Action Tracker experts, assessing the announcements and commitments to track their compatibility with the two-degree Celsius threshold, currently conclude that existing and announced measures lead to an increase above 3 degrees and possibly as high as 3.8 degrees in global temperatures. The latest IEA assessment indicates that given the INDCs submitted so far and the planned energy policies in those countries that have yet to submit, the path would be "consistent with an average temperature increase of around 2.6°C by 2100 and 3.5°C after 2200." (See p. 12 in: [URL](#)). That IEA scenario assumes that countries will fulfil their climate commitments. However, we know full well that several countries will not honour their Copenhagen pledges and as a result, will not meet their GHG emissions reduction targets for 2020 ([URL](#)). So why should we assume that they will honour their Paris pledges?

### 1.3 The perils of commitments without instruments

The agreement reached by the Member States of the European Union in the fall of 2014 is a good illustration of the limitations of any strategy based on emission reduction targets alone, with no efficient and effective carbon pricing system. Indeed, the European "climate-energy package" can be considered a baseless pyramid: the greenhouse gas emission reduction target of 40 percent by 2030 is only supported by non-binding energy efficiency and renewable energy targets, which themselves are not underpinned by a true carbon pricing reform.

At the basis of the European agreement lies a dysfunctional, derelict carbon pricing system. The end result: commitments without instruments, and "ambitious" emission reduction targets suspended over a sea of ambiguity. The same can be said of most current national commitments that are lacking adequate instruments.

COP 21 needs to achieve a much more substantial outcome. National emission reduction targets must absolutely be accompanied by adequate and coordinated implementation tools, including a true global carbon price. In other words, negotiators should aim for a "commitments + instruments" rather than a "commitments-only" agreement.

### 1.4 The need for climate justice

In Copenhagen (COP 15) and Cancun (COP 16), the developed countries committed to a contribution of 100 billion US dollars per year beginning in 2020, to help developing nations fight – and adapt to – climate change. A fund – the "Green Climate Fund" – has been created for this purpose, to provide developing countries with the substantial financial and technological assistance they require.

Developing countries take this commitment very seriously. They have made it known that no agreement will be possible in Paris without the conclusion of a clear plan for the delivering, through the Green Climate Fund, of the committed US\$100 billion per year by 2020.

Unfortunately, despite years of ongoing discussion over this agreed \$100 billion target, nobody knows how much each developed country is supposed to contribute. What we do

know, however, is that raising such a sum will require private sector contributions. This will not happen in the absence of a fully functional, robust and comprehensive carbon pricing system.

Focusing negotiations on a world carbon price in addition to quantitative reductions of emissions can alleviate all four problems: first, it can strengthen the Paris accord by providing economic incentives so that countries take charge of their climate commitments rather than engage in carbon free riding ; second, it can serve as a tool for adjusting climate commitments and hence gradually increasing the level of ambition of Nation-States so that the gap between commitments and science-based requirements can be progressively closed, and it can enhance the efficiency of the agreement by controlling carbon flows; third, it can provide a credible instrumental basis for climate commitments; finally, it can provide the source of the \$100 billion pledged by developed countries to fight climate change globally.

## 2 Building the carbon convergence

Governments and businesses are unlikely to realize their climate change goals if they have no definite assurance that their competitors will play by the same rules. To address this stalemate, we need an international agreement that gives them that assurance, one that changes the rules of the game so that they apply to every player. We need to create a system whereby every decision maker, public or private, is responsible for taking into account the true cost of global warming, and is secure in the knowledge that the competitors are doing the same.

This explains why more and more experts – including every author of the Symposium on ‘International Climate Negotiations’ – agree that putting a price on carbon is essential to the success of any serious, comprehensive climate plan. The International Monetary Fund now recommends it. As does the OECD. The World Bank convinced 73 countries, 22 subnational jurisdictions and over 1,000 companies and investors to declare their support for a price on carbon. The Global Commission on the Economy and Climate has also pointed out that a carbon price may be beneficial for the economy.

There are opportunities to explore linkages between carbon pricing and the new international climate change agreement to be reached in Paris. But the main challenge facing us is how to evolve from a hodge-podge of local or national carbon prices to a global, harmonized carbon pricing system. IPCC recommends a solution: adopting a "single global carbon price." The price should be high enough to create the necessary incentives to limit global warming to about two degrees Celsius. The International Energy Agency (IEA) recommends that the price of a tonne of CO<sub>2</sub> be gradually raised by 2040, to \$140 for developed countries and \$125 for China, Russia, Brazil and South Africa (in US 2013 dollars). According to the IEA, this can be done without harming economic growth.

It is impossible to reach a global carbon price of \$125 or \$140 per tonne of CO<sub>2</sub> without first having negotiated an international agreement that can assure all economic agents that their competitors will play by the same climate rules. Indeed, carbon pricing will not reach the desired level as long as individual countries fear that carbon price setting within their respective jurisdictions will scare away businesses and investments send them off to countries where carbon dioxide emissions are cheaper or free of charge. The idea is to refocus these international efforts on negotiating a global, harmonized carbon price signal.

All countries would pledge to introduce, in their respective jurisdictions, a gradually evolving carbon price based on a scientifically validated international standard, in order for the world to keep global warming as close as possible to two degrees Celsius over pre-industrial levels. Countries may levy this price through carbon taxes or emission quotas. Governments would be free to invest, as they see fit, any revenues accruing from carbon emission levies and the corresponding – and necessary – gradual elimination of fossil energy subsidies.

In keeping with the principle of "Common But Differentiated Responsibility", developed countries would be required to set aside part of their carbon pricing revenues to help developing countries introduce policies to lower their emissions, adapt to climate change impacts and create carbon sinks (through reforestation, for example). This requirement would help fund the yet unsourced \$100 billion annual injection into the Green Climate Fund that was promised to developing countries for 2020 to help them deal with climate change. That amount could even be increased. We propose that the contributions of individual developed countries would be set according to the proportion of total developed country emissions that their respective GHG emissions represent. The lower a country's emission level, the lower its share of the financial effort this serves as a further incentive for emission reductions. Other formulas are also conceivable, such as making the contributions proportional to emissions in excess of the global average per-capita rate, but the argument will likely be made that the most advanced economies, – those that have the best technological capacities – should be the ones helping the others.

This international carbon pricing agreement would allow countries to levy border taxes on products from countries that have not established a carbon price signal in accordance with the international standard. That would be a solution of last resort, to be applied after the usual warnings have been issued. In this manner, it will be in each country's interest to comply with the international agreement, levy a carbon price on its own emissions and use the resulting revenue as it sees fit.

### 3 Conclusion: from climate science to climate justice

Climate negotiations are not only a technical discussion based on scientific data but also a political dialogue ultimately based on ethical criteria, and we need the Paris Conference to be informed by both sets of criteria: climate science and climate justice must be combined in a single plan.

That is precisely why our plan brings together the logic of science-based efficiency and the logic of ethics-based justice.

1. Science-based efficiency: a carbon budget set to the two-degree limit leads to the establishment of a differentiated trajectory of gradually converging global pricing of carbon, each country freely determining the mix of instruments used to raise its price;
2. Ethics-based Justice: our carbon price system addresses inequalities between countries (through modulations and compensations) and inequalities within countries (accelerating adaptation of financing).

An international carbon price agreement would provide the world with an excellent instrument for sustainable development. After decades of international stalemate, carbon

emitters would have to acknowledge the obvious social and environmental cost of pollution. Consumers and manufacturers would have an incentive to choose lower-carbon-content goods and services and to invest in new energy-saving and emission-reducing technologies. Governments and legislators would have the tool to achieve the scientific climate targets that they have endorsed.

This plan is necessary – more so than ever – to protect humankind from the threat of a three-degree Celsius – or more – global warming. Current initiatives are not without merit but are insufficient. Our world leaders must champion what is needed for a comprehensive and effective climate/energy policy – a worldwide, harmonized carbon price.



# Chapter 8

## An International Carbon-Price Commitment Promotes Cooperation

PETER CRAMTON,<sup>a</sup> AXEL OCKENFELS,<sup>b</sup> and STEVEN STOFT<sup>c</sup>

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### ABSTRACT

*To promote cooperation in international climate negotiations, negotiators should focus on a common commitment. Such commitments have the advantage of facilitating reciprocal “I will if you will” agreements in a group. Reciprocity is the basis for cooperation in repeated public goods games, and a uniform price would provide a natural focal point for a common international commitment. Such a price is also essential for efficient abatement. Countries would retain flexibility in how to implement the price—with cap-and-trade, a carbon tax, or a hybrid approach. Country risk is reduced relative to risk under international cap-and-trade since carbon revenues stay within the country. Price commitments also tend to equalize effort intensity and can facilitate enforcement. To encourage participation by less-developed countries, a green fund is needed to transfer money from richer to poorer countries. Transfers are smaller and more predictable with a uniform price commitment than with international cap and trade.*

**Keywords:** Climate change, global warming, carbon pricing, international public goods, UN climate negotiations, prices versus quantities

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### ✎ HOW A COMMON COMMITMENT PROMOTES INTERNATIONAL AGREEMENT ✎

For twenty years, climate negotiators have been stymied by the most challenging tragedy of the commons ever encountered. The central problem is well understood. All countries can use the atmospheric commons for free, but only a small fraction of the benefits of investing in CO<sub>2</sub> reductions accrue to the country that incurs the cost of such an investment. As a result, self-interested countries rationally invest too little in CO<sub>2</sub> abatement, and instead attempt to free-ride on the hoped-for investments of others. Indeed, “climate change is a public good (bad) par excellence” (Arrow 2007).

The Kyoto process started with a natural approach to breaking the free-rider deadlock: agree on a *common commitment*. A common commitment helps realign self-interest with the common good by assuring all parties that they will only be required to contribute to the common good if all are required to follow the same commitment rule. This “I will if you will” feature is critical for solving problems of the commons.<sup>1</sup>

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1. We will return to this later. For the moment, observe that democracies habitually solve national public-goods problems by voting on a common commitment. Usually this is a commitment to pay a uniform tax with revenues used for public goods, such as parks, highways, education, defense, or cleaning up toxic waste. Voting for a tax is an organized approach to saying “I will adhere to the common commitment if you will.”

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A common commitment needs to be enforced like any other commitment. Yet the fairness that comes with protection from exploitation offered by a reciprocal common commitment removes one reason to defect. Also, since defecting will weaken the common commitment and hence jeopardize the contributions of others, a well-structured common commitment automatically embodies some enforcement.<sup>2</sup> Moreover, as we show below, a price commitment reduces risks compared to quantity commitments, and thus reduces the needed size of the enforcement penalty.

In a nutshell, a common commitment facilitates the collective reciprocity which is the only known way of overcoming free riding—the central problem of climate negotiations (Weitzman 2015a). Moreover it is likely a necessary precursor to the implementation of effective enforcement. Yet Kyoto failed to find such a commitment. This failure was no accident. The quantity commitments needed for international cap-and-trade preclude a common commitment. This paper suggests this deficiency of quantity commitments is the motivation underlying the proposals for an international price commitment by Cooper (2004), Nordhaus (2013), Stiglitz (2015), Weitzman (2015a) and ourselves.

### ✎ WHY KYOTO FAILED ✎

Initially, many countries supported a common commitment by all to reduce their emissions by an equal, agreed percentage below their 1990 emission levels. Such a general percentage-reduction rule—as opposed to individually pledged percentages—would constitute a common commitment. But many disagreed, and at least ten other formulas were developed and considered. After many failed attempts, the resolve to forge a common commitment was broken and replaced with a resignation to accept *individual* commitments. Indeed, even before concluding the negotiations, Chairman Estrada allowed parties “to negotiate their own targets,” and finally “invited Annex I Parties to submit their revised, final, numbers to the podium” without any restrictions (Depledge 2000, ¶192, 214).

The EU offered a 15% emission cut with a common commitment, but accepted only 8% when that failed.<sup>3</sup> Russia accepted 0%, Australia and Iceland accepted 8% and 10% increases respectively, and the US, a 7% cut which was not serious. Of course the developing countries accepted nothing, and the EU’s 8% reduction masked cuts that ranged from 30 percent to an increase of 40%. The 95 to 0 rejection by the US Senate was explicitly linked to the fear of free riding although there were other motives as well. The lack of an acceptable common commitment meant there was little check on free riding, but if any common commitment had been forced on the parties, the outcome would have been worse, which is why none was agreed to.

The Kyoto negotiations were right to focus on the search for a common commitment, but what they proved, after more than a year of searching, was that no common *quantity* commitment can be found. The result was a weak and fragile international cap and the mistaken conclusion that a common commitment is impossible. The mistake was accepting the international-cap-and-trade straight jacket as inevitable.

Interestingly, the Kyoto Protocol also failed to achieve its second goal, equalized prices. International permits were implemented in the form of Assigned Amount Units (AAUs). The

2. In other words, a treaty based on a common commitment is a partially self-enforcing treaty.

3. Kyoto Chairman Estrada personally suggested the target of “8% below 1990 emissions” for many countries, and many adopted his suggestion when submitting their final pledges.

Soviet Bloc's AAUs are referred to as "hot air" in the popular press and, in fact, some AAU trades that took place simply enriched those in Eastern Europe who faced no burden from the Kyoto Protocol. Because trading was seen as inappropriately redistributive and evasive of climate commitments, AAU trading became so controversial that Japan had to publicly deny purchasing AAUs from countries previously in the Soviet Bloc.<sup>4</sup> And now the U.N. has restricted AAU trading.<sup>5</sup> As a result, and because of political uncertainties (Edenhofer et al. 2014) and various regulatory interventions (Marcantonini and Ellerman 2014), quantity commitments did not lead to anything like the hoped-for equalization of carbon prices.

Stiglitz (2006b, 2015) has explained why there is no reason to believe anyone will ever come up with a quantity-based emissions rule. The history of the Kyoto negotiations strongly confirms that requiring quantity targets will block any hope of a broad common commitment even without including the developing countries. The US government has now come to the same conclusion.<sup>6</sup> Without a common commitment, any agreement, if one could be reached, would again be weak and fragile. And it would not produce anything like a uniform price on carbon. Kyoto was a useful experiment, but the world learned the wrong lesson.

### ✎ KYOTO'S LEGACY FOR PARIS ✎

In response to Kyoto's dramatic failure, and then Copenhagen's, the idea of striving for a common global commitment has been abandoned on the way to Paris. Rather, it is hoped now that individually-selected quantity targets will cover the bulk of global emissions with sufficient stringency. Indeed, the plan for Paris is to let every country simply pledge to do whatever it wants. There will be reviews without consequences for hundreds of incomparable proposals (Gollier and Tirole 2015). And if countries fall short of their pledges, there still will be no consequences.

This pledge-and-review approach for Paris is unlikely to work. As the Kyoto Protocol demonstrates, individually adopted targets do not change self-interest, at least not by enough to notice. The reason is that such agreements are not of the "I will if you will" type. In fact, under the Kyoto Protocol, several countries, including the US, Canada, New Zealand, Japan and Russia, have said "We won't" while the others continue to say "We will." So the Protocol is an "I will, even if you won't" agreement. This is an agreement of nations acting altruistically—a coalition of the politically willing. But, as explained by Gollier and Tirole (2015), there is no reason to suppose that altruism can solve the tragedy of the commons. Conditional cooperation in the vein of "I will if you will," on the other hand, provides a strong source of cooperation, as explained by Weitzman (2015a). Indeed, conditional cooperation is the most robust pattern of cooperation seen in laboratory, field and theoretical studies of free-rider situations, and is—unlike unilateral altruism—consistently found to stabilize higher cooperation levels. Numerous studies show that conditionally cooperative strategies can promote

4. "Japan is defending itself against criticism that it's exploiting a surplus of Kyoto assigned credits and using 'hot air' to meet emission targets." Bloomberg, 23 July 2009. The importance of high-profile political ramifications caused by unpredictable public transfers between rival countries was anticipated by Cooper (2004), "*What US Senator, once s/he understands the full implications of a trading regime, can vote for a procedure which could result in the unconditional transfer of billions of dollars, even tens of billions, to the government of communist China, or to Castro's Cuba, or even to Putin's Russia?*"

5. "After tense negotiations, countries decided to restrict how much of this [AAU] surplus can be used for compliance with emission reduction targets." Doha, March 2013, [carbonmarketwatch.org/doha-on-aau-the-future-of-the-phantom-menace](http://carbonmarketwatch.org/doha-on-aau-the-future-of-the-phantom-menace).

6. In its 11 March 2013 submission, the US stated, "It is hard to imagine agreement on any formula or criteria for imposition of contributions, as this would get into the most controversial issues."

cooperation levels among selfish players well beyond what is theoretically sustainable. One reason is that conditional cooperation—unlike unilateral altruism—is considered fair (see Bolton and Ockenfels 2000, Cramton et al. 2015, Hauser et al. 2015, Kraft-Todd et al. 2015, and the references therein).

This is why we advocate that negotiations again focus on a common commitment. While a common *quantity* commitment proved infeasible, we argue that a common *price* commitment can substantially mitigate many of the problems associated with quantity commitments (see also Stiglitz 2015, Weitzman 2015a). One reason is that there is near-unanimous agreement that each country should commit to the same price, which thus constitutes what Schelling (1960) calls a focal point. Such a common commitment makes possible the type of agreement that changes self-interests for the better: “I will commit to the common price if you will.”

The difference between the two commitments, price and quantity, has been overlooked in part because the two can be economically equivalent in a world without uncertainty. A global cap induces a carbon price, and taxing carbon at that price would limit emissions to that cap. But for reaching agreements, the two targets are substantially different. Before exploring that in more depth, it is useful to review why international commitments do not automatically induce specific national policies.

### ✎ INTERNATIONAL COMMITMENTS ARE NOT NATIONAL POLICIES ✎

Economists sometimes imagine that caps or taxes could be implemented by an international tax-collection agency or by an international cap-and-trade market covering a large majority of each-country’s carbon emissions. Such plans assume a dose of top-down regulation that is presently infeasible.

However, a different pair of alternatives requires no such top-down apparatus and would allow countries tremendous flexibility. Under these alternatives, countries simply commit to a set of quantity commitments (regarding carbon permits) or to a price. Either type of commitment could be met by national or regional cap-and-trade markets, fossil-fuel taxes, or any mixture of these along with bonus-malus systems applied to, for example, auto emissions estimated at the time of sale. An example of a mixture is the EU’s reliance on a weak cap-and-trade market and a strong tax on carbon in the form of a tax on oil. Another possibility is cap-and-trade with a floor price. This flexibility should minimize the acrimonious debate over caps and taxes to the extent possible, since all countries could adopt linked cap-and-trade markets under either a global price commitment or a global quantity commitment. And countries also comply with either commitment by using fossil-fuel taxes.

### ✎ DEFINING A GLOBAL PRICE COMMITMENT ✎

A country that commits to the global price only needs to meet the commitment on average. The average carbon price is simply the country’s carbon revenues divided by its emissions. The revenue can, of course, come from selling permits under cap-and-trade, from fossil fuel taxes, or from calculations on other pricing-compatible regulation.

There should be some restrictions on how unevenly a country prices its carbon. For example exports should face a price rather close to the global price. (And the same is true under an international cap.) But we will not get into such details.

Also, our definition leaves a question of how to count pre-existing taxes. There are at least two views on this. For accounting simplicity, all carbon charges would be counted towards compliance. This is the approach that we would prefer for pragmatic reasons. Another view is that this would be true after some base year, say 2015, and the fossil-fuel tax rate in that base year (excluding any taxes imposed for climate reasons) would be subtracted from all future carbon-price measurements. Both approaches are quite simple, and from an implementation point of view, the only difference is that the second approach requires a one-time accounting of fossil-fuel tax revenues at the start. There is no need to untangle taxes by purpose after the initial accounting and even that may be unnecessary. So there is no possibility of gaming the commitment by saying a non-climate tax is for the climate. Going forward all taxes count.

Of course, it is inefficient to credit a new tax to pay for highways as if it were a carbon tax for the climate (Gollier and Tirole 2015). But this is simply the minor inefficiency of not having a perfectly uniform tax—which seems even more out-of-reach with an international cap-and-trade scheme, as we will explain below.

#### ✎ PRICE VERSUS QUANTITY COMMITMENTS: A COMPARISON ✎

This paper argues for correcting the flaw that derailed the Kyoto process and for returning to Kyoto's sound fundamental principle: agree on a common commitment that leads to (fairly) uniform carbon pricing. And it proposes to do so in the most straightforward way—by using a global price commitment. Similar views have been expressed by Cooper (2004, 2008), Nordhaus (2013), Weitzman (2014, 2015a), and Cramton and Stoff (2012a, b).

While a single price commitment would be effective and is within reach, as we discuss throughout this paper, it appears impossible to agree on  $n$  national quantity commitments. Stiglitz (2015) has made the case that there is no way to achieve a compromise between rich and poor countries regarding quantity commitments, and Weitzman (2015a) too argues that quantities cannot be successfully negotiated. We add that history confirms this. The hope of finding a common quantity commitment was high at the start of the Kyoto treaty but has declined steadily ever since to the point where no one any longer mentions the possibility. Neither is there any discussion of how individual quantity commitments might be negotiated, even in this symposium which raise this as the central topic for discussion. This explains why we will not attempt to refute any arguments that quantity commitments, common or individual, could be successfully negotiated. Rather, we will focus on comparing the two negotiation processes in terms of reciprocity and common commitments.

Importantly, cap-and-trade advocates and tax proponents nearly always agree that a uniform global price is the desired outcome. So unlike quantity, for which there is little if any agreement on the appropriate common commitment rule, there is nearly universal agreement that a common price commitment should be a uniform price commitment (or more precisely a uniform price floor). That is, a uniform price is a natural focal point. This facilitates negotiations about the price commitment (Weitzman 2015a, Schelling 1960).

There is an apparent, but not actual, symmetry between the global cap of Gollier and Tirole (2015) and the global price of our approach. Gollier and Tirole suggest a cap corresponding to 2°C, which is likely a focal point. Also, as they point out, negotiating a cap avoids the free-rider problem much like negotiating a price. However, there is an important difference. While a global price is a common commitment, a global quantity is only a common

aspiration. Individual countries can implement the global price, and their commitment to the price is in principle enforceable. But no country can implement the global cap. And an aspiration cannot be enforced.

The practical benefit of a price commitment is that it takes us most of the way to the set of final commitments. It resolves who will do how much for the climate, and of course it can also strive to reach the 2°C goal or any other focal climate goal. It leaves only the question of equity transfers to be resolved. This is still a crucial and difficult question (and we will get to it below) but focusing on price helps to disentangle it from the larger question of climate efforts.

Another advantage is that price is an inherently more fair measure of effort intensity than is a Kyoto-style quantity measure. The US has tried to persuade India to commit to a cap in the vicinity of its emissions level, which would have been lower than the per-capita emission of the US in 1880. Not surprisingly, India rejected this idea. Accepting a carbon price would not limit India to any lower emission rate or “intensity rate” than the US, and would even allow India to emit as much or even more per-capita than the United States. A price treats India more equitably and it is at least as efficient as a cap that induces the same carbon emissions.

### Monitoring and corruption

For the two global commitments (as opposed to national policies) there are two main questions that will determine which is best. The first concerns reaching an agreement (discussed above), and the second concerns whether compliance can be verified. Here we discuss verification.

*Local monitoring and corruption.* Under a commitment to either price or quantity, it is possible for emitters to bribe the carbon-tax collector or the carbon-permit collector (Victor 2001, Tirole 2012). Such corruption will impose an inefficiency on the country but will not disrupt the enforcement of the international commitment, which only requires information of a more aggregate nature. If a power plant dodges its carbon charge, national carbon revenues are reduced. So the country must charge other emitters more to meet its average-price commitment, but the national commitment is still verifiable.

*National monitoring and corruption.* Emissions should be measured by monitoring the inflow of fossil fuel from extraction and from net imports. Even so, with over 500 coal mines in India and over 18,000 in China, emissions monitoring could be poorly enforced or deliberately distorted. Similarly, under a price commitment, national carbon-pricing revenues could be falsely reported. Although this could be a serious problem in a number of countries, there are several ways to mitigate such problems. There could be monitoring by the IMF, World Bank, IEA or WTO, all of which do some similar monitoring already. Countries receiving green funds could be required to open their national accounting books in order to receive such funds.

Finally, most real carbon pricing will be reflected in visible prices at gas stations, in home heating bills and in retail electricity prices. These prices could be easily monitored. So verification is possible under either commitment, but in a few countries it may require a significant effort. Both commitments would include a requirement to allow verification, and any country that did not cooperate would be considered to be out of compliance and would be sanctioned just as if it had not met its price or quantity commitment.

*International monitoring and corruption.* On a global level, the corruption problem is asymmetric. Suppose a local official, on behalf of a kleptocratic ruler, allows a company to under-report emission so that it needs fewer carbon permits. The kleptocrat then sells supposedly-surplus international carbon permits to a perfectly honest country. As Nordhaus (2008) explained, both the government and private company benefit, because this shifts money from honest to corrupt countries. It also crowds out the honest country's abatements.

*Conclusion on monitoring.* Proponents of international cap-and-trade claim a carbon price cannot be monitored. Yet they claim that cap-and-trade will solve the export-import problem that results from international carbon-price differentials. But as we saw above, equality of nationally-traded permit prices says nothing about the price of carbon emissions from exporters or from anyone else. So the export-import problem can only be solved by monitoring the carbon prices paid by exporters. In other words, a crucial claim of cap-and-trade proponents relies on the assumption that carbon prices can be monitored accurately under the worst of conditions—at the local level, in industries where (unlike at gas stations) the price can be camouflaged, and where there is, perhaps, the strongest incentive for corruption.

Overall, looking at the various arguments in favor and against each commitment type with respect to monitoring and corruption, we tend to agree with Nordhaus (2008) who concludes, “quantity-type systems are much more susceptible to corruption than price-type regimes,” and with Cooper (2008) who concludes that a global cap-and-trade system “will unavoidably foster rampant corruption.”

### Will carbon emission actually be priced?

The point of international cap-and-trade is usually viewed as *imposing on* “all CO<sub>2</sub> emitters the cost of their damage to the climate.”<sup>7</sup> The result of this would be an *economically* efficient reduction in emissions. This efficiency is a central goal of the policy, partly because cost reduction is a great help in making a strong policy sustainable. Environmentalists, however, generally have quite a different goal for cap-and-trade. Their view is that the price doesn't matter but that the cap is a good old-fashioned command-and-control mechanism.

So the question is, will *international cap-and-trade* induce a uniform and efficient carbon price as economists would like, or will it produced an inefficient mix of national command-and-control policies? Let us look at the Kyoto protocol, which priced international permits and allowed any national policy. This is also specified by Gollier and Tirole, who note that within the OECD countries, there were direct subsidies to green technologies which resulted in implicit carbon prices that range from “less than 0” to “as large as 1,000 €.” It is likely that most of this range was spanned within countries that were under the Kyoto Protocol. Gollier and Tirole conclude that such policies demonstrate “the inefficiency of this command-and-control approach.”

In other words, in the only test case, the outcome was, by and large, not what economists hoped for but rather the inefficient command-and-control policies. Two conclusions seem evident. International cap-and-trade need not induce much if anything in way of actual carbon pricing, and it may leave the current command-and-control approaches untouched. In other words, international cap-and-trade may not achieve the central objective of its proponents, but rather, the opposite.

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7. From [sites.google.com/a/chaireconomieduclimat.org/tse-cec-joint-initiative/some-economic-perspectives](https://sites.google.com/a/chaireconomieduclimat.org/tse-cec-joint-initiative/some-economic-perspectives), accessed 14 July 2015.

### Committing to a price is less risky

Quantity targets are favored because they supposedly remove the risk of emission and climate uncertainty and shift that risk to nations in the form of price and cost uncertainty. While their success at limiting climate risk has been dismal, in part due to the uncertainty of the resulting quantity agreements and disagreements, quantity targets do impose risks on the countries that adopt them.

More specifically, accepting a quantity commitment entails risk, because future business-as-usual (BAU) emissions and abatement costs are both highly uncertain. Suppose that a country expects BAU emissions of 100 Mt and considers two commitments: (1) a quantity reduction to 90 Mt and (2) a price of \$20/t. Assume these are equivalent (they both cause the same price and same emission quantity). Furthermore, assume that the global carbon price will be \$20/t.

Now suppose, that the country's BAU emissions turn out to be 110 Mt (10 Mt higher than expected). Under the quantity commitment, the \$20/t global price will reduce emissions 10% to 99 Mt. But the country will only have been issued 90 Mt of permits, so it will need to buy 9 Mt of permits on the world market for a cost of \$180 M. Under a price commitment, the country simply sets its carbon price to \$20/t as if nothing had changed.

Even though the price-commitment policy specifies that countries keep all of the carbon revenues from pricing carbon, there is still a social cost. To find that cost, note that the more that is abated, the greater the cost per ton abated, with the per-unit cost starting at \$0/ton and reaching a maximum of \$P/ton. So the standard estimate of the cost of abatement,  $A$ , under carbon price,  $P$ , is  $A \times P/2$ , or in this case  $11 \text{ Mt} \times (\$20/\text{t})/2$ , which equals \$110 M. This cost occurs under either policy because the global price of \$20 causes 11 Mt of abatement in both cases.

Hence the total cost under the quantity commitment is  $\$180 \text{ M} + \$110 \text{ M} = \$290 \text{ M}$ . That's 2.6 times as much as the \$110 M cost under the price commitment. But some cost was expected to occur under the expected BAU emission of 100 Mt. That expected cost was  $10 \text{ M} \times \$20 / 2$ , or \$100 M. So the unexpected cost under the quantity policy is  $\$290 \text{ M} - \$100 \text{ M} = \$190 \text{ M}$ , while the unexpected cost under the price commitment is  $\$110 \text{ M} - \$100 \text{ M} = \$10 \text{ M}$ . The financial risk from a possible 10% shock to BAU emissions in this example is 19 times greater with caps than under a price commitment.<sup>8</sup>

This example does not exaggerate the risks of quantity commitments. In 2000, the US DOE's International Energy Outlook predicted China's 2010 emissions would be 1.5 Gt, but in the event, emissions were over 7 Gt—nearly a 400% error rather than the 10% error assumed in the above example. And quantity targets generally have been set 10 to 15 years in advance. Moreover quantity errors can have a high political sensitivity. If China had committed to a cap in 2000 equal to its expected BAU emissions (not reduced by any cooperative climate efforts) it would have been purchasing over 5 billion tons of permits annually by 2010 from, perhaps the US and the EU. This would have likely cause a dramatic permit shortage and high carbon prices, but even at \$20/ton this comes to \$100 billion per year in highly visible transfers to foreign countries. If China had made anything like the quantity commitments desired of it by cap-and-trade advocates at that time, quantity risks would have likely destroyed

8. Based on our example, Weitzman (2015b) has recently shown in a rigorous and general model, that under uncertainty, internationally-tradable permits expose a country to unambiguously greater risk than the imposition of a uniform carbon price whose tax proceeds are domestically retained.



that international quantity commitment and any associated cap-and-trade treaty. China was right to reject such quantity commitments.

### Enforcement

A major advantage of monitoring and enforcement of a price commitment is that it is an annual rather than a once-in-15-year event, like the Kyoto Protocol or like China's recent commitment to cap emissions in 2030. This creates free-riding incentives and diffuses responsibilities among successive governments within countries, and makes it difficult to repair non-compliance. Annual price commitments have the advantage that cheating can be quickly detected, and can be quickly corrected, because full compliance can be achieved simply by increasing the carbon charge. Indeed, frequent monitoring is known to be one of the most critical aspects of self-enforcing cooperation (Ostrom 1990).

Gollier and Tirole (2015) propose a fix for this problem: "countries will have to match pollution and permits at the end of the year to avoid creating unfulfilled climatic debt." Unfortunately, this proposal blocks banking and borrowing of permits, the standard method of mitigating the volatility of permit prices. Such price volatility is likely to be unpopular with investors and the public.<sup>9</sup>

Successful enforcement is one key to successful cooperation (Nordhaus 2015). We have argued before that cooperation based on a common commitment is relatively easy to enforce, because the common commitment enables a reciprocal relationship, which is known to promote cooperation. Here we argue that a common price commitment facilitates enforcement compared to a quantity commitment. One reason is that a price commitment is continuously monitored and thus more easily enforceable (see above). Another reason is that it reduces risks (as discussed above). Risks can produce strong incentives to leave or avoid a quantity commitment. Without such strong negative incentives, the needed size of the enforcement penalty is reduced. Finally, price commitments reduce the required size of equity transfers (as we describe below), which also reduces the needed size of the enforcement penalty.

There are various complementary mechanisms that can further ease the enforcement of price commitments. For instance, efficient performance, which we borrow from modern electricity markets where deviations from plans are settled at the market price for carbon revenues. In other words a country that exceeds its commitment can sell its excess performance to a country that falls short. This guarantees that plans are met in aggregate and yet gives countries the flexibility to easily and efficiently react in an uncertain environment. Efficient resolution of deviations from plans greatly reduces risks, facilitates performance, and encourages participation.

### The waiting game

Gollier and Tirole (2015) explain that negotiations that are currently ineffective but are likely to eventually result in individual pledges contribute to what they call the "waiting game." The result of this game is that present behavior, while waiting for an agreement on individual commitments, can be even worse than the outcome of the non-cooperative Nash equilibrium of the public goods game—worse than without any thought of cooperation.

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9. In that respect, the first trading period in the context of the EU-ETS provides a good lesson of undesired price effects when banking and borrowing is not allowed.

The problem does not arise if a *common* commitment is expected to be the eventual outcome. Yet if individual climate commitments are expected, it pays countries to jockey now for position in the final round of commitments. For example, if it is expected that commitments will be made relative to 2020 emissions or some future BAU emissions, then it pays to not take easy actions to reduce emissions before 2020.

But if the eventual commitment will be a common price, then having higher emissions in 2020 will simply mean more emissions will be taxed at the global price. This confers no advantage on the recalcitrant country. That is, deciding now to agree on a common price ends the waiting game now, even though there is still a wait for the actual agreement.

## ✎ THE ROLE OF THE GREEN FUND AND EQUITY TRANSFERS ✎

### Equity transfers are less expensive with price commitments

Agreeing on price as the indicator of global action opens the door to a common commitment. But poorer countries like India will feel that they should receive significant help with it. Fortunately, this is relatively inexpensive. Since India's carbon-pricing revenues would stay in India, pricing India's two billion tons of emissions at \$20 per ton will have a *net* cost to India of only about \$2 B if emissions were reduced 10%—far less than the planned \$100 B per year Green Climate Fund. This is not to suggest that India should be given an exception to the common commitment. Rather, the common commitment should include a green-fund formula for providing assistance from richer, high-emission countries to poorer, low-emission countries. In this way, the common pricing commitment would respect the UN's principle of "common but differentiated responsibilities."

Equity transfers need not be as high with price commitments, because risk is lower. As seen in the above example of price and quantity risk, if a country expects a \$100 M cost of abatement, but there is a risk that its BAU emissions will be unexpectedly high by 10%, this would add \$190 M in the case of a quantity commitment and only \$10 M in the case of a price commitment. If the country demands that this risk be covered by equity transfers, these will need to be \$180 M larger in the case of a quantity commitment. Politically it seems difficult for a poor country to risk having its equity transfer obliterated by a miscalculation of future BAU emissions.

### Choosing a green fund formula

By committing to a uniform global price, we have confined the differentiated-responsibilities problem to the green-fund formula. This makes possible a natural, and less-divisive, principle for national differentiation. The new design principle is to choose the green-fund formula that maximizes global emissions abatement.

This suggests a two-step design: first select the green-fund formula, then choose the common price. This is similar to many political processes in which it is common to specify the payment and benefit structure before deciding how much to spend on a program, say a school system. If voters are pleased with the payment-benefit structure they will be generous in voting for a strong program. If they are displeased they will be less generous. This arrangement gives those designing the payment-benefit structure, in this case the green-fund structure, a strong incentive to design the structure to please all of those whose support is needed. It also allows the funders to have peace of mind when the funders delegate authority to those

negotiating the structure—first because they know that they can reject or minimize the proposed structure if it is not to their liking, and second because they know the negotiator/designers will be well aware of this.

Compare this to the cap-and-trade alternative, which is also a two-step approach. First the global cap  $Q$  is selected and then the permit allocations  $\{A_j\}$  are negotiated. But, as noted above,  $Q$  is an aspiration and not a commitment, so all of the work of solving both the climate-effort problem and the equity-transfer problem are bundled into the single step of negotiating  $\{A_j\}$ . In contrast the two-step approach of pricing breaks the problem in two—choosing climate effort ( $P$ ) and negotiating equity transfers  $\{G_j\}$ —this simplifies both negotiations. Then it links the two halves so that the availability of the step-two price decision provides good incentives for, and confidence in, the green-fund design process. And the green-fund design is properly focussed on making the price negotiation successful. This is why the “ $\{G_j\}$  then  $P$ ” negotiation process can outperform the “ $Q$  then  $\{A_j\}$ ” process.

We now describe, for the sake of concreteness, a possible pair of negotiating procedures, beginning with the step-two price negotiation. To set the price, countries pledge their highest acceptable global price target, taking the step-one green-fund formula into account. Then the highest price target acceptable to, say, 70% of the countries (emissions-weighted), determines the global price commitment.<sup>10</sup> Only countries that have pledged at least that price would sign the global-pricing agreement and participate in the green fund.<sup>11</sup> (This “club” could then implement enforcement that could induce additional members to join; see Stiglitz 2015.)

Before describing step-one, the green-fund negotiation, we note that, as pointed out by Gollier and Tirole (2015), it is an  $n$ -dimensional negotiation and hence difficult. As with the climate-effort negotiations, a common formula is needed, but here we are not lucky enough to have something as simple and well-agreed-upon as a uniform price. Nonetheless, it pays to look for an equity formula that is focal and has a single parameter that can differentiate responsibilities to the extent required. Of course in reality no simple formula will be sufficient. However, this example will serve to illustrate the value of looking for a common-commitment formula, even if the actual one needs to weight multiple relevant variables.

The formula that we propose as most simple and focal for green-fund transfers is to make transfers proportional to a country’s excess emissions. These are defined as emissions that are in excess of what the country would emit if it had world-average per-capita emissions. Countries pay into the green fund in proportion their excess emissions and receive payments from the green fund in proportion to their negative excess emissions.

There seems little doubt that this formula would work if accepted, because perfection is not required. But it would likely not achieve as high a price as a more detailed and thoughtfully designed formula. The formula should be judged by how high a price results from its use in the stage-two voting process.

The excess-emissions formula must also include a generosity parameter,  $G$ , that determines its strength—how many dollars per ton of excess emissions will be transferred. If the green-fund formula is too generous, rich countries will hold down the global price to reduce green-fund payments. And if the formula is too miserly, poor countries will hold down the carbon price to reduce the burden of carbon pricing. Only a compromise on generosity will lead to

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10. The higher the coverage of global emissions, the lower the price that will be agreed to by all the countries that must be included to achieve that coverage.

11. Countries may also agree on a price path. In any case, this initial agreement would be updated periodically with the intention of increasing its coverage and strength, and of reflecting the improving estimates of costs and benefits of climate change.

the highest agreed global carbon price and maximize abatement ambition. Hence, the objective of maximizing ambition leads naturally to a reasonably fair compromise on differentiation of responsibilities.

To assure that the generosity of the green-fund formula is set objectively to maximize climate ambition, it will be best to rely on countries that have the least stake in green-fund payments. Such countries will base their recommendations on climate considerations rather than on green-fund considerations. Within such a group, the median (not the average) opinion should determine the outcome. This prevents any one country from having too much influence (Cramton and Stoft 2012a, b).

When proposing individual commitments, the US argues (2013) that it is “hard to imagine that Parties would be willing to have other Parties dictate their contributions.” But the above illustrative agreement shows the US argument is irrelevant. Under such an agreement no country will ever be asked to commit to a price higher than it nominates voluntarily with full knowledge of the generosity of the green fund. Nothing is “dictated” by other Parties. But in spite of the completely voluntary nature of this treaty, the resulting agreement captures the “I will if you will” effect of a common commitment that modifies self-interest within the agreeing group. Hence, each country’s self-interest in naming a high price will be increased dramatically relative to the individual commitments the US is proposing.

### **Why opaqueness is not an argument for quantity commitments**

Some observers argue that a green fund is too transparent to be politically acceptable, and that a supposed lack of transparency is a major advantage of cap-and-trade. However, the cap-and-trade programs often referred to are domestic, and are opaque for a different reason. Their transfers are not in the form of traceable money. Companies get paid mainly by raising commodity prices by an amount that is hard to measure and that most people cannot comprehend. On the other hand, international purchases of AAU’s—the real standard of comparison—have been extremely controversial, as we described in our introduction. Indeed, we find it difficult to believe that large cross-border money transfers through perfectly transparent markets would not catch the public’s attention. It seems even more likely that the transfer will become obvious at an earlier stage. To give India a large transfer, India must receive a cap that is far above its BAU emissions level. This part of the transfer will be highly visible and past comments have shown that environmentalists will find this highly objectionable. It will also make it impossible to explain to the US public why the US is giving a multibillion dollar climate transfer to a country that is required to do less than nothing.

That said, even if the supposed opaqueness of permit transfers is something worth taking advantage of, this might be possible under a price commitment without incurring the political risk premiums associated with quantity commitments. For example, instead of the US government paying India \$100 M, it could allow US businesses to purchase offsets from the Indian government at the global price of carbon, and India could be issued a package of say 5 million one ton permits. While these would be just as visible as permits under cap-and-trade, they would not cause the financial risks of cap-and-trade.

## **✎ CONCLUSIONS ✎**

Despite much rhetoric, there is almost no hope that the Paris negotiations, if based on individual pledges, can solve the climate dilemma. Rather, to address the dilemma, we agree with

all experts in this symposium that a common commitment is necessary. In this piece, we reiterate Weitzman's plea that price and quantity commitments be compared on a level playing field. This seems eminently reasonable since quantity commitments have had the field to themselves for over 20 years, and failed repeatedly. Quantity commitments have been favored partly because of the misperception that caps provide stronger incentives and more certainty than a price, together with an incorrect analogy between an easily-enforced domestic cap and unenforced international caps. Yet, for reasons that we and other contributors to this symposium explain, a price commitment is likely a much more promising basis for a common commitment; it is a fair focal point, reduces risks, is easier to enforce, and is consistent with climate policies already in place. Indeed, one beauty of a carbon price commitment is that it will not interfere with the current, dispersed cap-and-trade experiments, thereby leaving the door open to a future rehabilitation of caps, while keeping alive the fundamental idea of using price.

Promoting cooperation in international climate negotiations is *the* crux of the climate problem. We hope our paper, along with the other contributions in the symposium, will provide guidance to those negotiating the necessary global agreements. After over 20 years of failure, surely it is worth attempting a fresh approach, one that is guided by insights from the science of cooperation.

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## Frequently Asked Questions

# About “Global Carbon Pricing”

### **Q1. Does it mean a global tax?**

No. It does not require that any carbon taxes or fossil fuel taxes be implemented. See Q3.

### **Q2. What is it?**

An agreement between countries responsible for most of the world’s greenhouse gas emissions to price their own fossil-fuel emissions at least as high (on average) as the agreed upon global price,  $P$ .

### **Q3. What does “to price their own emissions” mean?**

Typically this means using either cap-and-trade, fossil-fuel taxes, or both. Also hybrid systems and bonus-malus schemes can be used. And early on, even renewables programs could count, but they would be judged by carbon saved, and not by money spent.

### **Q4. What does “on average” mean?**

Countries could price gasoline at one level, diesel at another and coal at another. All that matters is  $(\text{total carbon revenue})/(\text{total carbon emissions}) \geq P$ . There could even be averaging from one year to the next.

### **Q5. Who would set the global price?**

It would be negotiated by a “coalition of the willing,” AKA Carbon Club.

### **Q6. Why does a price-agreement help?**

It forms a common commitment, so each country in the coalition is saying “We will price carbon at  $P$  if all of you will too.” Read the preface to see how this works. A

### **Q7. Is it fair to poor countries?**

Not without a green climate fund. This must be a separate but related negotiation. The UNFCC requires “common but differentiated responsibilities.” The global price is the common part and the climate fund is the differentiated part. Read the Introduction, sections 5 and 6.

### **Q8. Why not stick with global cap-and-trade?**

There’s a reason it’s been getting less popular for 20 years. It was accidentally designed to be hard to negotiate. The idea was to make it safe for the climate but risky for countries (see the Introduction, section 8). Global pricing was scientifically designed for cooperation, and it can be adjusted to hit climate targets just as well, probably better, than global cap-and-trade.

### **Q9. Who’s in favor of it?**

Everyone on the list of contributors is in favor of global carbon pricing. The authors have alternative views on how best to implement it.

**Q10. With your green climate fund, how big would the transfers be from rich to poor?**

At the start, a very high-end estimate might be €36 billion per year, and a low-end estimate might be €5 or €10 billion. It will be determined by negotiation, not science, so it can't really be calculated. Negotiators will balance rich-country reluctance against poor-country needs and demands.

Note that the high end is about one third of what US Secretary of State Clinton promised at Copenhagen. To put this in perspective, this is about 1/10<sup>th</sup> of one percent of the rich-country's GDP. This is for a €30/tonne carbon price. Eventually it would need to go much higher. But by then the world will likely have seen enough to be willing to spend more.

Consider the high estimate first. World CO<sub>2</sub> emissions from fossil fuel are a bit less than 36 billion tonnes. China has said it doesn't need climate-fund subsidies, so that leaves about [one third of the emissions](#) (12 billion) coming from poor countries that need climate funds. A tremendously strong start would be a €30/tonne carbon price, and that might reduce emissions by as much as 20%, or by 2.4 billion tonnes in poor countries. Some abatement will be cheap to free and some would cost as much as the €30 carbon prices, so on average the cost would be about €15/tonne, for a total cost of  $15 \times 2.4 = €36$  B/year. So the high-end number assumes rich countries pay 100% of the costs and somewhat more since, since when the poor countries stop subsidizing fossil fuel that actually saves them money (it prevents waste).

But €30/tonne is a very high starting price, and 100% is a very high subsidy rate, and not all of these countries will join and need subsidies (for example, some of the OPEC countries). In fact it may be necessary to begin quite slowly. But after 20 years without any global cooperative agreement, a slow but solid beginning would be enormous progress. Also remember, that without any transfer from rich to poor, very little is likely to get done.

**Q11. What carbon price do you think the EU countries, for example, would vote for?**

This brings up the central advantage of global carbon pricing. But first, note that the UK is already paying over £100<sup>1</sup> and more per tonne of carbon saved and the OECD<sup>2</sup> finds that feed-in-tariffs cost an average of €169 per tonne saved, and there are other subsidies on top of those.

Second, notice that a £100 carbon tax, if implemented as a tax shift would be close to free. The tax that was shifted away would return as much revenue as the carbon tax collected, and the distortions and inefficiencies of the old tax would be eliminated. These would roughly match the cost of carbon abatements, and those abatements would have the added benefit of reducing damage from domestic pollution. So not even counting the climate benefit, this policy might produce a net benefit.<sup>3</sup>

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<sup>1</sup> Take the CFD strike prices for new onshore wind or new nuclear, roughly 90 per MWh, or recent RO bands (roughly 45 pounds per MWh subsidy). If this is substituting for gas-generated electricity at 450kg/MWh then we have a subsidy of 45 pounds per 0.45 t CO<sub>2</sub> abated, or 100 pounds per tonne.

<sup>2</sup> "Climate and Carbon: Aligning Prices and Policies," OECD Environment Policy Paper 1, OECD Publishing, Paris, 2013.

<sup>3</sup> And an economy-wide tax-shift involving a carbon price of 100 pounds per tonne, and reductions of other taxes would have little effect on the budgets of a typical family, although



Now turn to our best feature. Global carbon pricing is not an individualistic approach. The EU would not be doing this without major partners, at least the U.S. and China, and probably more, even at the start. The agreement would be that all countries price as high as the global price. Now we have no illusion that the EU will suddenly impose a £100 carbon charge. More likely they will be inclined toward some timid level, such as €25/tonne. But with our proposal the EU would then realize that if it advocates €35, getting that accepted would bring China, the US and others along with it. So why not advocate €35? You only have to do that if you gain the satisfaction of finally bringing the U.S. and China along with you. And bringing them along would at least quadruple the impact of that €10 increase.

So we can't predict the EU's price proposal and we certainly cannot predict what the coalition of the willing will agree to, but we can tell you that even a €30 price on carbon could save a lot of money while doing far more good for the climate than current policies.

**Q12: What if some countries have large-scale, relatively cheap and measurable carbon-capture potential (e.g. afforestation)? How could that be harnessed with a global carbon price?**

This will require an add-on mechanism, but a fairly simple one once the negative emissions become measurable. The measurement process would supply the negative-carbon facility with a one-tonne carbon credit for each tonne captured. The add-on mechanism would require that all private carbon emitters can use a negative-carbon credit (a negatonne) in place of buying a carbon credit in their cap-and-trade market or in place of paying their fossil-fuel tax. Every country in the climate coalition would be required to allow this.

The negative-carbon credits would be purchased by those subject to the highest carbon prices anywhere within the coalition. Competition would then set the price of negatonnes of carbon at the highest carbon charge imposed, and since the global price  $P$ , is the average of all such charges, the price of a negatonne would always be higher than  $P$ .

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there might need to be distributional corrections, such as already exist (for example, winter fuel payments targeted at all old people, and other social mechanisms to protect those in “fuel poverty”).

# Glossary and Variable Definitions

AAU	Assigned Amount Unit. A one-tonne CO <sub>2</sub> equivalent emission permit under the Kyoto Protocol that is tradeable among governments that ratified the treaty
Ambition	Various meanings with no official definition. ( <a href="#">WRO definition</a> .) A replacement for “political will.” Generally indicates a desire or willingness to take action to reduce global warming. Robert Stavins defines a zero-ambition contribution or commitment to be one that would be taken purely out of self-interest. However, China’s INDC appears to fall into this category according to their own statements and documents, and still is appears to generally be considered quite ambitious.
BAU	Business as usual emissions.
C	Carbon
$C_i$	Contribution of country $i$ to a green climate fund.
Cap-and-trade	A system in which pollution permits are issued or sold at auction to a set of regulated entities, usually national government (global cap-and-trade) or businesses (standard cap-and-trade). The total amount of permits issued covering at given year, is that years cap. The permits can be freely traded between entities.
Carbon	Short for carbon dioxide (CO <sub>2</sub> ) in much climate literature, and usually short for “any greenhouse gas. However sometimes carbon means carbon. In this case one ton of (true) carbon emissions = (44/12) tons of CO <sub>2</sub> emissions, since the atomic weight of C is 12 and of O is 16 (to a very good approximately).
Carbon price commitment:	See Global carbon-price commitment.
Carbon price	Typical the cost of a permit to emit one ton of CO <sub>2e</sub> emission or the tax on one ton.
CO <sub>2</sub>	Carbon dioxide. A weak greenhouse gas but human produced gas having the largest effect on climate. Water vapor (invisible) has a much larger total warming effect than CO <sub>2</sub> , but humans have a negligible effect on its concentration.
Climate Club	A term used by William Nordhaus. A group of countries that commit to the same average price of carbon.
Climate Fund	A fund which collects money from rich, high-emission countries and distributes it to poor, low-emission countries. One example is the
Coalition of the willing:	Essentially the same as a Climate Club.
Enforcement	A combination of monitoring for compliance with a reward or penalty

ETS (EU ETS)	The Emission Trading Scheme (or System) set up by the EU under the Kyoto Protocol. It covers about half of the EU's emissions, but the price of its permits has been volatile and often quite low (under €10). This has been caused by wasteful subsidies of renewables and by the politics of permit allocations.
Externality	An good or effect that happens outside the market and hence is not priced. For example, global warming is an externality caused by greenhouse gas emissions. Externalities can be positive (good) or negative (bad).
Focal point	A term in game theory indicating a set of strategies for all players that all would consider to be sensible or a best guess at what others would do. For example, suppose the game is "pick a time of day, and if all pick the same without communication, all win \$10." Noon would be the focal point.
Free Riding	Making use of the efforts of other without providing fair compensation, and generally without providing any compensation. Public goods invite free riding because they are non-exclusive—users of the good cannot be kept from using it. Free riding is extremely common, for example using Wikipedia without contributing is free riding. This greatly hinders the provision of an efficient supply of most public goods.
$G_i$	Payment into the Green Climate Fund by country $i$ . (used in Introduction)
$g$	The generosity parameter in the Green Fund formula. Also in Gollier and Tirole's permit-allocation formula. In this case it is defined as identical to $(1 - \hat{g})$ .
$\hat{g}$	The grandfathering coefficient in Gollier and Tirole's permit-allocation formula. Defined as identical to $(1 - g)$ .
GHG emissions	Greenhouse gas emissions, AKA carbon emissions.
Global carbon price:	The price committed to. See Global carbon price commitment.
Global carbon pricing:	Short for the system of agreeing to a "global carbon price commitment."
Global carbon-price commitment:	A system in which a group of government, national or possible provincial, agree to price greenhouse gas emissions at an agreed-upon uniform floor price. It is different from a carbon tax or cap-and-trade, because it allows pricing under either system as well as bonus-malus schemes.
Global cap-and-trade:	A system like the Kyoto Protocol.
Green Climate Fund:	(GCF) Officially, this is a fund within the framework of the UNFCCC founded as a mechanism to assist developing countries in adaptation and mitigation practices to counter climate change. In this book it is sometimes used generically to means simple any climate fund.

Green Fund Formula:  $G_j = g \times X_j \times P$ . Payment into fund equals generosity time excess emissions time global price.

INDC Intended Nationally Determined Contributions.

Internalize Used in “internalize the climate externality” (see Weitzman) it means to bring the externality into the market by charging for it appropriately.

$P$  In the Introduction: The global carbon price commitment of the coalition of the willing (Climate Club). In Gollier and Tirole: Population.

$P_a$  The price of carbon allowances (permits) when Gollier and Tirole’s permit allocation formula is used to re-adjust permit allocations periodically. In this case it will not equal  $P_c$ .

$P_c$  The same as  $P$ .

Pledge and review: The system of INDC pledges and reviews

Price coherence The uniformity of the carbon price across all sources of carbon emissions.

$Q, q_i$  Total number of permits and the number of permits given to country  $i$ .  

$$Q = \sum_{i=1} q_i$$

Reciprocity The practice of responding to benevolent actions benevolently or mean actions with meanness. These two type of reciprocity are often respectively termed positive and negative reciprocity. Weak reciprocity is engaged in for reasons of self-interest. Strong reciprocity is not engaged in for self-interest.

Uniform price commitment: The same as a global carbon price commitment. Used by Weitzman.

Waiting game A game defined and analyzed by Beccherle and Tirole (2011), which involves an amplification of the free riding incentive by the incentive to achieve a better deal at the bargaining table in the future (see Gollier and Tirole).

WCA World Climate Assembly (See Weitzman).

$X_j$  Excess emissions for country  $i$ . The amount emitted minus the amount that would have been emitted if they country had the world-average emissions per capita. (Used in the introduction.)

$X, x_i$  Global and country- $i$  emissions in Gollier and Tirole