



CENTER FOR GLOBAL DEVELOPMENT  
AND PETERSON INSTITUTE FOR INTERNATIONAL ECONOMICS

*Present*

***Bill Cline's Global Warming and Agriculture: Impact  
Estimates by Country***

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*[TRANSCRIPT PREPARED FROM AUDIO RECORDING]*

**Fred Bergsten:** Could I have your attention, and we'll get going. Let me ask again everyone to take her or his place and we will start up. Let me welcome you today, here at the Peterson Institute for International Economics, for a release of a joint project that we have conducted over the last year or so with our close friends and partners at the Center for Global Development. A study that brings together two of the most important issues facing both the world economy as a whole and the development issue in poorer countries, global warming, and agriculture. Not too many people could combine a study of those two elements the way that Bill Cline has done and I think this project was an unusually apt one for us and the Center to work on together.

The study addresses global macro issues, what will be the impact of global warming on world agriculture, and therefore on the world economy. It also addresses very directly the impact on the United States and other rich countries. Getting in turn, therefore, to the politics of the issue here and elsewhere, in some of the key players in the global warming debate. At the same time, the issue is of course critical to many developing countries, and this, I think, is the first in-depth analysis of the impact of global warming on the prospects for agricultural production in the whole range of developing countries, including China, India and the poorer countries in Africa and elsewhere. So, I think it's fair to say, as Nick Stern and Gus Speth and others have said already in their comments on the book, that this is really a path breaking effort on critically important issues for the world economy and therefore for development as well.

This is a joint project between our Peterson Institute, the Center for Global Development. We're also happy to have cooperation in it from our friends at the World Resources Institute. Jonathan Lash is here to participate in the initiation of the study today. So, I will turn to my partner, colleague, and close friend, Nancy Birdsall to introduce the specifics of the program for the day. Nancy!

**Nancy Birdsall:** Well, thank you very much, Fred. It's a pleasure for those of us at the Center for Global Development to see how this book and this work is attracting a larger audience that I hope will bring together more effectively those concerned with environmental issues and those concerned with development issues. Many people in the room have worked on that jointness for many years. I think the global warming issue will bring us together even more. I wanted to say a word on why a book on global warming from the Center for Global Development. Fred mentioned the macro estimates, but what inspired it – it, from our point of view at the Center, and why is this particular book so important from a development perspective. And, I have two reasons.

One, is that if you think about the issue of global warming as a development person, there are three issues. There's mitigation, there's impact, and there's the challenge of adaptation over the next many decades. This book is about impact and I would say how it's absolutely important, from a development perspective, because impact is the key starting point to motivate mitigation in a much larger part of the world than is now the case and amongst many more groups and people, and impact is also absolutely fundamental if we care about global poverty and inequality in thinking about the adaptation challenge for the next 40 or 50 years.

What are the implications for aid flows? What are the implications for global support for agricultural research? In the particular case Bill has studied, impact on agriculture. What are the implications for the way we should be thinking about the problems in global health,

another key area for the Center, over the next 20-30 years because changes in climate will affect changes in disease patterns and vulnerability to different diseases. So, that's one point.

And the second point I wanted to make is that it – I have been educated by this book and some of our own discussions around it to the value of quantifying the impact on developing countries at the – at the country level, which is a great contribution, as you'll hear of this book, quantifying the impact within regions in China and amongst – on countries such as India and Brazil. Why? Because, obviously, it can be a contribution to getting to yes between the rich world and the developing world on how to have a much more far-reaching approach to mitigation.

I did want to mention in this context that our colleague, David Wheeler at the Center, would just have a new working paper out by him and unfortunately he's traveling and couldn't be here today. But, in this working paper, he shows that even if emissions from the north had never existed and were zero, by the year 2025 emissions of greenhouse gases from developing countries will be sufficient to create a problem for them comparable to the problem that existed for the world by the late 90s. So, this has really interesting and important implications. The developing world will never reach northern income levels on the carbon-intensive path that it is on now. So, it creates a whole new set of – it has to, I think, motivate some new thinking about the challenge of mitigation, as well as adaptation, in the south.

Well, let me go from there to – I think I've been asked by Fred to mention what happens next. So, what will happen next is we'll hear from Bill Cline and from Jonathan Lash and then we'll have some discussion on a small panel. I guess it's Bill, Jonathan, Nancy and Fred, and then we'll turn to all of you for questions and comments. So, before we go to Bill, let me introduce a little bit more formally Bill Cline and Jonathan Lash. Well, not too formally in the case of Bill. Many of you know him from past work. Bill is one of the most productive think tank thinkers that I can imagine over the last 10 or 20, 30 years. I have many times, before I was a think tanker myself, turned to Bill's work.

Many of you will know that he did impressive work for the IIE on climate change more than ten years ago. Bill joined the then-Institute for National Economics in 1981. He spent time at the Institute for National Finance and we were very fortunate when the Center for Global Development opened its doors in late 2001, Fred let me have some jointness with Bill Cline and he has – he – you'll hear more from him but I – I have to say that Bill is a person with a kind of acuity about issues. He frames them, he's great fun to have in any seminar, he sees right through to the heart of the matter, and then he digs in and puts together the evidence and tries to assess the relationships on any subject, in this case so important, that matter.

Then, we will have the honor of having Jonathan Lash comment. Jonathan is – has been the president of the World Resources Institute for ten years. The WRI has been a great partner to us at the Center on the environmental component of our commitment to development index. It's impressive what the WRI does. In fact, I'm going to say to Jonathan, I hope it's okay, that before I came to the Center, when I was at the Carnegie Endowment, the president of Carnegie Endowment is Jessica Matthews, and she used to say to her colleagues at Carnegie, that's the model, the way it's going at the World Resources Institute, of good research and good policy work leading to real action and real interaction with the business community, with the policy community, with government, to bring about change.

So, at the Center for Global Development, we've tried to put together a model that combines the best of the Peterson Institute and Bill Cline stands for that, and this action and change oriented emphasis of the WRI. I think you all have bios so I won't give more details, but ask Bill to come up and start us off.

**Bill Cline:** Thank you very much, Nancy, for that generous introduction, and I would like to start with thanks to both Nancy and Fred for their support and patience on this project. I'd like to give a special thanks to Rachel Block, who's back there somewhere, for her excellent research assistance work on this book and her contribution to developing the methodology for converting massive amounts of data all to very detailed geographical areas. And I should also acknowledge at the outset my debt in this book to the work of two researchers in this field in particular, Robert Mendelsohn of Yale University and Cynthia Rosenzweig of Columbia University, both of whose models and model families I have used.

The bottom line of my book is that world agriculture does stand in jeopardy by the end of this century if nothing is done to curb global warming. At the aggregate level, globally reductions in productivity would range at least 5 to 15 percent. Moreover, there could be large losses in the developing countries, as high as 30 to 40 percent in South Asia, 20 to 25 percent in Africa and Latin America. Now, these results are consistent with findings summarized in the new report of the intergovernmental panel on climate change. However, my study provides greater country detail than previously available on a methodologically consistent basis, and it's also the first study that I know of that explicitly integrates the two approaches to the agricultural impact, the crop model approach and the so-called Ricardian statistical model approach.

Before turning to the analysis, though, let me give a bit of background. My 1992 book on the economics of global warming concluded that it made sense on economic grounds to adopt an aggressive worldwide program of abatement of carbon dioxide emissions. In many ways, that book anticipated the analysis of the stern review by Sir Nicholas Stern for the UK Treasury in a much simpler fashion. I have returned to this issue to look at agriculture in particular, basically because I consider the world's capacity for agricultural production to be the most basic resource of all and because agriculture is the economic sector most exposed to climate change. There are strong reasons for concern that severe global warming could sharply reduce agricultural capacity.

I suspect that most of you have read John Steinbeck's book The Grapes of Wrath about the dust bowl in the 1930s. Hot, dry conditions and prolonged droughts are devastating to agriculture. A motivation for this study was also a seeming tendency in the recent climate economic literature to downplay the risk to agriculture, and even to argue that a couple of degrees Celsius global warming could be good for world agriculture. Typically such studies do not seem to focus on the potential risks of the kind of warming that could occur on the land-based areas before the end of the century, on the order of 4 to 5 degrees Celsius, but instead are talking about gains from 1 to 2 degrees Celsius. So, these tend to be sort of a short-term view. Because, if we're not going to adopt major policy changes in the next decade or two, after you allow for the several decades of lags, we will be on a trajectory that takes us toward that much higher warming by the end of the century.

Now, just how does global warming affect agriculture? Beyond a certain range of temperatures, warming tends to reduce agricultural yields. One reason is that high temperatures tend to speed crops through their development process, allowing less grain

filling. Also, higher temperatures increase evapotranspiration, or the evaporation from the soil and transpiration of water through leaves causing a loss of soil moisture and water stress. Global warming does increase precipitation and the net effect on water availability is a race – depends on a race between a higher evapotranspiration and higher precipitation. Typically, this race is won by higher evapotranspiration. In some areas, there would even be a decline in precipitation, for example, in Mexico. That is reminiscent of Steinbeck's dust bowl.

Now, against these negative effects, there are positive effects for the high latitude countries where temperatures are below optimal levels and there's also the major question of whether more carbon dioxide in the atmosphere will act in effect as a fertilizer. After all, carbon dioxide plus water plus sunlight is the process of photosynthesis, yielding a carbohydrate. Carbo for the carbon, hydrate for the water, and if you have more of one of the inputs into a product, economists would naturally think you'll get more of the product.

There has been a lot of recent work that has developed – pardon me – statistical models of agricultural impact, including key very new studies on Africa and Latin America at the World Bank. In addition, there's extensive international field work by agronomists estimating crop models and I decided it would make sense to combine this growing body of models of – of agricultural impact with the climate models to see what might be expected of the – be the impact on agriculture toward the end of the century. I chose the periods 2070 to 2100, which is a benchmark for which these climate model projections are available and I call it loosely the 2080s. That's far enough in the future for these major effects to show themselves and it's close enough to the present to make us think that it's not completely abstract. Anybody here who has a small child or small grandchild should – should worry about this because that person will very probably be alive at the time that I'm talking about here.

So, let me begin with the climate models. I used the six climate models that are shown in this slide. These are large, general circulation models that use the physics of fluid dynamics and heat transfer to estimate changes in a whole set of climate variables that occur as global warming takes place. The most important parameter is the climate sensitivity parameter, this capital "S". This tells the amount of eventual equilibrium warming – warming after the flags from a doubling of atmospheric carbon dioxide. The IPCC range for the climate sensitivity parameter is 1 ½ degrees to 4 ½ degrees Celsius, and since the – and the parameter in these six models is about 3 degrees Celsius and they are mainstream. I should emphasize that the risk and the tail of this distribution is on the upside. To get a 95 percent certainty you would have to have this sensitivity parameter be 9 degrees Celsius for a doubling. I use as a business-as-usual benchmark for emissions Scenario A2 from the IPCC, which I consider to be the most reasonable.

At present, emissions amount to seven billion tons of carbon per year. That would rise to about 16 billion tons by 2050 and 27 billion tons by 2100. The major source of this extra carbon is the likely increase in the share of coal in global energy and coal is more carbon-intensive than oil and especially natural gas. The corresponding atmospheric concentrations are on a trajectory to reach, compared with 280 million parts per million in the pre-industrial period, and 370 today, to reach 735 parts per million by 2085. That is obviously well beyond the doubling of pre-industrial carbon dioxide. To arrive at a consensus forecast for climate, it was necessary to harmonize these six climate models to standardized grids – geographical regions. These models have varying grid sizes and we developed a method to convert this massive detailed information at different grid sizes to standardized grid sizes. The actual climate data for 1960 to 1990 as the base are available, or we –we actually take them up from

an even more detailed level to one degree by one degree level, which gives you 65,000 grid cells, of which about one-third are for land areas. We standardized to a grid of 2 degrees latitude by 3 degrees longitude, which gives 3,700 more or less land cells.

Now, this makes it possible to divide the world into various fine areas and we look at 112 countries and regions and within 7 large countries there are sub regions of about 4 to 6 per country, for Australia, Brazil, Canada, China, India, Russia, and the U.S. The average surface temperature increase by the 2080s for the six climate models amounts to 5 degrees Celsius for land, if you weight by land area; 4.4 degrees Celsius if you weight by farm area, reflecting the greater warming toward the poles. This is higher than the global mean warming – warming of 3 degrees Celsius, reflecting the well recognized fact that land is going to warm – warm considerably more than the ocean. Global mean temperature by farm area, weighting by farm area, rises from 16.2 degrees Celsius to 20.6 degrees Celsius. Precipitation rises as well, but not by much, by only 2.9 percent.

My study then turns to the models of impact on agricultural productivity. There are two families of models. The first is an international set of agronomic crop models, which relate – start with relationship of inputs to outputs for specific crops, whether it's fertilizer, land quality, including the climate variables and then incorporate adaptation, including shifting the crop pattern in order to see the impact of changes in climate on agricultural productivity. The results for a large body of these field experiment station studies have been compiled by Rosenzweig and Iglesias in a fashion that can be downloaded electronically for alternative climate scenarios and I have used those data directly.

The second family of models are statistical studies of how farm productivity and land values vary across farms in differing climatic regions. These models were called Ricardian in a seminal article by Bill Nordhouse and Robert Mendelsohn and I.G. Shaw at Yale University in the mid-90s. The name refers to David Ricardo, the classical economist whose theory was that the rent of land is determined by the difference between the quality of the land in question and the quality of the most marginal land that is just brought into production. But the notion is that you can statistically infer the impact of temperature and precipitation on agricultural productivity by looking at the relationship of the land price to the climate.

For example, in the United States by comparing it to county level, productivity in Texas versus Illinois. These relationships are non-linear. They involve the square term as well as the first term for both temperature and for precipitation and there's a sharp penalty for moving away from the optimum. Agriculture productivity is hill-shaped. It improves going from cold to warm, then deteriorates going from warm to hot. For a given temperature, productivity is higher if there's more precipitation. I should emphasize one key feature of the Ricardian models. By comparing, say, Illinois against Arizona, they tend to depend crucially on results reflecting irrigation because there is greater incidence of irrigation in the drier states. So they implicitly assume that there will be enough water available in the future to irrigate as needed, and that's a somewhat dangerous assumption for areas such as Africa where there is widely expected to be greater stress on the availability of water from global warming.

It is also the case that the parameters may be somewhat biased favorably by attributing benefits to warmer climates that are really benefits to irrigation given the fact that the incidence of irrigation is greater in the warmer climates. A central issue is just how much impact can be expected from so-called carbon fertilization. There are two classes of crops,

there's the so-called C3 crops, wheat, rice, soybeans, which respond substantially to higher carbon enrichment. They are not at the point where their carbon availability is redundant. The C4 crops, corn and sugar cane, in contrast have much less response.

Early laboratory experiments found something like 30 percent increase in yields from doubling of carbon dioxide but more recent open air experiments have found lesser increases and it is on the latter basis that I have tried to arrive at the central estimate that I use, and that is with carbon dioxide at 735 parts per million, after taking account of the relative weight, which is about three-fourths for the C3 crops and one-fourth for the C4 crops, you would get a 15 percent weighted average increase in yields from carbon fertilization. This is much smaller than in some of the previous studies that have used some of the same models that I'm using to estimate at a much broader level of aggregation, global impacts and that's one of the reasons that some of those studies had much more sanguine estimates.

My study applies to two schools of agricultural impact to the consensus, what I call a consensus climate projection, to obtain estimates of global warming on agriculture by the 2080s. For the Ricardian models, the World Bank study on India, for 27 countries in Africa, 7 countries in Latin America, provides the directly estimated models. The United States, I used the model by Mendelssohn and Schlesinger and I also applied the U.S. model to countries for which there is not a specifically estimated Ricardian model. I used the Rosenzweig-Iglesias compilation, as I mentioned, for the crop model school.

There is some consolation that there's a certain similarity in the two approaches, as this figure shows. There's a tendency to show major negative effects under both schools of models and where there are positive effects they tend to be found by both schools. There is some tendency for the Ricardian models to show a wider range of variation than the crop models. I arrived at my preferred estimate by taking the simple average of the crop model estimate and the Ricardian model estimate for India, for Africa, for Latin America, for Canada, and for the United States. These are the places where we have Ricardian models that have been directly estimated for the region in question.

For the other countries, I applied the U.S. default model as the Ricardian model but I only give it a one-third weight and I give a two-thirds weight to the crop model because those crop models were estimated for those regions themselves. That then gives me the estimate of the impacts without taking into account carbon fertilization and then I – given what that level of productivity would be – I add 15 percent to get what the contribution would be for carbon fertilization. In the book, Table 5.8 reports the results country by country. Perhaps we can focus on a few key countries here to get a sense of what's going on.

You see, for example, potentially sizeable losses in Argentina and Brazil if carbon fertilization does not materialize. You see moderate losses in Brazil even if it does. In the case of the United States, the overall outcome would be minus 6 percent without carbon fertilization, plus 8 percent with carbon fertilization, but this masks very important regional differences. There are very substantial losses in the southeast and the southwest. In the southwest plains here, losses of 25 percent, even with carbon fertilization. In contrast, China would have a more moderate range. I'm sorry. The most disturbing single set of results is that for India. India indicates that the losses would be on the range of 30 to 40 percent.

Now, in contrast, China would have a more moderate range, from minus 7 percent to plus 7 percent. Now, what you sort of see here is China's very much like the United States, and if

you think about it, there's a – there's an underlying reason for that. China is located at about the same latitude as the United States. Sort of the central latitude for both countries is 38 degrees North. India is located further toward the equator at 22 degrees North. Now, this is a chart that I didn't think of until the book was published, but, you know, it shows this. This shows the percent impact on agricultural productivity, not including the carbon fertilization in this case.

On the vertical axis and on the horizontal axis, it shows the degrees of latitude that the country is away from the equator, whether it's to the north or to the south, and there's a quite clear pattern that it is the countries that are close to the equator, down there in the lower left-hand corner, that get clobbered and it is the countries that are far from the equator, there toward the right, that might do better. Another set of lesser effects shows quite substantial losses in Mexico, 25 to 30 – 35 percent. One sort of wonders what happens to illegal immigration under those conditions. South Africa, losses of 23 to 33 percent.

In contrast, Canada and Germany show small losses without carbon fertilization but gains with it. Spain shows somewhat less favorable results, again reflecting latitudinal difference. Ethiopia and Nigeria, large African countries, show much larger losses. This map shows the impact by country in color code. The darkest red, which is nearly brown, is declines of 25 percent or more. Red is 15 to 25 percent decline, orange 5 to 15 percent. As you'll notice, these three colors cover much of the world. The reddest regions are Africa and Latin America. If you include fertilization, the picture changes, but Africa and Latin America still show very adverse outcomes, except for Argentina. The southern United States is still negatively affected. Although this time, Russia shows gains, as does China.

Globally, the aggregate impact, weighting by production, of baseline global warming by the 2080s is a reduction of agricultural productivity by 16 percent without carbon fertilization, a reduction by 3 percent if carbon fertilization benefits do materialize. My view as a policy maker should err on the prudent side, so they should tend to consider these estimates as perhaps understated rather than overstated. There are some biases, as I say, in the Ricardian models, with regard to assumptions about water availability for irrigation and other things that are missing from the calculations. There's no specific treatment for the increased incidence of insect pests, increased incidence of very extreme weather events such as draught and floods.

More fundamentally, in my 1992 book I said that you should be looking at 300 years as your horizon for this problem. And looking at the 2080s, just shows how bad things might get within this century. They would continue to get worse and worse and worse in following decades if nothing is done. Moreover, perhaps more importantly, the goal aggregates do not tell the whole story. The key result is the sharp concentration of losses in the developing countries. Globally, the industrial countries have an average gain of 8 percent if carbon fertilization materializes; a loss of only 6 percent if it doesn't. But, the developing regions suffer losses of about 25 percent without carbon fertilization and 10 to 15 percent even if carbon fertilization is included. The single output weighted number for developing countries is a loss of 21 percent without carbon fertilization and 9 percent even with it. South Asia, Africa, and Latin America the most severely affected regions.

My study also considers the argument that technological changes, sort of a fact of life in agriculture, and we have great historical experiences with the green revolution, and surely the rise in yields from technological change over this long a period of time will totally swamp

any kind of loss to global warming. Well, I've concluded that the technological change path is no panacea. It turns out that the green revolution is slowing down. It turns out that the average annual yield increase for 1960s and 1970s was 2.7 percent per year. That slowed down to 1.6 percent per year from the 1980s to 2005. Now, even if there's no further slowdown, it turns out that there's a fairly close race between rising food demand and rising output. Rising world population combined with rising income and a shift toward a more meat-intensive diet will approximately triple global demand for food by the 2080s.

It is also quite likely that a very substantial part of land will begin to be shifted to the production of ethanol for fuel. I've used an illustrative 30 percent. So, if you reduce the fraction of the land that's available for food, you triple the demand for food, then you're gonna need a lot of that technological change to produce that food. In – in the final, those two blue comparisons, I actually show the supply index going up somewhat less than the demand index. But the point is, one starts to then compare a 20 percent reduction from global warming, for example, against a much narrower gap between supply and demand and that is why I think it is fundamentally mistaken to say that since there's gonna be so much more production from technological change in the distant future, we don't need to worry about global warming.

Finally, there's another panacea that is sometimes suggested, and that's international trade, and here, particularly at – on this street, we love international trade. I guess I would say that I am skeptical of the notion that including trade can make the losses for the developing countries somehow disappear. Yes, some of the higher latitude countries might produce more agricultural goods, and they might export more to India, which would produce less, but to me, there's a certain "let them eat cake" flavor to this way of conceptualizing the problem. The big losers after all, are in the developing countries. They're already the poorer countries. They would have to devote more resources to the production of textiles and other manufactured goods to purchase these agricultural goods from the lucky few and would drive down their terms of trade to do so. The lucky few might include Russia and Canada, who by that time would be making so much money selling energy that they would have a Dutch disease and not be very interested in selling grains to Africa.

So, especially when you consider that it takes a lot of additional assumptions to posit a global trade model, especially one that can take account of possible political changes, such as the one in 1974 when the United States put a grain embargo on soybeans because we didn't like our inflation in agriculture and then to posit what the entire political economy of trade will look like in the 2080s, it seems to me a real stretch to impose on top of all this a – a trade model which then somehow makes the problem disappear.

So, in conclusion, my findings suggest that the global warming stakes for agriculture are substantial. The drift in recent years toward a view that global warming might actually be good for global agriculture, I think should be seen with considerable suspicion. It should be recognized as a short-term view. There are much clearer indications of a swing toward negative results by late in the century. Several implications follow from these results. The losses would begin to show up by late in the century if nothing is done to stop global warming and these losses are particularly potentially serious if the hope for carbon enrichment effect in fact does not do as much good for yields as hoped, and especially taking account of some of the other factors I mentioned.

Secondly, the losses will be much more severe for the developing countries than the industrial countries. Now, this pattern means it is greatly in the developing countries' own interest to ensure that a coordinated global program of abatement is achieved. They will need to change their position on this issue from the typical position that is the following: The rich countries caused this problem; they put the carbon up there. This is a problem that is a luxury for the rich people to worry about. Poor countries can't afford to do anything about it. They will need to change that posture to a posture that recognizes much of the future emissions are on a trajectory to come from us, the developing countries, and if we don't do something about it, this warming is gonna happen and it's gonna hurt our countries the most.

One reason it will be necessary for this shift to occur, for the developing countries to begin to think of being active participants in a program of global abatement, is that if they do not do so, it will be all the more difficult to convince the United States, the largest polluter, to start to take measures because the classic argument in this country has been, there's no question the United States being able to do anything about this if China, India, and all these other competitors get a free ride. But more fundamentally, it is their own contribution to future emissions and warming that drives the need for developing countries to make sure that they are part of the eventual solution. China's emissions in particular already exceed those of the European Union and are on track to exceed those of the United States \*\*\*\* soon.

Third, it is striking that the two largest developing countries, India and China, have somewhat conflicting interests in this political issue. With a broadly neutral, or even conceivably positive effect, China could well be less interested in international efforts to limit emissions than India, which faces major losses. Hopefully, India and other developing countries will be able to exert peer pressure on China to persuade China to participate in an international abatement program, in part on grounds that China itself has certain regions that would suffer very substantially. I would close by reiterating that the damage would grow even larger as you go beyond this period into the 22<sup>nd</sup> Century and that if anything, these estimates are overly optimistic, rather than overly pessimistic. Thank you.

**Jonathan Lash:** Well, Bill, that was terrific. This is an important contribution to the debate. If anyone came in late, I'm Jonathan Lash. I'm the president of the World Resources Institute and Fred and Nancy, I am very pleased and honored to – to be here. I have to tell you all, in fact, why it is such a pleasure to be here. Not just because I respect what – what the Peterson Institute and the Center for Global Development do and I'm glad to have them in this discussion. You'll be important contributors.

But this is something like the 40<sup>th</sup> climate-related talk I've given this year and because some months ago I – I published a piece in the Harvard Business Review about climate and business advantage, the overwhelming majority of the talks I've given here have been before business audiences, mostly, in fact, collections of investors, whose response is, don't tell me about the impacts. I don't want to know about policy. Where's the money going? So, it's a real pleasure to be with analysts and policy wonks again, my home family.

I'd like to begin with three intrepid predictions that I think are useful premises for discussion of the work that – that Bill has done. Maybe actually as you hear them they're not so very intrepid, but I think they're useful. The first is that the United States will take meaningful and mandatory national action to reduce greenhouse gas emissions within the next three years. Probably not before 2009, almost certainly soon after the new Congress and new White House come in, in 2009. For those of you that follow it, there are all kinds of signs, there are

dozens of bills in Congress, scores of hearings, members are educating themselves. They're talking about climate issues when they go back home. A group that I participated in, in the United States Climate Action Partnership, gathered the CEOs of a group of big companies and a few environmental groups to make recommendations for very stringent mandatory action. That group has now grown to include 30 companies, whose output is about \$3,000,000,000,000.00 a year. \$3,000,000,000,000.00 a year, ranging from GE and – and General Motors to Duke Power, Caterpillar, and Alcoa. And continues to hold together, insisting that the business case and the environmental case fraction on climate change coincide. I think there's gonna be action.

In fact, increasingly recently I find myself being pitched by companies who come in to say, you know, we're with you completely. It's time for action and – and we support the idea of a cap in trade approach to reducing greenhouse gases but we wanna explain why our situation is different and we need special treatment. It's an interesting indication that we're in the endgame here. People are trying to carve out their place in what they see as virtually inevitable legislation. So, that was intrepid prediction No. 1. There's gonna be action in the United States. No. 2, regardless of what we or anyone else does, and this – this isn't really a prediction, this is just science, regardless of what we or anyone else does we will see accelerating warming and growing consequences from warming, not only through our lifetimes, but throughout the period that Bill studied. It's just locked in.

Even if we take drastic actions, concentrations of greenhouse gases in the atmosphere will continue to rise. There is virtually no way that we will stop the increase in concentrations of greenhouse gases soon enough to avoid at least a rise of 2 degrees Celsius and that's pretty significant. I don't – do – do you follow this stuff in the papers? There was just a story last week about the latest findings from the Arctic this summer. The scientists are saying that an area the size of the United Kingdom has melted; that the melting in the Arctic is simply astonishing them because it is going so much faster than their models predicted. They see an ice-free Arctic during our lifetimes and that, what we're seeing now is the consequence of less than 1 degree Celsius global average warming. We're – we're absolutely committed to at least 2 degrees. This is all going to happen. It – it's not even a prediction – it's just the way it works out.

Third prediction. As the climate warms and the wealthy nations begin to respond to warming with increasingly aggressive programs to reduce emissions, the poor will lose. That doesn't take much prediction. They always do. But, it's perhaps particularly important to think about in – in this instance. Well, Bill has given us a terrific set of illustrations about how they're gonna lose from the consequences of – of warming. I saw a story recently about one of my favorite parks in Uganda, the Mount Elgon Park. It's a spectacular place. About 9,000 hectares which had been protected by a group of Dutch energy companies, who initiated the voluntary program to protect existing forests in order to offset the CO2 emissions from all of their air travel.

The problem was that there were thousands of people whose livelihoods depended on that forest and the Dutch had believed they would all get jobs as nurserymen or foresters. They didn't quite see it that way and last year, with the – the tolerance of – of Ugandan officials, they began to invade the area that was set aside. They've deforested about 1,300 hectares and turned it to agricultural land, which they regard as productive, and insisted on their rights. It's just a neat illustration of the kinds of conflicts we're going to see. The trees really were

storehouses of carbon. The Dutch are very responsible about this. This – this was done with extraordinary care, and here we have this direct conflict arising.

Of course, when our political process goes forward, we will be working very hard to find ways to deal with the fact that the impacts of reducing emissions will be unequal around the country, depending on what policy instruments we use and whether you live in a coal-dependent region and so forth. Members of Congress will go to extraordinary lengths to protect the interests of their constituents. That's their – their obligation and – and their interests. But it's unlikely that the interests of either Ugandan farmers or Indian farmers are going to be high in the scale of interests being considered in that debate, and what we do will affect them in other ways than simply the question of whether we slow the process of warming. And, of course, they are the most vulnerable and least able to respond.

If you look at the low lying areas of the world that are likely to be affected by storms and sea level rise, if you look at the driest areas of the world that'll be affected first by reduced rainfall and so forth, you find the poorest and most rapidly growing populations of the – the world. And, really, that's why Bill's book, which takes one slice of this and looks at it quantitatively is so powerful and so important. It gives us a vehicle for having this discussion other than just it's your fault, no, it's your fault, it's unfair, no, it's not unfair. It gives us some basis for approaching this set of issues and saying how would we address that if we chose to address it.

Of course, it's not just agriculture. For the rural poor, who are about three-quarters of the world's poorest people, about 75 percent, 1.2 billion, I guess would be the number for the rural poor, they are utterly dependent on ecosystems generally, agriculture in particular, but ecosystems more broadly, and the ecosystems on which they are dependent are all affected by the process of climate change. They're all part of the – the constellation of issues that Bill has looked at. So, if you begin to think of this in terms of a policy issue that needs to be addressed as we think how we will respond to climate change, it's important to get past the chirpy assurance that agricultural production will rise somewhere in the world, so we'll be okay.

The – the rural poor will not be okay. They are not beneficiaries of global trade, even if it is open global trade. It's enormously useful, as both Nancy and Bill pointed out, to get past the false dichotomy that there's a choice between development and addressing climate change issues. There's probably actually much more a coincidence between long-term development interests and addressing climate issues. And, if you are looking at policy measures based on thinking about vulnerability and adaptation, of which agriculture is a huge piece, beginning to think about development policies that encourage resilience, that encourage the management of the ecosystems on which the poor depend, and the assumption that the conditions are going to change significantly becomes a highest priority for those programs that we develop in an effort to respond to the needs of the poorest people and particularly the rural poor.

And the record is full of examples of very, very good efforts to create ecosystem-wide management programs that benefit incomes and also create resilient systems. There's a wonderful example in – in India of a set of projects to restore watersheds that both double rural incomes and raise groundwater levels and increase rainfall. They're community-based management programs. Those are the kinds of programs that we need to be looking at, to respond to what Bill has so effectively documented. Thank you all for coming and – and

being interested in this issue. It's gonna be important to us for many, many, many years. Thanks.

**Nancy Birdsall:** Let me welcome Fred and myself, along with Bill and Jonathan to the – to the front, and we want to turn to you for questions and comments, but I – I can't resist asking both Bill and Jonathan and Fred, if he likes, to – to say a word about this tradeoff that Jonathan raised at the end and implicitly between taking steps now to increase economic growth, which would make people better off and perhaps more ready to deal with the costs of reducing emissions, versus spending resources in some sense to reduce emissions now.

Now, I know Bill Cline won't even like the way I framed it because what I have in mind is to give Bill an opportunity, and Jonathan, to respond to the Copenhagen Consensus outcome, now embodied in this new book of Bjorn Lomborg called Cool It, in which he outlines this tradeoff and maintains, well, better not to worry about this issue but to get on with reducing AIDS, dealing with malaria, doing microenterprise programs, educating girls, all those sorts of things, which will bring benefits in the near-term without – and hopefully increase incomes in the medium-term, rather than worrying about global warming and its impact on the poor. I'm sorry for a long, discursive question, but...

Next Speaker: There's an answer in there somewhere, Nancy.

**Nancy Birdsall:** Maybe each of you could say a word, and Fred, if you want. I don't know if you're familiar with the – the book and with Bill's role in particular in the process that led to the Copenhagen Consensus. You wanna go first, Bill?

**Bill Cline:** Sure. I guess – I guess what I kinda wish is that the Copenhagen Consensus panel and its luminary economists might have had Joe Stiglitz as a Nobel Prize winner instead of a Tom Schilling; a Ken Arrow instead of another Nobel Prize winner or two. The – the Copenhagen Consensus has basically got hung up on this fundamental question of how you time-discount something that that's far out, and one of the distinguished economists on that panel wanted to discount everything at 5 percent. Well, if you discount everything at 5 percent, 30 years from now basically doesn't matter, and certainly 80 or certainly not my 300 years doesn't matter. So, that is a debate that continues.

I think increasingly what's gonna happen is Marty Weitzman at MIT is hammering away that the real question on this issue is the fat tail of the massive damage and it – you work through the mathematics and it doesn't take much – you can have pretty high discount rates, and that'll still get you do to something. So, I, unfortunately, I think that – that where the Copenhagen Consensus came out, from my standpoint, was basically a red herring, especially in the version, the first version where they said none of the actions, at least that I suggested on global warming, were a good idea.

Nonetheless, I'm glad I did that paper because it forced that sharp – that sharp debate. Does participation in resolution of the problem, abatement by China, by India, by Brazil, by Mexico, reduce their growth? Well, my preferred strategy is that everybody pays a carbon levy – I will not use the three letter word – pays a carbon levy of \$100.00 per ton of carbon, and that's internationally agreed. The Brazilians collect it domestically, they use it domestically for school programs or for whatever they want to use it for, but that sets a price that gets the world off of carbon energy and prods the system toward non-carbon energy. Can you have growth with that? Well, I would suggest that there are probably lots of

countries where if they had a stronger revenue base they could get a lot of growth from improved macro conditions that would more than swamp any cramping – cramping of their style from shifting from carbon energy toward non-carbon energy. It's also very clear that if this process is going to work, there will have to be some really fundamental resolutions of the equity questions.

Whether there are country quotas, whether there are – there are taxes. There will have to be some increased technological transfer, increased aid flows, etc. And that is a – a can of worms that remains to be sorted out. But the bottom line for me is that it is very myopic for developing countries, forget about the industrial countries, to think that if anything is done to stop global warming, it will stymie their growth unless they simply don't care about their children and grandchildren.

**Nancy Birdsall:** Jonathan, you were so eloquent on this last point, that the poor will be hurt most, and that's within countries, as well as across countries. This kind of work, of Lomborg, that's getting a lot of press, maybe you can help us think together, what's the way to, you know, characterize, and how to – how to improve the conversation about this issue and not have that point of view, which seems popular, monopolizing the way, the framework around which Americans and others in the rich world will be thinking about this.

**Jonathan Lash:** The first time I debated Professor Lomborg he didn't believe in global climate change. So, it's a – we're a step ahead. He now takes it as a serious issue that we should address where it is basically cost-free to do so, which I – I think is where the global consensus was about 1990, at the time of Rio. I guess I'd like to make three fairly simple points about this, one of which isn't directly about climate change. I was born just at the end of the Second World War in New York City. A very, very dirty city at the time. A city that was covered in soot and the soot was full of lead from leaded gasoline, the city burned coal for virtually all of its electricity. If my parents wanted to sit out on their back porch they had to scrub off the furniture every night because it was covered with this oily soot. When I first went to the top of the Empire State Building as a kid, we were really excited that we could see the Chrysler Building, five blocks away. But New Jersey was out of the question. Well, of course, that's changed.

That pollution has been eliminated. In the time since I was born our economy has grown something like ten-fold. In that same period of time, for the substances that we regulated, we've reduced them in absolute terms, not in intensity terms, in absolute terms by 40 to 90 percent for the things we chose to regulate. That's why you can see New Jersey now from the top of the Empire State Building. It's why you don't have to scrub off the – the furniture every day. It's why we're not dying of lung diseases as much as we would have. It's why kids don't have high levels of lead in their bloodstream. Okay.

Did – did making those huge reductions, instead of a 1,000 percent increase, 40 to 90 percent decreases, destroy the U.S. economy? Evidently not, right? Did it obstruct the – the evolution of technology? No. Our growth was driven by one of the most remarkable outpourings of technology that – that humankind has ever seen in the period from 1945 to – to today. So, boy, the consequences weren't unacceptable economically or in terms of innovation. Have you ever encountered anybody who would say, I wish we had more pollution. I wish we hadn't controlled it back then in the 70s and 80s. It'd be so nice to have soot all over everything. It – it was a real winner for us. It drove innovation that was in – in fact helpful to the economy and much of that was done, as my friend, Tim Wirth knows, in

the face of arguments that it would make much more sense to put this money into stopping smoking, or making – giving people more early childhood medical care. It would be good to do those things, but doing what we did on pollution was helpful. That's point one.

Point two, I think that among other things, change in the developing world is going to be ultimately driven by the desire to sell into low carbon markets. As the wealthy world decides that it wants to reduce emissions, and we're gonna have to reduce emissions one way or the other, there's gonna be a huge market for technologies, for low carbon technologies. If you want to sell into a market that demands low carbon technologies, you need to provide – provide a national platform that encourages the development and rewards innovation in those areas. I think that'll move the Chinese as soon as anything else.

Third, very brief point. We – we get in this debate. It's the beginning of every conversation with the Chinese official, although you can get past it, about their right to CO2 emissions. Well, CO2 emissions aren't a benefit, actually. They're just a byproduct. The right is to improve peoples' lives and if you're looking for the best way to improve peoples' lives, it's going to be to change technologies so you can expand wealth and reduce emissions.

**Fred Bergsten:** Yeah. I want to pick up on a related political economy question and put it to Bill because to me, there was one profoundly pessimistic implication of his study, in terms of the likelihood of galvanizing action on global warming off his analysis of the agricultural problem. The two biggest polluters in the world are the United States and China. Bill's numbers show that for those two biggest polluters the outcome of global warming on agricultural output is about zero. He's got a range from a small negative to a small positive, depends on fertilization. But the average is about zero.

So from an aggregate national standpoint you might say, the two biggest polluters are not gonna worry. They're not going to be adversely affected, in terms at least of this big variable, by global warming, so why should they take any action? At least on these grounds. And since these grounds are one of the most important variables, I would ask Bill, does that strike you as a profoundly pessimistic implication or is there some good answer to what I suspect will be a Chinese, and maybe to some extent, American response to your numbers, which will say, well, let the Indians figure it out.

**Bill Cline:** Well, Fred, maybe we should confiscate all the copies of the book that have been circulated. The American public, I think, is getting very restless on this issue and thinks it's high time to do something. And, I don't think the fact that the United States might not be really, really hit terribly in agriculture would dissuade them from that. First of all, as I say, this is, as this thing goes, this is – this is kind of short-term. I mean, the Stern review was through 2200 and it's in the next century that you get massive losses pretty much everywhere. Agriculture is an important part, but it's not the only thing. There are a whole range of risks out there. I think actually, the thing that really got the American public's attention was Hurricane Katrina.

So, agriculture's not the only issue that will develop – determine peoples' position on this, so I think this is a great concern and would that – that would not be reversed by the fact that it's – there's a chance that the United States might still be ahead, even as late as the – the horizon I'm looking at. The second thing is, I think you said in the press cover – press – press release, that the internal politics often dominate the – the – the average and it's not at all clear to me that the politics if the politics were to be driven by these results, I could easily see the entire

southern delegation, you know, rising up in arms and saying it's time to do something, and that would not be offset by the northern delegation saying, not on your life. My situation might get a little bit better. And, interestingly enough, that's also true of China, and again, it's not too surprising because it's sort of the same latitude. So, those are my – my principal answers to your question.

Next Speaker: I hope you're right.

**Nancy Birdsall:** There's also, to add to Fred's political economy worry, you know, this issue requires a kind of global collective action, which is hard to do in the first place, and then we have a world, unfortunately, in which those most – the countries most likely to pay the highest cost, are the least powerful, economically, militarily, politically, and the least well represented in any real way in most of our global forum. So, I think that there's a sense in which this issue hopefully could be the leading wedge of change, at least in the way we organize ourselves globally to address what are global challenges. But, there's no reason –

Next Speaker: Nancy, Nancy \*\*\*\*.

Next Speaker: – to be particularly optimistic, you know. It's – it's going to be very tough. We see that already in settings like the World Bank, the IMF, the United Nations, that this is – this is a tough row to hoe because the status quo does provide more power and more influence to countries that turn out to be those less likely to pay high costs for global warming.

Next Speaker: Well, let me just challenge that modestly, and then we ought to open to the audience. The world trade negotiations now have been driven by the G4, of whom two, India and Brazil, are among the biggest losers on this issue. What's evolved is the government structure of the global trading system gives at least equal weight to developing countries and puts them in a position, as they have chosen to do, erroneously in my view, to veto essentially, a successful Doha Round. But they've got plenty of voice, plenty of power, at least in the global trading system, and so, I'm not sure that their impotence will – will rule them out. The issue is what positions they take. Do they believe Bill's numbers? Can they be influenced by them? Will they then step up and use their increased voice and – and relative weight in the international economy to push these issues? That remains to be seen. A critical question will be whether India, which has been blocking global action on warming, gets along –

Next Speaker: Not on warming, on – on Doha.

Next Speaker: On warming also!

Next Speaker: On warming also! No, I'm talking about has blocked action on warming, in addition to Doha, but it's blocked action on warming, whether it believes in Bill's numbers, and suddenly says, I got it wrong in terms of my own interest. Let's find out. I don't worry as much about their clout as I do about their own position and whether they're going to take the constructive view in light of the kinds of arguments that Bill has made.

Next Speaker: Very good. Let's be hopeful. Okay. \*\*\*\*. Introduce yourself, please.

Next Speaker: I'm Phil Musgrove, and I'm a Deputy Editor of Health Affairs, which has nothing to do with my being here today. Thanks for inviting me. Two quick questions for Bill. One is that all of this modeling about agriculture seems to me to be saying, this is the potential. This is what happens if temperatures rise and rainfall changes. Doesn't get into the question who's going to be farming that land. It doesn't get into how the society will continue to function, so the first question is: If things start to break down, if yields fall, if people are being impoverished, is that likely to push things even worse for actual output, given that these are basically potential output models; and the second question – I did not have time to read all of this during lunch, but I don't see any mention of sea level rise. Is it safe to assume that that won't be significant by the 2080s or it could be very significant later on? Because, clearly, if some of this agricultural land goes under water, then all of your estimates become extremely optimistic.

**Bill Cline:** Yeah. I think that – my impression is that the – the sea level rise, first of all, let's talk of the magnitude of the sea level rise by that period of time. It's something like half a meter or – or perhaps less in the IPCC central estimates. I think that some of the areas, I think it's quite possible that the Egypt numbers that I have may be overstated for failure to take into account a sea level rise, so, yes, that could have some direct adverse effect on agriculture. I don't think it would be large enough, I mean, if you think about it, agriculture is massively on the interiors of countries and not strictly along the coastal peripherals, so the direct effect would tend to be limited. There would be some countries, certainly for some individual countries, the numbers could be much worse.

On the question of, you know, does – do you get some sort of a downward spiral, I'm not quite sure how that would, that would work out. I mean, presumably, I mean, in some sense this is all a – a benchmark of what you'd like to avoid, so, this is not necessarily a prediction, in fact, you hope it's not a prediction. You hope it's – but, if you – if you – and then when you start taking sort of a second derivatives of the – the prediction, you hope it doesn't happen. It – it starts to get a little hairy, but presumably the farmers, if things start to get worse, you know, the prices would go up, there would be some increased incentive for staying. I'm not quite sure how fruitful that additional layer would be, but I think it's something to think about.

Next Speaker: Tim Wirth from the UN Foundation. Nancy and Fred, thank you very much for doing this. Bill, let me ask you to expand a little bit on the water variable as it impacts on agriculture. You said in your opening comments you had not factored into analysis the impact of insect pests, drought or loss of irrigation, so – loss of water for irrigation. Let me focus on the last part in particular. Jonathan, in his remarks, noted the surprising and very sharp decline in the Arctic icepack, how rapidly that had melted, and I think that the evidence is that glacier melting in the Himalayas, in the Sierras, in Latin America has also been equally rapid, equally surprising and potentially equally devastating. Now what would be the impacts, do you think in your analysis, if you had vectored in – factored in to your analysis this surprising and sharp increase in melting?

It also, Fred, goes to the question of China, India and their potential political position. China is very dependent upon melting from – water melting from the Tibetan plateau and all evidence is that that's going to change significantly as a result of climate change, and, Nancy, the stupidity of the Lomborgian analysis, which does not take into account the fact that even in this 30-year period of time in which those economists benignly suggest that everything is going to remain static while the world gets richer, I mean that's insane. We're going to see,

you know, the flooding of aquifers, as suggested in the previous questions, the melting of glaciers and you can't get that back again. We can be as rich as we possibly want, but there's no way that we're going to be able to reverse – you know, what are these impacts in the meantime and that is not taken into account at all, you know, by the so-called Stockholm consensus, I think – or Copenhagen consensus.

Next Speaker: I think we should call it the Copenhagen syndrome. The – it's a very interesting question. What would do to these estimates to take account of possible losses of irrigation from glacier melt. My hunch is it wouldn't make a lot of difference. The great bulk of world agriculture is rain fed, even in Africa, it's only about 6 percent of the land is – is irrigated, but, again, it's quite possible that in some specific countries that are relying – and I wasn't aware of the China-Tibet point – that some of the individual-country estimates could be substantially affected.

Next Speaker: I saw some other hands. Let's go to the back there. Or maybe – let's do John Williamson's, just because he's right there, and then to the back.

Next Speaker: In answering your question about the Copenhagen consensus, the – the leading Copenhagen dissident remarked – he invoked the name of Marty Weitzman, who, indeed, has been writing about these topics and that – as I understand his – his argument, it is that what one really needs to worry about isn't the fat tails, it is the small probability of a really disastrous outcome, but that it doesn't – the trajectory we're on is nothing particularly to worry about, and that's not the impression I got from you and it's not the impression I got from Jonathan Lash today. \*\*\*\*\* is a distributional problem. It may be that there were one or two countries which – which unfortunately look like they may be the critical ones, which would not suffer too much, but it looks pretty disastrous. Is – is that a correct reading?

Next Speaker: It is – it is for me, and I certainly don't mean to – the thing is that Marty is – he wants to use a – a higher discount rate than I think is appropriate, and he is emphasizing the fact that even if you do use a higher discount rate, if you take the fat tail into account, you better do something. So I – I consider that, basically, to be an additional layer of argument of why you should do something, but at the substructure I continue to – to consider these kinds of damages, and – and my kind of discount rate is the kind of discount rate that Mick Stern used to be the right way to look at it.

Next Speaker: I – I would answer from a slightly different viewpoint, but the same answer. Yes. I – I gave the – the anecdote about the Arctic. What stuns the best scientists is that the melting is going so much faster than the models predict. In fact, if you look at all of the now rapidly accumulating evidence of current impacts of climate change, it is generally at the top range of what the models thought might happen where the models had a prediction, and they – they – they are necessarily ranges, and they are appropriately conservative. So when – when Bill said, at the beginning, well, if you wanted – what was it, 85 percent certainty?

Next Speaker: 95 percent certainty.

Next Speaker: 95 percent certainty, you get out into the fat part of the tail, and you were talking about 13 –

Next Speaker: Nine degrees.

Next Speaker: Nine degrees Schlessinger.

Next Speaker: Nine degrees Schlessinger. Right. Those are stunning shifts that are with the range of what the current models suggest and – and we're seeing that they are very conservative.

Next Speaker: That's a good essay or something, but the models – we may already – even this book may already be understating the nature of the problem to the extent that the models have been wrong, yes. All the way in the back.

Next Speaker: John Klug from the World Bank. I think this is a terrific piece of analysis, and it's very rich in terms of the policy recommendations that are clear from it, but at the risk of sounding churlish, I want to come back to the point that I think Tim Wirth was raising about what is not included, and that's the issue of the sudden climate shocks, the droughts and – the droughts and floods in particular. I think what the book does is it shows very clearly that if you aggregate the small changes and the small impacts over time, you get a very large impact that can't be ignored, but I think superimposed on this, as climate scientists know, is the increasing likelihood of shorter-range, very sudden shocks that will have major impacts on – on people, which – which I think need to be included for two important reasons.

One is that those are likely to increase the aggregate picture, particularly in countries like China where the vulnerability to drought is – and, indeed, to floods, as history has shown, is – is quite severe, but also the – in terms of the impact of the poorest people – the most vulnerable people, it is these more shorter-range climate shocks that will have a really major impact on the survival and on the ability of those people to retain their land tenure and so on, and – and I think, by the way, also that the humanitarian disasters that we all see more and more of would also be a major imperative for political action. \*\*\*\* the slight question about Egypt, why Egypt comes – comes across so positive in terms of the impact of climate change.

**Nancy Birdsall:** Now, it's 2:30 and I think we want to be disciplined about stopping. My suggestion is that we actually hear any other questions, but desist from providing any answers so that we get the input and bilaterally, perhaps, some of those issues can be addressed. So –

Next Speaker: Typical think tanks. We love the questions, but the answers?

Next Speaker: So, please, yes. I see two hands \*\*\*\*.

Next Speaker: Just a question to Bill.

Next Speaker: You imply change in productivity or prices being equal. I suppose you were talking about physical productivity in the agricultural sector, but there are massive impacts of \*\*\*\* of trade and prices that are unfolding right now. The drought, the \*\*\*\* episodes that we – we make – I mean, depends on how you classify them, but there are incredible gains in terms of trade that are accruing to poor countries that have huge opportunities in this environment, and if you eliminate trade, I think that the price impact on developed countries is not a marginal factor. So I think the 2050 horizon is a lot longer in terms of economics than it is in terms of climate.

Next Speaker: Very interesting, and one last one. Please introduce yourself.

Next Speaker: I'm Julian Josephson with Bootstrap Press in Bethesda, Maryland. Back in 2002, I was at a Marine Technology Society meeting, which was in February 2002, in which they predicted already the contraction of the sea ice in the Arctic to the point at which the fabled Northeast/Northwest Passages actually could be open not only for shipping, but for establishing force. I was a little – \*\*\*\* from agriculture itself, but you're looking at less-expensive shipping because \*\*\*\*, and with the \*\*\*\* and the exploitation of the resources there, a tremendous water-pollution potential that probably, indirectly at least, could affect agriculture in the long run, and I just want – I just want to put out some food for thought.

**Nancy Birdsall:** Right, another example. Bill, is it okay if we don't give you a last word? Instead, thank you heartily for this really important work. I can see lots more that we need to do to make sure that the world understand it. Thank all of you for joining us. Thanks Jonathan and Fred, as well, and go on out and see the book as a call to action, if you wish.