Global Harmonized Carbon Pricing: Looking Beyond Paris

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Session One:

Why insist on an international carbon price?

Presentations and Discussion

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Session One — Why insist on an international carbon price?

This discussion is intended for reviewing in a distilled way the theoretical and experiential arguments leading to the presumption that an effective international regime to mitigate climate change would be one in which the parties agree on a harmonized carbon pricing trajectory rather than the global cap and trade pursued so far. Ultimately, we wish to have those arguments articulated in a way that could be effectively conveyed to policymakers, other informed readers or interlocutors and usable for the "term sheet" mentioned below.

Presentations

William Nordhaus

First I'd like to offer my own welcome to those of you who have come from near and far. This is a conference that those of us who are at Yale see from time to time. It is a conference that only Ernesto could organize, which takes a topic of great importance and thinks carefully about who around the country and around the world would make the most contribution to it and then brings them here. So those of you who've come, we're very, very grateful to you for coming. And we're very grateful to Ernesto for organizing this.

I want to start with some short introductory comments, and then say something about the logistics, how I propose we run the session. Ernesto gave you an overview of his vision of what he would like to do over the next couple of days. I will just give some substantive introduction about how I see the state of play. Taking the larger view of where we are in the area of climate change, climate change economics, climate change policy, politics, and negotiations, I see four topics that we have been, and need to, grapple with to make progress and to really tame the beast, so to speak.

The first one is climate science. That's something with which many people in this room are familiar, but there are few climatologists in the room. My own view is that this is a mature science. It's controversial; it's also extremely complicated. It's a system that is full of very interesting but also complex nonlinear dynamics, and so much of it continues to be poorly understood or at least imperfectly understood. As a mature science, it's one that we have to take as the baseline for what we do, and there always will be critics, and I think critics need to be listened to and addressed. But I think on

the scientific side, we've got a serious group of scientists who have spent decades and decades on this, refining the basic conclusions and modeling. It will go on and will continue to be improved.

A second area, which is getting closer to the topics we will deal with here, moving into the economics and related areas, is the subject of the costs of slowing climate change, on the one hand, and the impacts of not slowing climate change on the other; the costs and benefits, if you like, of taking steps to slow climate change. This also is an area, that's not quite as mature as the climate science is, but in which people have been working for perhaps 30 years.

My own view is that on the mitigation and abatement side, it actually is a pretty mature discipline. It grows out of energy economics and energy science, which have been around quite a while. And so while I think there are obviously uncertainties about mitigation costs, I think that we have several reasonable models. Dale Jorgenson is here, just to point one finger at one person who has been working on this for many years in many countries and many sectors. His work has been particularly fruitful in illuminating abatement costs.

The work of Dale and his associates is one side of this; the other side of this is the impacts/damages. I think this has proved much more difficult, much more elusive. And I think we have perhaps order of magnitude estimates, but those are much less certain. So I think that's an area where we are still

thinking about issues such as what the damages are, the non-market damages, what are the fat tails of these damages, and what the whole shape of those looks like. We have numbers, but I think we're much less sure there.

The other two areas are ones that I think are central to this conference. First, the question of instruments and what kind of policy instruments should be used to implement policy. And the second is the problem of global negotiations, and the global free riding problem. On the first one, which is central to the topic as Ernesto introduced it, is what kinds of instruments we should use.

For strange historical reasons, the quantitative approach of tradable emissions allowances took center stage in the late 1990s. And you can see the reasons. It's not important to talk about right at this moment, but you can see the reasons that it did what it did. And it's really held center stage the entire time, both domestically in the U.S., and in the only system that really is working now, which is the EU system. It's a system that has flaws, some of which are pretty bad, but that works. It's a system that at least has been out on the track, and it runs.

The other system, which also has been operating in several countries, is the carbon tax system. And that's the central focus of this conference. So when I think about the first approximation of these, they are the same. They both raise carbon prices if they're implemented on a universal basis. And that's really what we need to do. We need to raise carbon prices everywhere in a durable and credible way. So to a first approximation, they do the same thing. But it's actually the second approximations, or the second order effects that we'll talk about today and tomorrow, that are the crucial differences. And I think at least the domestic differences between carbon taxes and cap and trade are one central reason why carbon taxes look in the long run to be a better solution.

And then the fourth area is how are you going to get countries together to act and to participate. And not just to participate in the sense of signing a piece of paper, but participate in the sense of going beyond what would be in their own national self-interest; what would be beyond a non-cooperative solution, in the language of game theory, to a cooperative solution which would involve almost surely deep and costly emissions reductions.

How are we going to get countries to go from the non-cooperative to the cooperative solution? I think it's undeniable that what we've done to date has not been successful. Aside from the fact the Kyoto Protocol has died, even when it was in place it had relatively shallow emissions reductions. And the countries that were called on to make deep emissions reductions, like the U.S. and Canada, dropped out.

So I think the one attempt to have an international agreement clearly failed the free rider test, the test of avoiding free riders. My view is that's the key issue that we have been unable to address in our international negotiations. And as far as Paris is concerned, I don't even need to read the newspaper because I know what's going to happen. It cannot succeed. It cannot succeed because it doesn't

have the incentives for countries to go beyond their non-cooperative, nationalistic, to use a pun, interest. I'm going to talk about that more tomorrow.

To tie these together, I think these two last points about the instruments and the need for international agreements are very, very closely entwined. You need to think how you're going to overcome the free riding problem, but you need to think also about what kinds of instruments you can use to do that, what kind of measures you can use to do that. And that's where the very, very strong logic of carbon pricing, and carbon taxes in particular, comes into the picture to mesh with the need for overcoming free riding. This last interaction between the instrument and the need for overcoming free riding is a subtle and important aspect that we need to address because it's not just one or the other. It's actually how you're going to make the two work together.

That's my warm-up. I suggest that the speakers come up one by one and then we will go for approximately an hour. Each of the speakers can take 15 minutes, no more than 20, then we'll bring the panel up here, and we'll open it up for general conversation. So again, Ernesto, thank you for convening us. And we'll welcome to the podium Martin Weitzman.

Martin Weitzman

I'm going to go through some classical and non-classical arguments in favor of prices or taxes as opposed to tradable caps. I'm not going to spend any time on where the global warming public goods problem now stands. My feeling is that we've not made much progress. The spirit of Kyoto really hasn't carried over.

There are classical arguments (I'm calling them classical only because they're not new) for a harmonized tax or price over tradable permits. There are three points that I think are most salient.

First, stabilizing a price seems like it may be more important than stabilizing a quantity. There's a theoretical prices-versus-quantity type argument on the marginal benefit-flow of a stock externality. In any given period of a year or ten years, the marginal benefit curve is likely to be flat. And the classical theory tells us that in those situations, prices should be favored over tradable permits. There have been computer simulations that seem to show this.

There's also a political economy, practical argument that relates to strong public aversion to price volatility, and which is probably more important. The public doesn't tolerate price volatility in important commodities like energy and everything that emanates from energy. And what I fear here is that if we went to cap and trade or a quantity system, the prices are likely to fluctuate. That's what we seemed to see in the past. And I can imagine a worst-case scenario where this price volatility sours the public on any economic approach to curtailing greenhouse emissions. I can just see what would happen now. The price spikes up; it comes down. Wall Street firms have taken a position on these quantities. And there'll be all kinds of looking for whose fault this is. And it could set back the cause of using either economic or any economic approach. So this strong public aversion to price volatility is an important argument for harmonized prices through a tax.

Second, is that tradable permits inherently involve large international transfers of revenues across borders. There'll be a very big multi-billion, multi-hundred billion-dollar transfer from the U.S. to China, or from one part of the world to another part. And I don't think that's very well tolerated. The tax or price has its own problems, but it's internally retained in these schemes, including mine. And it could be used to offset other, less efficient taxes. It might even be a benefit if it's used to offset taxes that are more distortionary.

Third and finally, I believe that an internationally harmonized tax price is administratively more transparent and less prone to corruption or stealing of valuable permits than international cap and trade. This is not so powerful an argument within the U.S. or within the Western European countries, but it's a big issue when it comes to including the whole world, including China and India and other countries. These permits are valuable, and it just requires more administration to keep track of them and to make sure somebody is not stealing.

Now there also exist arguments favoring cap and trade over harmonized prices. I'm not going to go over them because I don't have much time. These arguments could reverse some of my conclusions here. I think these three arguments carry the day over other arguments in favor of cap and trade.

I now want to add some relatively new, I'll call them game theoretic, arguments in favor of negotiating a minimum carbon price that's internationally harmonized but domestically retained. I'm going to try to argue that a core issue is that it's more difficult to negotiate N quantities where N is some moderately big number than it is to negotiate one price. This argument is going to be incomplete. I'm not satisfied that I've gotten it, or anybody has gotten at the core essence of this. But I do think it is very important, this issue of N negotiating instruments versus one negotiating instrument.

So let's go back to basics and look at the two leading candidate instruments we are discussing: cap and trade and internationally harmonized prices that are domestically collected. There are three desirable properties in any instrument. One is that they induce cost effectiveness. I don't have to convince an audience of economists that this is an important issue.

A second property is that this instrument is centered on a single natural focal point. We're trying to facilitate an agreement with relatively low transactions cost. I could try to cite the spirit of Coase with transaction costs and say they're larger for N parties than they are for N instruments than they are for one instrument. Or Thomas Schelling, who popularized the idea of negotiating a salient focal point. One of the problems I'm running up against is what is a natural focal point? I think that a natural focal point is what people think is a natural focal point. It's very hard to push it further in terms of some information content or something like that. And so there's inescapably some sort of subjective element in deciding what is a focal point.

And the third point, maybe the most important, is that you want the instrument or instruments to give an incentive to internalize the externality. You want the thing set up with an instrument so that not everybody wants to push it as big as possible or as small as possible, but they're doing some internal balancing.

Now here comes a series of subtleties about how to set this problem up and how to think about it. If you negotiate N caps with or without tradable permits, at best you're going to satisfy cost effectiveness. Every country wants a low cap, and there's a free rider problem. I don't have to dwell on that here. There's no incentive, the way this is set up in my mind, to internalize the externality; in fact, just the opposite. Everyone wants the free ride off the externality.

Now let's consider a binding agreement to adhere to a uniform minimum carbon price, which is then negotiated. How do you ever get everyone to agree to a uniform minimum carbon price? Suppose you have gotten everyone to agree to this uniform minimum carbon price. It's negotiated or it's voted on, or something like that, and each country keeps these tax-like proceeds. You've now reduced the problem to one dimension, arguing about a single price. Of course it also has cost effectiveness.

It has a third property also, because if we're voting on, or negotiating on a single uniform price throughout the world, then when I do my voting or negotiating, I don't necessarily want this uniform price to be as low as possible. If the price is lowered, then it's advantageous to me because I don't have to spend so much money on alternative technologies. On the other hand, if the price is lowered, then that means that everybody else is going to be emitting more emissions, and it'll come to hurt me on the benefits side. So there's a kind of an internal balance where I lose this property of just wanting it to go in one direction.

I've worked out, with a bunch of other assumptions, what the mechanics of this internalization look like. And if you put enough extra structure on the problem, what you can get is that basically when you're negotiating one price, and let's say you use as a model majority voting, that the majority voting will get the mean of the marginal benefits throughout the population. But with voting you'll get the median. So this is coming close enough in my opinion. There's something good about this. It's capturing the median marginal benefit. It should be capturing the mean, but maybe there's not that much distinction.

I want to finish up by bending over backwards to try to talk about how a quantity system, a cap and trade, might be forced into this same kind of a framework. I'm going to conclude that it's harder to do with cap and trade. But much of that argument has to do with what is a focal point. Okay, so is this unfair to cap and trade? You could imagine the way I first set up the cap and trade, there were N negotiations to be agreed upon. But suppose that you restructured the cap and trade so that everyone votes or negotiates the total emissions level, given proportional reduction coefficients.

So it's like each country has a share of the abatement. Each country has a share of emissions, a fraction of emissions. These fractions add up to one, but then the countries negotiate the total emissions level. There's an analogy here for those who know it with the Icelandic fishery, ITQ, individual tradable quotas, and TAC, total allowable catch system. The way that works, and it's worked really quite well over 20 or 30 years now, is that there are individual catch coefficients, so if you have a chit, you're entitled to 1%, let's say, of the total allowable catch. These individual transferable quotas were set on the basis of historical catches in the early 1980's. And you're free to trade them. The government though sets the total allowable catch. It's this one-dimensional thing the government is doing.

And then it automatically divides down among the various nations according to what coefficients they're assigned. If you thought of a system like that, you're reducing the quantities to one dimension. But you have the same free riding problem, and there's stage one, assigning of these N proportional CO2 reduction coefficients. Iceland did, as a uniform government, but it's hard to see how this would be done in an international context.

Now let's bend over backwards to be even more fair or comparable. There's one price, and in a certain sense it's natural to think of one price of carbon, one uniform price. It's symmetric. You could think of an analogous symmetric allocation of quantities where everyone throughout the world is given the same per capita emissions coefficient. And you negotiate the total emissions level, and that's symmetric; everyone's being treated the same. They get the same allocations per capita of emissions, and then they vote on, or negotiate the total emissions, knowing it will break down this way. Now again, that has properties two and three. There's one dimension centered on this natural focal point of the total emissions. And also there's a countervailing force there, because when I want the emissions to be low, they're going to be high to save me money. I don't want it to be high for everybody else because that'll hurt me on the benefit side. So it's got this property. In some rigorous sense, this is more distorting than a price system.

So why is a uniform price a more natural focal point than a uniform per capita permit coefficient assignment in a cap and trade system? I can't lay out an argument from first principles why price is more salient than quantity. But I believe that's the case. If you have a uniform price, you're getting an equality of marginal effort. If you're giving everyone the same breakdown of emissions, you're ensuring what you might call equality of endowments.

And here's another point going against me, or against us who believe that overall a harmonized price system is superior. Here's a criticism of what I've been doing and saying. Any agreement probably requires some sort of a transfer to induce certain countries to participate. You could argue you're probably going to need some side payments. But now I wonder does that put the prices and the tradable permits on the same level of ultimately requiring the agreement of N parties; so does that negate what I said before when I was assuming that they were already in compliance? Maybe the N versus one argument applies as well when you recognize some side payments — again I don't think it's quite the same — but I can't find any argument from first principles that's doing that. And I think the transfers under this green fund for a uniform price would be less then. You can show that by fiddling around. Charging yourself a price, you're getting triangles of welfare loss. Having tradable permits, you're losing or gaining rectangles of welfare. So does it put prices and tradable permits on the same level of ultimately requiring the agreement of N parties? I don't know. I think so, but I can't back it up.

My own conclusion, which it has to be admitted relies on subjective elements, is that when all is said and done, it's plausible to conceptualize cap and trade as involving one more layer of N party negotiations on the N caps than a uniform price. If that's the case, then this one versus N argument holds water. But again, I admit on a theoretical level it's difficult to make this case from first principles.

So my conclusion would be that it's difficult to get nations, sovereign nations, to agree on any framework. But it's relatively easier for the reasons I went though, including some of these subjective aspects, to agree on one uniform price than N quantity caps, maybe because the distribution issue is somewhat diffused. It's not front and center as it is with tradable permits.

William Nordhaus

Thank you, Marty. That got us off for a good start. I actually think this is a really brilliant and important contribution. And I think in a way Marty understates its importance; the importance of moving to a single variable, we just go back to simple Arrow-like reasoning on voting mechanisms. As it's likely that countries have single peak preferences over that one instrument, then you have a hope of getting some decision or getting an answer. When you start introducing another dimension, say the distributional dimension, then one thing we know is that then any chance of getting single peak preferences is gone. So I think this is, aside from all the other points, really a central one in Marty's discussion. I'll talk about this a little bit more tomorrow but I think this is a really useful opener. Next we're going to move to Robert Schmidt on his presentation.

Robert Schmidt

As you all know, there's a long tradition in environmental economics to compare taxes with the policy instrument of cap and trade. Economic theorists, including me, often tend to be interested in kind of subtle issues, issues that are not obvious from the start, and you can use theoretical models, formal models, trying to analyze these issues. However, those subtle issues are not always at the core of the decision, so it is not always those issues that are most decisive in terms of policy making. I think we should try to make an effort from time to time to highlight those issues that are the most crucial ones,

even if they are not necessarily those that are the most interesting ones for economic theorists.

The purpose of this talk is to step back and try to have a look at those issues that, at least in my opinion, are the most important issues for policymakers, the first order effects. And then in the second half of this talk, I will also briefly sketch my own vision for climate negotiations.

A few arguments in favor of a carbon tax. Obviously, climate change is a complex issue. There's a lot of uncertainty surrounding this problem about damages of emissions, abatement costs, and low carbon technologies. However in my opinion, a complex disease doesn't necessarily imply a complicated treatment. There is an inherent property in CO2 emissions that I think is often being overlooked and this property makes it easy to address this problem from a policy perspective. Namely virtually every ton of carbon that is extracted from the earth's crust eventually ends up in the atmosphere in the form of CO2. That one-to-one ratio of carbon extraction and CO2 emissions makes the problem potentially easy to deal with from a policy perspective as it allows us to not tax the emissions. Instead, we can simply tax the carbon when it is extracted from the ground, or imported into the country from another country that charges a lower carbon price.

Let me point towards two specific reasons why I think that the extraction of carbon should be taxed rather than the final CO2 emissions. The first one is coverage. With an extraction tax, almost 100% of all CO2 emissions in the country are automatically covered, and that comprises emissions from electricity generation, production, transportation, consumption, services, anything. Every source of CO2 emissions is automatically covered because the price is essentially "in the carbon itself". And then it's passed on from producer to producers and to the consumers. As a result, goods and services with higher embedded emissions become relatively more expensive.

By contrast, under a cap and trade scheme, coverage tends to be lower. And that's related to the fact that there are a vast number of emitters. For instance, in the EU ETS, coverage amounts to only about 45% of all CO2 emissions. Therefore, other instruments are required to regulate those emissions that are not covered, if they can be regulated at all. By contrast, there's only a small number of extractors or importers of carbon.

That leads me directly to the second reason why the extraction of carbon should be taxed rather than the emissions. When you tax the CO2 emissions or when you implement a cap and trade scheme, then every single emitter needs to keep track of its emissions. For small emitters or households, that's basically not feasible, and there are significant welfare losses in the form of bureaucratic or transaction costs. By contrast, these costs, I believe, are virtually negligible in the case of an extraction tax. Under an extraction tax, firms and individuals don't even need to know their CO2 emissions. They simply respond to price signals and shift consumption and production patterns towards lower emissions. So these arguments, I believe, favor a carbon tax over cap and trade when the carbon tax is implemented in the form of an extraction tax.

But there are further reasons why I believe that a carbon (extraction) tax is a more suitable instrument to address the problem of global warming than cap and trade. They are related to the uncertainty about permit prices inherent in a cap and trade scheme. Let me put it very simply. If the permit price is high, there are considerable economic risks. It can lead to job losses, firm relocation, even to an economic crisis in the worst case. Conversely, if the permit price is low, as is currently the case in the EU ETS, then society is obviously not exploiting its potential to reduce the emissions further at a low cost. And last but not least, a volatile carbon price creates an unfavorable environment for investments into low carbon technologies.

In sum, both upwards and downwards shocks in the permit price are undesirable, and the obvious way to prevent both of them is to fix the price by implementing a tax. But can we achieve the two-degree target with a carbon tax? I believe we can. Of course, despite the low coverage, cap and trade could potentially deliver more certainty about short run emissions. However in my view, short run emissions are not decisive for climate change. What really matters is cumulative emissions because climate gases accumulate in the atmosphere and in the oceans over time. What countries need to do is to limit their cumulative emissions over the next decades in order to reach the two-degree target with a sufficiently high probability.

In my view, cumulative emissions can be adjusted much more easily with a carbon tax than short run emissions. For instance, if the emissions reduction under a carbon tax turns out to be lower in the short run than was anticipated, the price path can simply be adjusted upwards without any drastic changes in the tax rate. On the other hand, emissions might also decline more rapidly than anticipated. In that case, the tax rate might be raised more slowly over time. So implementing a carbon tax and readjusting it over time allows us to learn about the responsiveness of the economy to a price signal. Of course similar learning can occur also under cap and trade; but the tax has the advantage of a more stable price signal.

I now come to the second part of this talk with my own vision for climate negotiations. A uniform global carbon tax and ideally implemented in the form of an extraction and import tax is, in my view, the most efficient policy instrument available to combat climate change. However, I believe that a uniform carbon tax leads to unequal welfare costs across countries, and that makes it rather unlikely that

it will be implementable in the near term. A possible way out of that dilemma could be transfers, but these would have to be overwhelmingly high, and hence are also probably not implementable.

It turns out that the climate change problem itself has yet another intrinsic property that can be exploited here – namely, what we are facing is in fact a double public goods problem. On the one hand we have the global public good of stabilizing the climate, which means we need to reduce greenhouse gas emissions. But on the other hand we are facing the global public good of providing low carbon technologies, which at least to a large extent has public good properties because of knowledge spillovers. That suggests the following way out of the dilemma. If there's a country that suffers less under the uniform global carbon tax, or is perhaps unable to implement the carbon tax for some political reasons, that country could simply contribute more to the other global public good, technology provision.

My vision is to balance countries' efforts in climate stabilization by focusing on a fixed percentage cost of GDP for countries' total efforts which comprise both direct mitigation costs and costs of providing low carbon technologies. I believe that this suggestion has some nice fairness properties also. Namely, poorer countries pay less in absolute terms because they have a lower GDP. Furthermore, these balanced efforts can be achieved even when carbon prices (initially) differ across countries.

Marty argued that any useful proposal for climate negotiations should ideally focus on a one-dimensional target, and in addition, it should embody a countervailing force against narrow self-interest. Let's consider the balanced efforts approach. Here, countries do negotiate about a one-dimensional target, in this case the total effort cost of a country, as a percentage of its GDP. Of course that requires some pre-commitment to identical efforts, as a focal point here, for all countries. By contrast in Weitzman's paper, the focus is on an identical price. But it also requires that pre-commitment to negotiate only about the level of this one-dimensional target. In terms of countervailing force — I didn't check it formally and don't have a model on that — but I believe that there wouldn't be an interest for any country to vote for an excessively low effort cost target as a percentage of GDP because this would then imply that other countries will also exert a lower effort.

I have tried to highlight in this talk that a carbon tax, ideally implemented as an extraction and import tax for carbon, is the most efficient policy instrument available to combat climate change. From an efficiency perspective, all countries should implement a uniform carbon price. However, I'm afraid that this is not realistic because at least in the nearer term it might lead to large differences in welfare across countries. And furthermore, some countries may simply be unable to implement a tax for political reasons.

Does that mean we cannot cooperate? Or that a country that is willing to cooperate but cannot immediately implement the same carbon price as the other countries has to be excluded? I think it does not. We can balance countries' effort costs in climate stabilization via differentiated investments in low carbon technologies. And the message is quite simple: ask those countries that suffer

less under a uniform carbon tax, or perhaps cannot implement a tax, simply to invest more in low carbon technologies, which is the second global public good which we are facing here.

William Nordhaus

You didn't use up all your time, so could I just ask a follow-up question, which I was unclear on? In your carbon tax proposal, you suggested a production tax rather than a consumption tax, a tax on the production of fuels rather than consumption of fuels. Could you just spend a minute on that? Because I think that's actually a pretty big difference between some of the proposals.

Robert Schmidt

That's exactly right. So if I'm a company that drills oil from the ground, or which extracts coal, then I will have to pay the tax in proportion to the amount of carbon that I have extracted from the earth's crust. Or if I'm importing natural gas, say, from Russia, then I will have to pay for the amount of carbon I am importing. The tax would be levied either at the point where firms are extracting the carbon from the ground or where firms are importing the carbon from other countries.

William Nordhaus

So the only difference there is the trade component? Is the idea that if a country is a coal producer — Australia for example — they would levy a tax on coal extraction. And is the idea they would then rebate it on exports, and it would be taxed in Japan when it was imported? Because another way to do it would be just to do it at the point of consumption. I just want to make sure I'm clear on that.

Robert Schmidt

If the country that is extracting the carbon is part of a treaty, and all countries in the treaty ideally have the same carbon price, there's no need to reimburse or rebate anything.

Ernesto Zedillo

What about the question of carbon leakage? Because looking at Saudi Arabia exporting oil, let's say Saudi Arabia starts to develop petrochemical, cement, and aluminum industries. They will not be exporting oil but they will be exporting other goods that obviously have a high carbon content. I think you need to think about that next step.

Robert Schmidt

That leads to the issue of border tax adjustment, which was not part of my talk, but it's an important issue. I think we should discuss in greater detail about that later during the conference. Let me nevertheless point out already at this point that I am personally convinced that BCA (border carbon adjustment) measures will play a key role in reaching any agreement among a limited number of countries that are willing to move forward in climate protection, while others are still reluctant. Indeed, the fear of a loss of competitiveness (and a loss of jobs in particular) is probably one of the main reasons why many countries seem so reluctant to step forward with unilateral climate policy measures. BCA allows individual countries or groups of countries to do that and contribute to the global public good

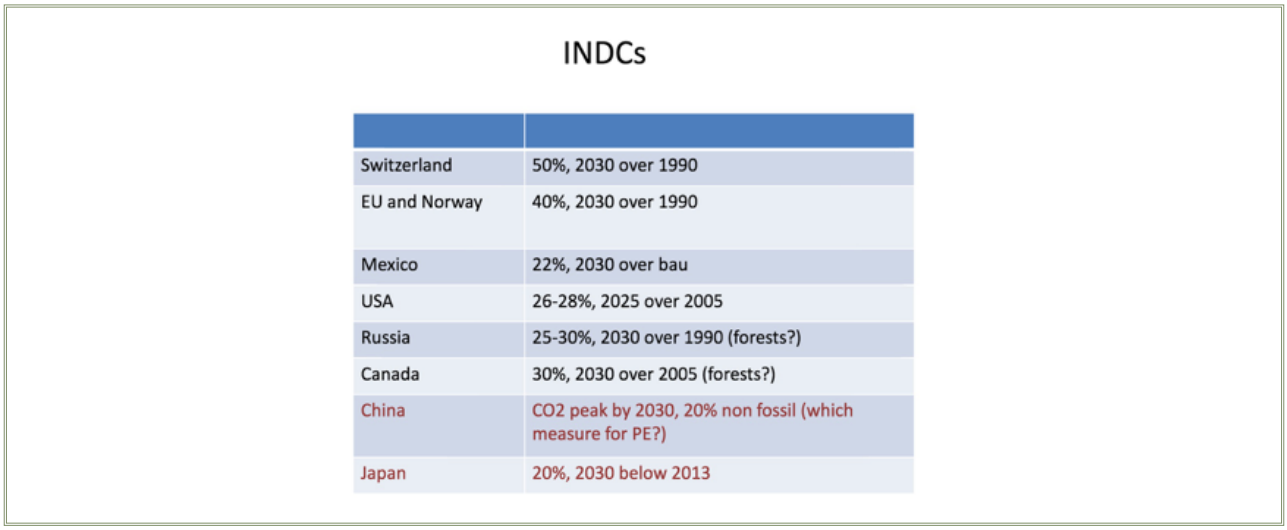
of climate stabilization without being "punished" disproportionally due to competitive disadvantages and job losses related with their unilateral efforts. The importance of BCA measures is, thus, hard to underestimate, and should deserve a lot of our attention during this conference.

William Nordhaus

Thank you very much. Our final presenter this morning is Massimo Tavoni.

Massimo Tavoni

Let me thank first of all Ernesto, Haynie, and Bill for having me here. I'm going to provide some more quantitative policymaking, some numbers, for quantitative analysis. Most of my work is actually on integrated assessment modeling, so I will have to translate some into formal arguments. Actually the title is Modeling INDCs (Intended Nationally Determined Contributions), but I actually won't do a lot of that because there's not much to model yet. I was checking the website the other day about which INDCs have been submitted so far. There's a bunch of them, and this is not even a complete list.



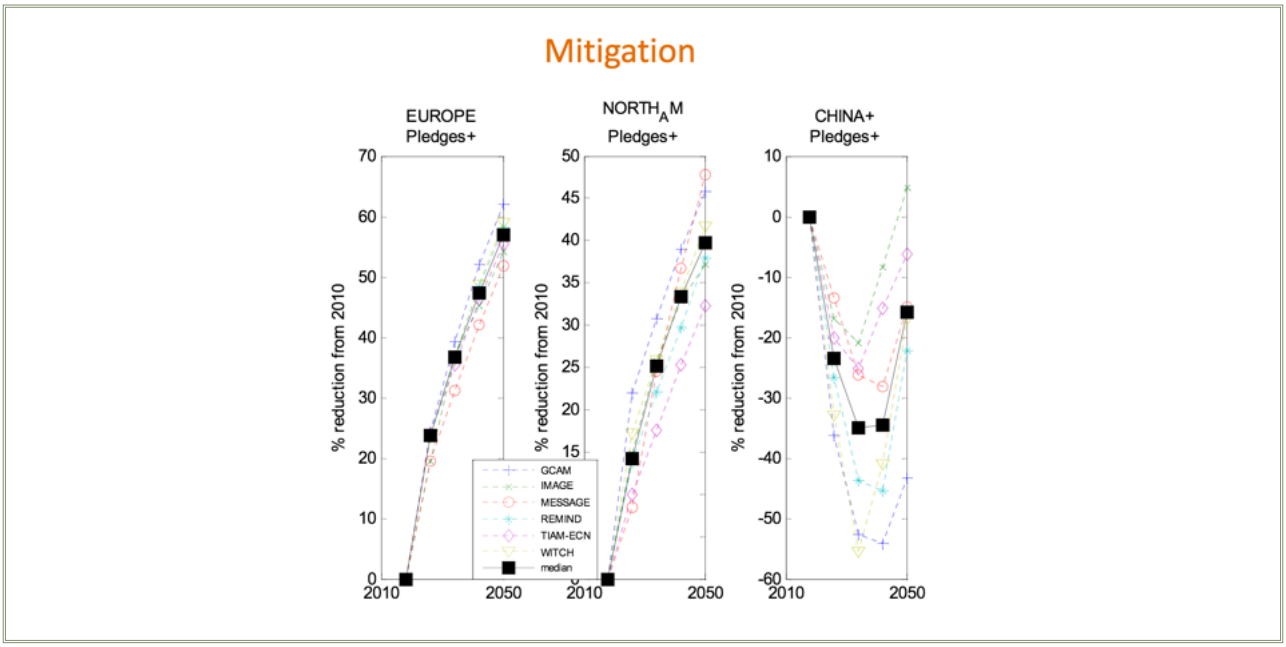
They also vary quite a bit in terms of reference points as you can imagine. But the most notable maybe are the European, 40%, 2030 over 1990, which is about 35% over 2005 in 2030 in terms of greenhouse gas emission reductions. The US has 26 to 28%, 2025 over 2005. Then Russia has put forward some proposals for the discussion, as well as Canada, about to what extent carbon sinks will actually be used to meet their targets. That obviously has big implications. Mexico has put forward also a target, this time, however, against business as usual.

And then of course there's China. The discussion about China, although this is not yet formally submitted, is about emission peaking by the year 2030, in addition to a target on how much fossil energy should be in the primary energy mix. This is looking to be about 20%, although it's not exactly clear to me what kind of metric will be used (e.g. final or primary energy).

Of course some important things we know already, and some big emitters are already there. I'm going to focus on the things that we more or less know a little bit about with the caveat that things will probably change over time. With regard to integrated assessment models, I'm going to focus on one example, where six models participated, and we looked at two different pledge scenarios under different cooperative scenarios, and also three different bargain sharing schemes, including a tax, a per capita convergence and equal costs, like the one Robert described, which is basically what allocation would equalize mitigation costs across countries.

I'll focus also a little bit on the results for the IPCC Working Group III, which has put forward a big database with almost 1,000 scenarios. Now some of these databases are part of each other, but some of these databases are publicly available. So if you're interested in playing with numbers and calibrating some of the formal theories of some of the models through these large modeling examples, there's a wealth of data out there that has only been partially explored so far.

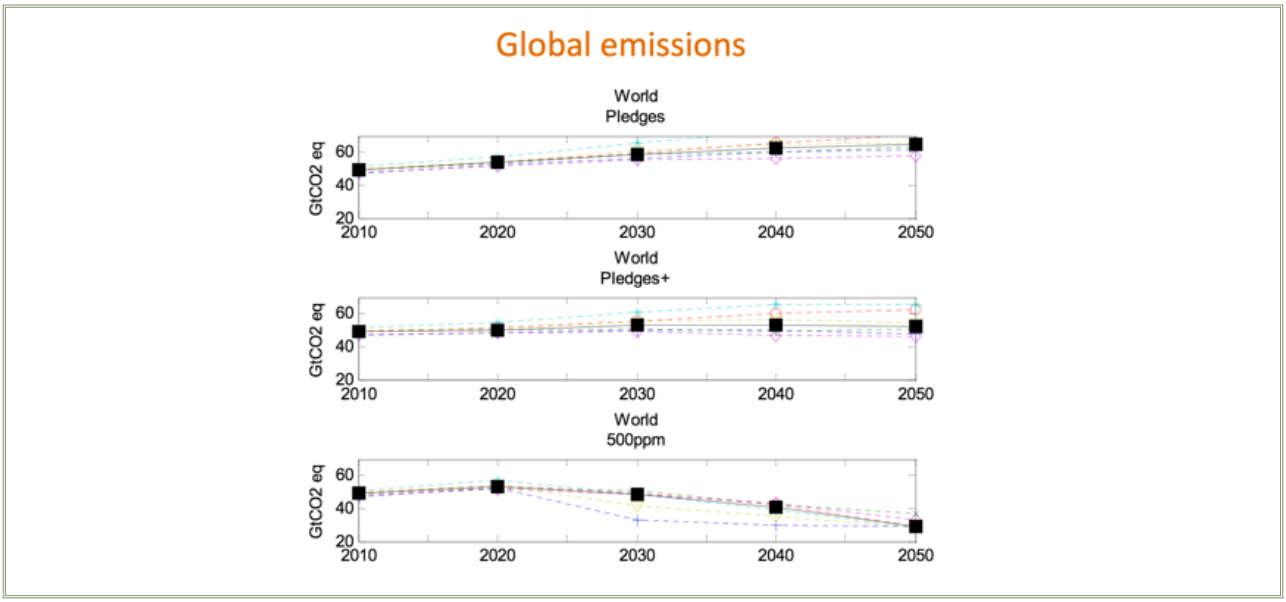
With that said, let's get into a little bit about numbers. This chart shows the mitigation efforts with respect to 2010 over time, between now and 2050, for three regions, which are Europe, North America, and China. For this scenario that we named "pledges plus" at the time, we extrapolated what were the pledges for 2020 forward, especially focusing on carbon-intensive targets for China and commitments for emission reductions in Europe and North America.



It turned out that those pledges plus were relatively accurate in terms of what the INDCs look like. So Europe, for example, in 2030 you're talking about emission reduction with respect to 2010, which is slightly below 40% — about 35%. This is not far off from whatever Europe has discussed and then increasing over time. For the US, about 25% over 2010, so more or less in the same ballpark, although the official reference point for the US is 2005. It turned out also that China, extrapolating what we thought could be reasonable for the 2020 carbon intensity target of China forward in time actually led to a peak in emissions, which is indeed around 2030. So again, you can see differences across models here because the carbon intensity target depends very much on what's the assumption about economic growth.

But across models, the peak is often around 2030. Now the question obviously is at what level will emissions in China peak. Again, the scale is reversed because we see it's a reduction from 2010, meaning emissions are higher than today's level. But again as you see, some models have peaks, which are 50% above today's. And some models have emissions which are maybe 30% above today's. All are compatible with the peaking of CO2 emissions in 2030 and the gradual return to today's emissions maybe by mid-century. But the extent to which the peak will be, that obviously matters a lot for carbon prices and for cumulative emissions.

Now obviously you can build from the INDC upward and try to understand what are the global emissions implications of all the INDCs. This is a chart showing the world global emissions over time for two of these pledging scenarios, the "pledge" and "pledge plus" scenarios that I told you about.



Depending on the extent to which all countries, not just Europe, North America, and China, but most notably also key emitters such as Indonesia and Latin American countries and the Middle East and other countries, will actually participate in any agreement or will actually commit to different levels of INDCs, the total outcome will be different. We're talking about emissions which either maybe at best stabilize or slightly increase from today's 45 billion tons of CO2, maybe to as high as 50 billion tons of CO2 by 2030 with stabilization of emissions afterwards. If other countries do not commit to INDCs as stringent as we have, the ones that we designed in this "pledge plus" scenario, then emissions would keep rising and maybe exceed 60 billion tons of CO2 by mid-century.

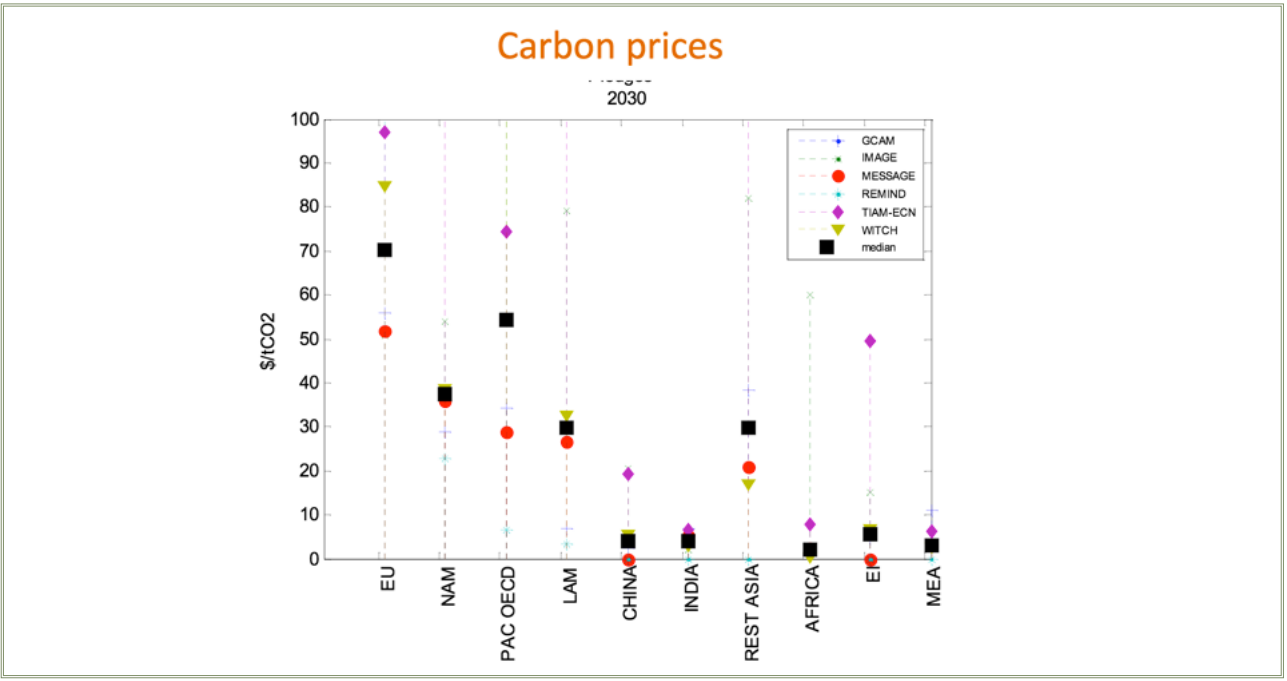
In all cases, this is different from what we were supposed to do or what we would need to do cooperatively if we were to stabilize concentrations. The lower panel shows the global emission profile over time for a target on concentrations, about 500 parts per million CO2 equivalent concentration. So we're talking about a policy that gives you 2 degrees with 50% chances.

With the world pledges, you get towards 600 parts per million, or towards the 600s or even a little bit more, depending on the pledges maybe 100 parts per million more. But that depends very much on what happens post 2050. But 2050 is a good horizon to focus on cumulative emissions. And if you do the same, the two start to diverge pretty rapidly already in 2030. And remember this is not even 450 parts per million. 450 parts per million will have a much more drastic reduction in global emissions. So I think this is no surprise. In a way, the pledges that we are seeing and that have been discussed do not have a level of emissions that one would need to have for each target, not 2 degrees but maybe not even 2.5 or 3 degrees.

This doesn't come as much of a surprise to me. In the short term, what you really see is that emissions would maybe pass this 50 billion tons of CO2, which is a little bit of a critical threshold for

being able to meet 2 degrees afterwards. They would essentially be not really compatible with 2 degrees. But that's part of the game, and that's, I think, the reason why we are here. We're trying to think about ways that will get us a little bit farther toward deep emission reductions than the INDCs would otherwise achieve alone.

Now obviously you get carbon prices from INDCs implemented without any harmonization. And this is a chart showing carbon prices in the year 2030 across ten regions. Again, focus on the median marker here because there's a lot of variation across IA models. This is just to say obviously these numbers depend very much on the target itself. Actually they are completely driven by the target itself. There's no trading whatsoever.



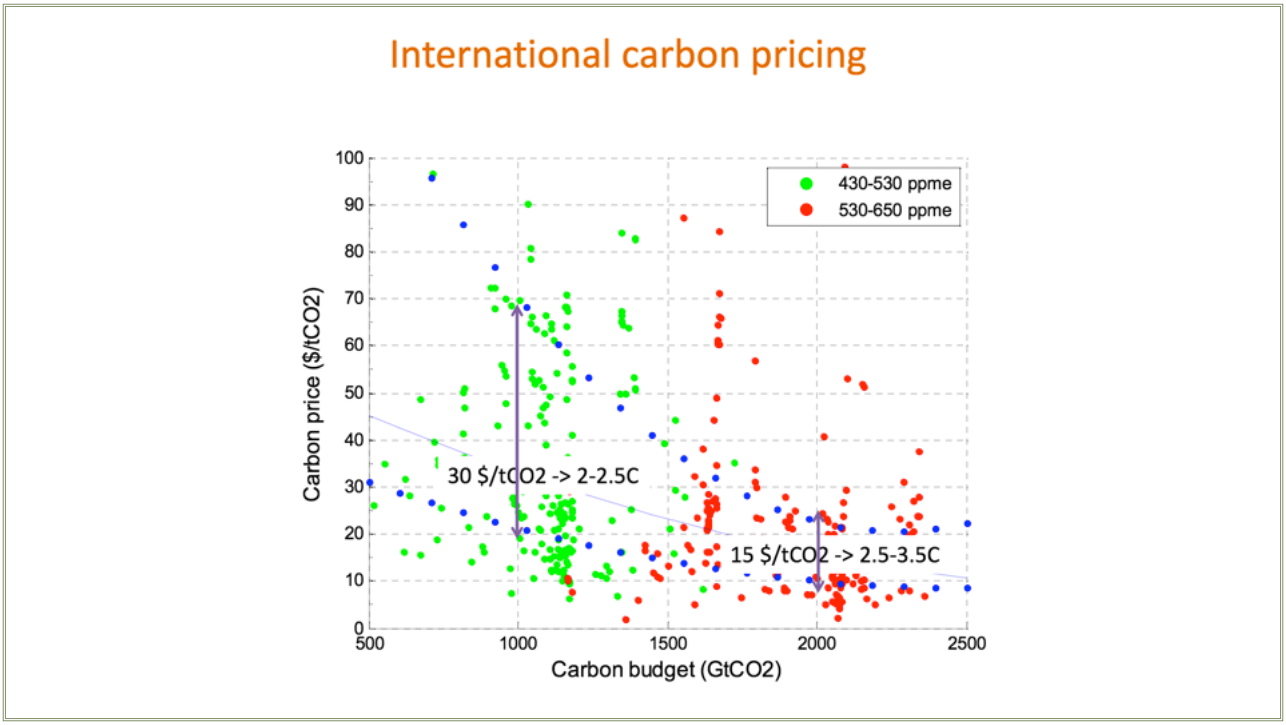
We see carbon prices higher in Europe and in North America, maybe between 40 and 70. Europe is a bit high, higher actually than what the Commission expects prices to be by the year 2030 with the target that they have put forward. And indeed that might be the case, especially given the very low emissions of Europe so far. We see carbon prices in China with the kind of target that led to a peak in 2030, which is greater than the Euro in the year 2030, but not so much different from the Euro — maybe a few dollars per ton of CO2. But again, that depends also on what kind of peak are we talking about. For some models, it could be as high as $20 per ton. It depends on where it will peak, not only on when it will peak.

In general though, you see a lot of different carbon prices. You will see other different carbon prices, generally speaking low carbon prices in most of the developing world. You have some exceptions here for the countries that have a lot of CO2 in the forest sinks, so Indonesia and Latin America, where we thought they could put forward some aggressive targets. You see a lot of inefficiency if you

want to go back to the argument about efficiency in terms of why the differentiated carbon prices, maybe on the order of several times one or the other.

So what's the alternative? And I guess the alternative is why not focus on one carbon price. Now the point though is what carbon price, at what level should we negotiate this? It could be an out and out negotiation, but it should also be grounded in science a bit more.

This is a chart showing some modeling from the IPCC. You see a lot of dots. Each dot is a model scenario. They're from several models; there are several scenarios. The same models run in more than one scenario.



On the X-axis, you see the carbon budget, which I think is a very important indicator. The carbon budget is cumulative emissions throughout the century, CO2 integrated over the century. Temperature is linear in carbon budgets. Climate science more or less is clear about this.

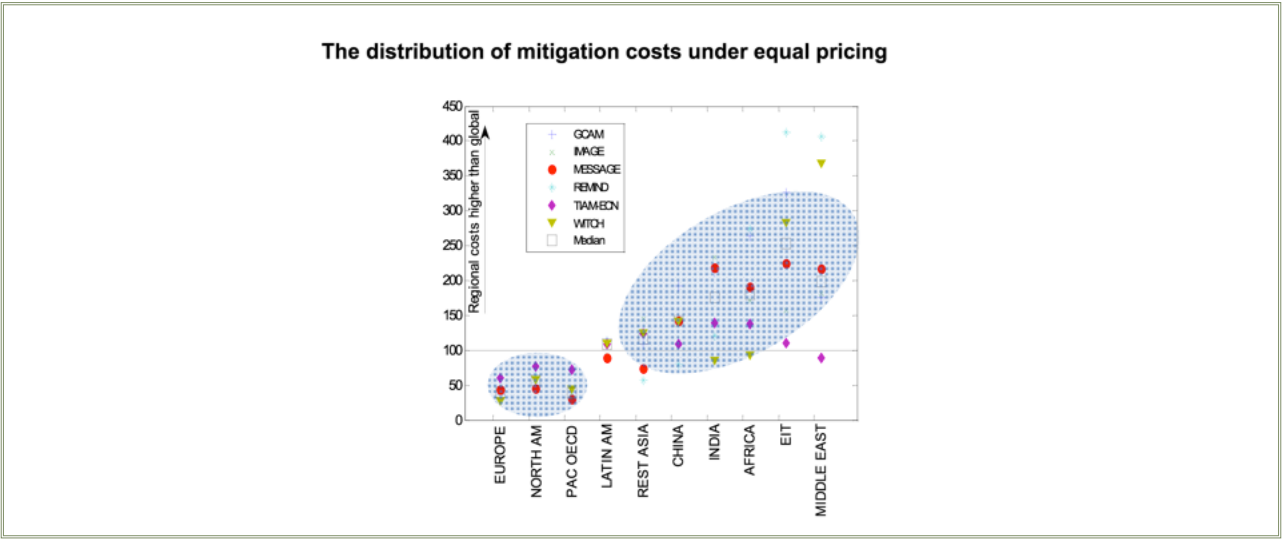
What you see is obviously that lower carbon budgets consistent with 2 or 2.5 degrees, 430 to 530 parts per million have higher carbon prices. Carbon prices here show a net present value carbon price, the price that you would have in 2020, and in international agreement after 2020, let's say in 2025, rising at 5% every year: so a price that would increase over time at the same rate, at 5% over time. It depends very much on what kind of policies we are thinking to implement. And if you're thinking about implementing policies, these green ones, which are about 2.5 degrees or so, then we're thinking maybe a net present value carbon price starting at $30 a ton of CO2, rising at 5% per year. And then

if you're thinking about targets that go throughout 3 degrees, or 3.5 degrees, then you deal with an initial price of $15 per ton of CO2 rising again over time.

Now there's a lot of uncertainty. I agree with Bill Nordhaus that we know mitigation more than we know the damages. But even in mitigation, there's huge uncertainty. The lines in the chart show the 25 to 75% percentiles fit, and you can see the ranges. The ranges increase the more stringent is the climate policy you're considering, just because the margin abatement cost curve is complex. So as a result, you have a bigger spread depending on assumptions, depending on the model, but also depending on whether the technologies will work to the extent that is foreseen.

These models are perturbed along many dimensions, including technology, with ranges between maybe 20 and 70, and for lower level emissions, actually this range is much more than 25. The price ranges between maybe $10 and $25 per ton of CO2. Still, there's a lot of uncertainty on what is actually the appropriate level of carbon pricing this would get you to, given a stabilization target. And obviously we talk about climate, so we need to connect a little bit more I think, even when we talk about prices. At least we need to know what are the consequences for temperature and climate.

Looking at the distribution of mitigation costs of input price, if we do price carbon equally, then what the models indicate is that some countries, and actually these are the wealthiest countries, would pay a lower cost than some other countries. This is the result of modeling emissions in terms of distribution of cost relative to the average across these ten regions. What you see below is that essentially we have a group of countries here that have relatively lower costs than average, specifically Europe, North America and Japan. Then you have a group of countries that actually have higher costs, especially energy-exporting countries, which are Russia and the Middle East, that have significantly higher cost than global average.



This is the ratio of country cost to the global average cost. Suppose that stabilizing at 2 degrees cost you globally 2% of GDP. If this ratio is 3, it means that this country pays 6% of GDP. If it's 50, it means that it pays 1% of GDP, so that's all in relative terms towards the global cost.

I had a discussion over email with Bill Nordhaus, and he encouraged me to look at the elasticity of income with respect to cost, using the original mitigation cost as percentage point of GDP lost by the policy, and the per capita income. As you can see in the table, it turns out that across models, these are the estimates of the elasticity across models. Policies for carbon pricing would be regressive.

Burden elasticity of income $\frac{\partial \ln(cost)}{\partial \ln(pc\ income)}$

Discount / Policy	5%	3%	0%
450 ppm eq	-0.48 (0.08)	-0.44 (0.09)	-0.34 (0.12)
500 ppm eq	-0.44 (0.13)	-0.36 (0.14)	-0.24 (0.15)

The extent of regressivity depends on the stringency of the policy, with more stringent policies being more regressive than less stringent policies. And also of course on the extent to which we discount future cost with lower discounting leading to lower regressivity. But in general, you see regressivity, which is non-trivial, for policies that are ambitious. Here I'm focusing on 450 to 500, which are pretty ambitious climate agreements with international carbon prices as we saw before on the order of $30 per ton of CO2 growing at 5%. For these kinds of policies, the regressivity effect would be significant.

And in the same project we looked at what would it take to make sure that that regressivity goes to zero. What kind of transfers or green funds should we establish to make sure that these numbers are zero? And the numbers that come out are relatively large, so we're talking about relatively big transfers. We're talking about transfers maybe on the order of less than other schemes, but on the order up to 100 billion USD per year by the year 2030. So it's relatively big. Of course, it depends on the carbon price. 450 parts per million has a higher carbon price, so the transfer would be bigger. Lower emissions would have lower transfers. But it's not easy to devise.

Discussion

William Nordhaus

I'll first turn to the panel and ask if they have any reactions to what they heard.

Robert Schmidt

On the issue of leakage, I think there was some confusion about my proposal. I'm not sure, but I think the issue of leakage, it's very much the same whether you apply the carbon tax more upstream or more downstream. I don't think that my proposal makes any difference in terms of carbon leakage and the necessity for border tax adjustments when there are some countries that are not going along and not implementing the carbon price.

Massimo Tavoni

Maybe going back to Marty's point, if you care about this regressivity, and we think this is serious enough, and you were suggesting that you would need to have a green fund that would essentially lead to two focal points, meaning for example a carbon price together with either some transfers of some sort of financial or technology-related transfer, would that be a big case against carbon pricing?

Martin Weitzman

I'm not sure. I really am not. It would've been nice to see a side-by-side comparison of the domestic cost increase under uniform carbon price versus the transfers that are involved. I did some back-of-the-envelope calculations that seem to show that the transfers were much bigger under cap and trade. I don't know what to answer to the point you're raising. It is disquieting that it's regressive, of course, so there would be some transfers. In theory, that could unscramble all the N dimensional versus one dimensional. But I do somehow have the feeling that there's still an N dimensional argument stuck in one more layer of the cap and trade than there is in the layer of uniform price.

Massimo Tavoni

Just to clarify why is it regressive? It's two things. Mostly it's carbon intensity in business-as-usual, so developing or lower income countries tend to have high carbon intensity to begin with. But also, a lot of regressivity is driven by the energy exporting countries who would lose big revenue. So now if you think about an international pricing that would not include the energy exporters, then one would need to re-compute the regressivity without that subset of countries, and that probably is much lower.

William Nordhaus

I'll just comment on that graph also. Massimo and I have talked about this before. One point is that it excludes damages. So in a way it excludes the whole reason we're doing this. And most people think that damages are regressive. But I think you've actually done some calculations in the modeling that mitigates some of the regressivity, but not all of it. The other point, which I actually hadn't appreciated until today, is that these carbon taxes are growing very rapidly. They're probably growing faster than the economies.

So you have to fold the discount rate into that as well. But it might be that what you're capturing is regressivity which is way in the future. And it's a pretty calculated computation. I just know that in some of the stuff that I've done, I didn't get the same results. I think it's a complicated calculation, particularly because of the dynamics. Let's open it up to questions from the floor. Glibert, you were first.

Gilbert Metcalf

These are great presentations to start us out. I had a couple of minor questions/comments for Robert. On this issue of immutability, I think that breaks down with natural gas if you have methane leakage along the way. But you could address that with a deposit refund system. So for example, if you're collecting a carbon tax at the wellhead for natural gas, but then putting in a leaky pipe so the methane is coming out, which has a higher global warming potential, that's a problem. But I think a deposit refund system would address that.

But I think the immutability is an important point, about the flexibility of where you put a carbon tax. The point that Bill raised for you about how are you handling where the tax is levied, I think this issue of whether it's a destination, a production basis versus consumption basis of a tax. The carbon tax in the country where the carbon comes out of the ground versus where it's consumed does make a difference in terms of who gets the revenue, so I think that's worth thinking about.

And for Marty, particularly in terms of some of the results from Massimo's presentation, why do we think a single price will be a focal point? Why wouldn't we think that the negotiations could devolve to end prices, particularly when side payments are introduced? We already know that climate negotiators are negotiating over lots of things. We're negotiating over adaptation, finance, mitigation, technology transfer. So that just concerns me that whether we're making it too simple to think that we can really get this to focus on one thing.

Robert Schmidt

Let me comment on that issue about upstream versus downstream taxation and the revenues. If you think about an idealized system where you compare my proposal to tax the extraction and import of carbon-containing fuels, if you compare that with an idealized system where you can tax all the CO2 emissions at the end, I don't think it makes a big difference in terms of revenues. I think, if I'm not mistaken, it should be the same. So if you're able to catch all the CO2 emissions at the end, it shouldn't make any difference.

In terms of revenue, I also think it doesn't make a difference. If you tax the extraction in your country, and you tax the import of carbon as compared to a system where you tax the emissions, that should also be the same. I want to think about it some more, but on the first shot I would say that it doesn't make a big difference. I think the question is then what to do with the revenues. That's an obvious question which is independent of whether you tax upstream or downstream. There are many things that could be said about keeping it revenue-neutral. Lowering other taxes is something that makes it easier for voters to accept the system, so that could be one obvious suggestion.

Martin Weitzman

To Gilbert Metcalf's central question, why is a single price a focal point when you think of side payments being involved, I don't have a good answer. I think Dale made some good points that this is an internally charged tax or price, so in principle, it could even be beneficial if it offsets other very distortionary taxes. But I think the point of departure would be that it's neutral in and of itself. What it does is really an internal transfer. And this does fit in quite well with the story that Bill wants to tell, that if you had a climate club, they've already got some sort of sharing of interest to get together on this. And maybe it's not so much of an extension to think of them getting together on one price.

Dale Jorgenson

I'd like to emphasize a point that Marty essentially added as kind of a throwaway, which is that a central part of his analysis is the idea that with a carbon tax, the countries would determine what the proceeds would buy. I think that's a very key idea, because that can be used to reduce the cost essentially to zero for many of the leading countries — the US, China, and India, for example, which account for about half of the total emissions. And therefore there are no side payments involved.

The second implication, though, is that with no side payments, you can simplify a story about clubs, which Bill is going to enlighten us about, as he did in his presidential address to the American Economic Association, to essentially a uniform price for the members of the club, and a border tax that would be imposed on non-members. And since that would be one-dimensional, you would have basically a two-dimensional story instead of a two-by-N-dimensional story. So it seems to me, Marty, if you incorporate a club story in your analysis, then you tip the scales very markedly in favor of a carbon tax, much more so than you suggested.

Richard Cooper

I have a question for Mr. Tavoni, which picks up on Dale's first point, and a general observation. The question goes to the chart that showed the costs. I've worked a lot on China. I was surprised to see such a big cost in China. My specific question is what assumption did you make about the disposition of the revenues from the tax? Because as Dale points out in his work and other work shows, how the revenues are used is critical in assessing the social costs of this. You can actually construct scenarios in which an appropriate use of the revenues actually makes the cost negative. But you made some assumption, and it would be interesting for you to tell us what assumptions you made about the use of the revenues.

My observation has to do with the international system as a whole. This conference is focused on one dimension, which is climate change. But there are many other dimensions of the international system. One in which I'm especially interested is the trading system. I'll just stipulate and involve a whole separate set of arguments that the trading system we've had has been a tremendous benefit to the world over the last half century. I assume that will continue to some extent, and therefore how and what we do in the name of climate change influences other parts of the system, are entirely relevant for policymakers.

Concretely, the difference in carbon charges, or carbon prices, whatever you want to call them, across countries, is going to raise the issue of competitiveness. And here I make a political economy point. Countries — many important countries — are not going to be willing to tolerate imperfect competitiveness arising from different climate change regimes and different implicit prices. This seems to me a compelling argument for a uniform carbon charge across the world, because it neutralizes completely the argument about competitiveness, which I think in the real world is actually going to be an extremely important argument if in fact carbon prices differ from country to country. My main point is that we need to look at a wider agenda than just climate change.

Massimo Tavoni

I think I mentioned here that the recycling was just through a lump sum. We made no assumption about changing other distortional, or reducing other kinds of taxation, for the class of models that, for simplicity, were involved here. It would make a tremendous difference had we done so, and indeed there were other model comparison studies that were actually focused on this. And there the results, you can get pretty much everything you want depending on how intelligently and smartly you can actually recycle the revenues. But it seems to me this is a bigger political issue, so I understand that it does make a big difference, and it would make a difference across countries, not just for China.

William Nordhaus

I think that's important. We shouldn't forget how these revenues are used. It's particularly important in a carbon tax, less important where you give away the revenues in a cap and trade system, because in a way it doesn't make any difference there.

Gabrielle Marceau

I'm a lawyer, so I may be missing something from Robert's presentation, but if an amount of coal is extracted and taxed there, and then taxed again on importation by the importing country then there's double, you tax it twice. And if you don't, then you need border adjustment.

Robert Schmidt

No, the double taxation wouldn't happen. Of course if you import carbon from a county in the form of natural gas, which has already levied a tax, say on extraction for instance, then you would only tax the difference. Ideally if that other country which has extracted the carbon has already levied the same tax, you wouldn't add any tax at all. You would just take the difference. Border tax adjust-

ment for me is more on the product side. If you import final goods, then you tax to the amount of embedded carbon emissions. Border tax adjustment I associate more with final products, or intermediate products. But raw materials like coal and natural gas, are those also border tax adjustments? I don't know.

Carolyn Fischer

Just as an observation I want to throw out for the session, I think especially what Marty raised in his talk, these are very intriguing ideas, being able to focus on a smaller set of things to negotiate over. And a carbon price would be, economically speaking, a great one. But you also mentioned within the cap, you're arguing for a rules-based negotiation approach. We could do the same thing with cap and trade.

But the problem is we have to agree on what the rule is, and we haven't been able to do that. What is an appropriate allocation of effort? Is it per capita; is it historical? In the international framework, we have not been able to agree upon that. I think there are complexities that we haven't been raising in this framework. One thing that could come out of the framework that is evolving is this opportunity for a collection of countries, a club of countries, afterwards to mutually negotiate what their commitments are going to be. And that could be a carbon price.

But I would like to hear from some of our political experts too. Fundamentally it will come down to will the US be able to ratify a treaty mandating a minimum carbon tax? The institutions involved and who is going to have to implement this policy is a pretty important complication that we should think about.

I also have a question a little more specific for Robert because you raised this interesting aspect of another option of effort in terms of the contribution to global public goods in terms of low carbon technology. Maybe you could explain a little bit more how that works and how that would be measured, that you're contributing to the global public good and not just committing to using a lot of low carbon technology deployment as your measure of effort, because that is a lot more expensive than using cost-effective carbon pricing.

Eric Toder

I'm going to assume that a carbon price, a uniform carbon price as you proposed, can be established. And I have just a couple of simple questions about tax incidents that haven't been answered even though Gilbert asked one of them. When countries have different profiles of consumption and production, a tax like this inevitably is going to redistribute income among countries. And how it does that depends on who gets to keep the revenues — that is, whether it's an origin-based or a destination-based tax, which is going to determine who collects the revenues, and therefore who can recycle it within their countries. The second thing it's going to depend on is whether you think this is going to raise the price of carbon to consumers or lower it to producing nations, and how much of

each. I would like to know what the assumptions are that are behind the distribution assertions and conclusions that have been reached, and how we should think about this.

Massimo Tavoni

I hope we're going to have sessions through the next couple of days to think more carefully about these issues of transfers and equity and actually they depend to what extent they would be implemented, what you're going to do with the revenues, and what other areas they're coming from. I think that the biggest thing there is mostly a political issue. You can do a lot with models, and you can actually turn our results upwards and get completely different results by just simply changing the recycling of the revenues, thus with little information for policy. That's my concern.

Robert Schmidt

I have two comments here. One is historically if you look at the negotiations, the focal point has always been emissions. This country should emit that much, and that country should emit that much — basically forcing countries to a certain limit on emissions, which can be quite restrictive and quite dangerous in terms of economic costs and risks. The proposal that we are discussing right now exchanges the quantities by the prices; but otherwise it's kind of similar, forcing every country to a single tool, like in that case not a quantity but then a price. I feel kind of uneasy about that.

If you have a club of countries that are willing to act here and to move forward, I don't know if it's really such a good idea to force countries into a single tool or instrument or target. Why not allow a country which says okay, domestically it's impossible for us to implement a carbon price, but we could do other things. We could invest in low carbon technologies. Why not allow for that diversity? Why not allow for more flexibility? And then compare more on the efforts, like more on the cost side and say okay, that effort, even though it looks quite different, it's comparable to this effort.

This is basically where I'm coming from, and it leads me also to the other question that I wanted to answer. How does it work with the low carbon technologies, how can you make that comparable? If a country like Germany has a feed-in tariff system, you can estimate the amounts of the economic costs involved in that feed-in tariff system. And just make that part of the total contribution of the country, not just plain mitigation costs, but also including the efforts that Germany or other countries have invested in that dimension.

Martin Weitzman

I had comments more directed toward Robert than the audience. First of all, this idea of introducing more flexibility — flexibility is a two-edged sword. You have some good aspects of it because countries that wouldn't otherwise join or cooperate then can get some tailored special plan for themselves. But you're opening up this can of multiple negotiations without a focal point. So it cuts both ways, and I'm tending to think that you really want this thing pretty streamlined on a focal point, admittedly maybe something subjective.

The other thing is about tax incidents. Whatever plan emerges, somehow the people of the world have to be sold on it. The idea that the polluter pays is a strong psychological argument that you're labeling these countries who are big users of carbon, you're naming them as the polluters, which indeed they are. They are the ones who have somehow to internally readjust. I also worry that if you tax carbon at the source, countries like Australia or Saudi Arabia are going to have a tremendous amount of internal adjustment to make. And somehow it doesn't look very symmetric or feel very symmetric.

William Nordhaus

I would say we've learned a lot this morning, both about the modeling aspects and some pretty impressive theory and different approaches. One key point I'd like to emphasize is that if we're going to do something that makes a difference, a 2-degree or even a 3-degree target, most countries won't want to do it. Most countries will not want to take the necessary actions. They're not going to want to do it on their own because it's expensive, and most of the benefits accrue outside the country.

And that's a key point to build in, because what it means is you need something that is agreed upon in the negotiations. First it has to be clean, it has to be simple, it has to be easy to verify. It has to be easy to measure. You've got to put together those two things. The countries don't want to do it, and therefore you're going to have to have something that's easy to measure and easy to define and easy to negotiate on, and hard to wiggle out of. I think a carbon tax meets that, but I think it requires a little more thought, and I found some pretty convincing discussion on that today.