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Efficient and Equitable Climate Policy in a Dynamic World

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Qi Ye:

Hello, everyone. Welcome to this special seminar on climate policy. And today, we have Professor Lucas Bretschger who's a professor from ETH in the area of economics and resource economics. Professor Bretschger holds many other titles and public services, one of the major public services he holds is the President-Elect of the European Association of Environmental and Resource Economists (EAERE). We were just discussing that this is a very large network that goes from Europe to America and reaches East Asia. And Professor also has other affiliations, including the University of Oxford. He is also a committee member of the Swiss national foundation. His main research interests are the theory and policy of natural resources in the environment of economic growth, trade, and policy in regional economics. Today his topic is on efficient and equitable climate policy in a dynamic world. This topic right now is very timely. We know just a few hours ago President Xi Jinping delivered a major policy speech and was co-sponsored by the Brookings Institution. One of the main topics for President Xi Jinping delivered to the United States and to the United Nations is on climate change and how we can make climate policy efficient and equitable. It is extremely important. We are very grateful to have Professor Bretschger to talk to us about his research and follow his speech in order to have Q&A and discussion about this subject. Without further ado, I would like to introduce Professor Bretschger.

Lucas Bretschger:

Thank you very much for this very nice presentation. I am glad to be here. This is my first trip to Beijing and I am very impressed already. I would like to talk about what was said already about this being a timely subject. Of course, as an economist, we think about efficient solutions all the time, but we should also think deeply about equitable allocations of the commonwealth just because in politics it is true that it is about equity and the distribution which we should think about more carefully, as lately there has been a manifesto saying we should implement a global carbon price, which is, of course, correct. This is an efficient solution, but this is a message that is not broadly accepted, as people do not like prices too much. People think it's not fair, or it's too costly to do carbon policy, which is why we need to think about the equitable solution as well.

So let me start with a little broader introduction and what people perceive. Public perception is we have a problem – like polar bears, which will disappear, and ice melting. But what are we going to do about it? Well, we have some politicians that will take care of this - that's what they said. They would decarbonize the world economy by the end of the century. So what is left and what's the problem? In economic theory, we have a solution. We know that when we have environmental pollution, we have externalities.

So we have a supply curve, which is shifting to the right. We have to increase the private costs because there are negative externalities. So we need to increase the cost curve and shift it over by implementing either a tax or limiting the quantity. You can decrease the quantity by having permits and you will have an increase in price, in quantity, and in welfare. And this is what we should do. We have seen the problem, we have the solution, but it is very, very difficult and so far, it has not happened. So we need to think about the real development. What's happening in reality? Why is it so complex?

There are many, many things that add to complexity here but one of the things that I want to stress is the dynamics. You see you have development of world GDP per capita. Growth is crucial, it is not a static game but the government, they really care about dynamics and growth and think that they want to develop. So what about development paths if you do climate policy? That is the first issue. In the middle you see, there is a deeply divided world when it comes to income distribution. There are very rich and very poor nations, but at the same time we have very poor nations that are very vulnerable to climate change so it is really inequitable at the moment. On the bottom you see that the prediction of natural sciences, which you see is the blue area and the red area. The red area would be business as usual and the blue area would be the two degrees Celsius tide. But both of them are very long run and both of them are very uncertain. So this is another issue, which politicians usually do not like – things that only come in the long run and things that are very uncertain. And I have many other complexities here that are very crucial and increase the complexity of politics.

So we talk about economic dynamics, long-run perspective, the uncertainties, and also the equity. International dimension because we have 194 parties and it is extremely difficult to come up with conclusions, then we have other issues like debate about how should development look like in general, how should population be treated, how should we change our lifestyle, and so on. Then in the end we talk about intuitions. Is United Nations the correct institution or should we have another frame of leadership?

So if you take all of these points, then it is clear that it is really difficult to come up with a good and stringent climate policy on a global level. Actually, there might be, if you know about the old Greeks, there was Hercules. And he had 12 tasks to perform, all of them very difficult. He was successful in the end but that was then and this is now. This was at COP in Copenhagen so people were desperate for a solution. It was just too difficult at the time. And now we ask ourselves, will Paris be different? Will the Eiffel Tower shine in the end or will these 12 tasks still be too difficult for us?

My question now is for research and for policy application – why is it especially so difficult in terms of climate and how can we think about distribution in this issue? And also, how can we link these climate issues to other long-run issues. So what is the contribution of economics? I don't know if all of you are economists, maybe not, you all may be in public policy or different fields. For us, of course, efficiency is the primary focus and we should come up with efficient solutions. I think this is what our comparative advantage is. But otherwise, we should also acknowledge that in politics, equity is very important. Countries care a lot about what they are doing relative to other countries. If they have too high of a burden or if it's a fair burden that they have to carry. So we should separate efficiency from equity but we should also go into this equity discussion and propose something. I actually have a proposition to do that because in the end, people want to know – how can we divide this burden among the different countries?

I would claim the following – I would say, well, if we are able to convince people that we should get the efficient issues right then we should have a look at the dynamic impact of our climate policies which are often not really dealt with in an accurate way. If you also consider this uncertain issue the correct way – if you have fair burden sharing and we look at these international asymmetries in a correct way then we could probably be more successful in the future. I don't say that this is a guarantee for success in Paris, but it could be something that we can make substantial progress on.

So I want to talk about the following topics in this talk – first of all, I want to talk about the costs of climate policy, then I want to link it to resource use and growth, which actually is often neglected but it has been there for a while. Resource use was a topic in class for economics even, so we have to think again about this issue. And I wanted to introduce climate change models in the correct way and talk about uncertainty. And then I wanted to change gears and say, well if we switch to equity, what could be equitable burden sharing in this case? What is the correct North-South perspective? And then I have other issues but maybe I won't have time to go into these because the time is limited.

When we do climate modeling in economics, it's clear that we should have suitable models; we should have accurate models to do this. And what you see, if you've ever looked into matters, that numerical models dominate the field. The Dice model is the best model but there are others that work. And you will also see a summary of several numerical simulation models, and of course they are important, they are crucial. What you will find is that numerical simulations are often like black boxes – you somehow

miss what are the basic mechanisms, what are the drivers of the whole thing, because you have a complex model, you throw in some numbers, and then you get some output and you don't really know why it happened or what are the main mechanisms driving the whole thing. So this is why we think that we should also have some analytical models and this is why we are doing both. We do CG models and we do small analytical models. As we do it in economics usually, we reduce complexity and we sometimes reduce complexity in a brutal way to have very simple equations to see what the main mechanisms are to get it more or less right in a general way, and even if you make small mistakes, you still know what's going on. If you have a numerical simulation model, you never know but you probably get major issues in an incorrect way. So that's why we should do both. And what I argue is that we have a long-term horizon, as we have the growth process of the economies, we have lower impacts of climate change, we should do dynamic modeling. We need to do it. It is a major challenge. It is one of the most difficult things you have to do in economics, but we cannot shy away, we have to do this.

To be a bit more concrete, I will not present many equations. I don't know if you like equations, so I will skip a little. But if you look at the cost of climate policy, people are concerned about the cost of climate policy. There are economists that say there are two parts of it, there's level and growth effect. The level effect is always negative because you have fewer inputs. You decrease common inputs, you decrease fossil fuel inputs, and so you'll have less output. This is what policy makers understand. On the right hand side, this is what we call growth accounting. You have inputs on the left hand side, so when you have less inputs, you get less outputs, this is clear. But many things are missing in this thing, especially the causal relationship between the variables, sectors, and countries. Everything is not included and for the long run, as we have it, people are concerned about development, so all of these growth aspects are not included.

So we have to look into the growth effects. I did growth theory for a long time and I think it's crucial here. So what is driving development in the long run? Well, it's capital formation and innovation. I think in China you know this very well. You have to build capital and you have to accumulate capital, otherwise there is no growth. And what happens is that these growth effects counter the level effects. So even in the current level when you have the negative effect of climate policy, you might get a positive growth impact and this would lead your economy to different development. Usually it's not that the cost will be negative or positive so that you will have some gains, even with climate policy. But the costs that you have will substantially reduce by the positive dynamic effects.

And as a demonstration, take the law of utility function here. So when you measure the welfare of a policy, you'll see what's the utility. Utility you'll divide from consumption and take it times 't' and discount it with the discount factor 'CO' and then take the integral of the whole thing, you'll see that your welfare depends on initial consumption and on the growth rate 'g' – and this is the discount rate. So if you have a policy, which decreases your 'CO', but increases your 'g', you have two effects and you have to look at the two effects together to get the whole effect of the policy. You cannot just ignore the effect from 'g'. So the effect of the growth rate is crucial here. These things are linked by climate policy and they're also linked by resource use. Suppose you have labor and you can use labor in the research lab to produce growth rate or you can reduce labor to produce, then it's about initial consumption. So you can shift labor between the two functions and you have either level of growth effect.

Now how costly is it to redirect the political economy? That's the main issue. We are in a certain way of development; we are very intensive in fossil fuel use. How difficult is it to get different development? People think a lot about these oil price jumps, and I know many of you are aware of what happened in the 1970s. I was a student at the time. The price of oil shifted overnight. And this was of course a shock to the economy, in Eastern Europe and the U.S. This caused a major recession. But it was not that this was the only reason for the recession at the time. We had a collapse of the Bretton Woods system, and we had political turmoil. There were all kinds of different changes. But what people generally took from it is that when the price of oil increases, then it's bad for the economy, it's bad for the growth rate. Now recently, in the recent episode, which you have probably experienced as well between 2003 and 2008, the oil price went from below \$30 per barrel to over \$140 per barrel. That's a major increase. It's five times higher. And what happened at the same time was the world economy was not in a recession, it boomed. And we had a recession but it wasn't because of the oil prices, it was because of the financial crisis. So then already you see if you stretch out development and also this is with carbon policy. We do carbon policy and you triple the price overnight, it's not good for the economy. We cannot just change it. You have your cars, you have your heating, and we cannot just adjust it overnight. And even if we do it over five years, or 40 years or 50 years, there's no urgency. We just have to do it. Then the economy can balance off of these changes. That's the major message here.

The cost could be different than what people think. So we could refer to Endogenous growth theory, and this is Paul Romer. He was the founder of Endogenous growth theory in 1990, and I also found an older paper from the Japanese economist Suzuki – in 1976, he had an endogenous growth model, including natural resources. I found this quite remarkable. And another contributor, which is John Hicks, you might

know. He talked about induced innovation in 1932 already. So this idea is about when you are increasing prices for one input – and at the time he talked about labor – if wages increase, then you won't, as a firm, you won't economize on labor because you won't be more efficient. You do your innovation in a sense to do labor progress. Adapted to our subject, it would mean if the price of fossil fuels increases over time, then you want to economize on fossil fuels. You want to make it more efficient. So this will be induced innovation. You direct your engineers; you direct your technical change in economizing and saving on fossil fuels. And this increases your resource efficiency and this can also increase your capital productivity, which is crucial for growth.

In general, if you link it to the sustainability discussion, if you think about the problems that we have in achieving sustainability, it is in fact very key that growth depends on capital accumulation. It is that we have not enough capital accumulation, not enough investment. Why is that in the long run? It is the whole idea that we have these capital resource models that when we have decrease in return on capital, which was a function before we had this endogenous growth theory. We have of course the resource depletion, even if you have no compost, even if you have a finite stock of fossil fuels, we will run out sooner or later of oil, and of course coal, we still have a lot but of course this is limited again. If you think about it in a synthetic way then you do have limited stock, which will eventually be depleted. And as climate change goes on here, we have capital depreciation, which is increasing, so all of that is leading to too little capital investment and too little growth rate.

So what is the solution to the original capital resource models of the 1970s here? Well, if we have an input, which is shrinking, then we need another input, which is increasing, which was capital and we need to put substitutions. And we have to assume that there is some technical progress around. Of course technical progress is crucial but I think it's not good to just say 'oh there will always be some around', we have to understand it from economic fundamentals. How much will be there? How much can we expect? Or another thing you can do is to say, well, if you don't have enough savings to do a capital investment, you just have to enforce it. So you enforce sufficient savings then you have investments, which are sufficient, and these will drive the growth rate.

But these are all solutions in the traditional capital resource model. The recent solutions look a bit different. What we do of course is endogenous innovation, endogenous capital formation, endogenous central change, and I will show this in a minute. We also have to include risk, which was not included in the older capital resource models. We talk about momentum effects, which are normally narratives in

the development, so sometimes you have a trigger point and then you have fast development in that direction. And we have to integrate it into the whole equation and also look into an appropriate policy mix of course.

So here on the horizontal axis, you have time. On the vertical axis, you have consumption per capita. And I just take the law that I have for growth development here. If I have a constant growth rate, the law keeps it a linear function. And you can see that the development of per capita consumption depends. See initial consumption here and the growth rate, this is per capita consumption growth. And actually, it's interesting, but now I want to shift a bit with my growth model, interesting thing is that I have two parts of the whole thing. So this is the productivity part, this is my capital, π , and this is capital depreciation, d , affected by climate change. So actually I can either shift the red curve now or I have the shift of the green curve, and that will have an impact on growth rate. So let's see what we can do with this. This is my growth development, say the growth rate of China, and then I can have changes in π and in d and I can see what is the result of my growth rate. So this is more or less the equation. I can see the different components but actually I don't do everything here.

I want to talk about this capital return a little bit. I want to talk about depreciation. This is the curvature of the utility function, many people talked about discount rate. So I want to talk a little bit about what we can do to make our capital more productive to increase the growth rate, and what we can do to protect our investment – not to have too much climate change which would make the depreciation too high. Because if depreciation increases, your growth rate is decreasing or if the marginal return increases then we have a higher growth rate. So it all depends, what is the impact of climate change or climate policy?

I can say that usually when you look at this marginal return on capital, capital π , many models assume a one-sector economy. Actually, this is the general expression that I have here – this is the marginal physical increase in output. So when I increase my marginal physical capital input, what happens with my output? But actually, in a multi-sector economy, this is what we're using. We should also have prices. So this is the price of output, the price of capital, so this is the whole marginal return. And if you have a one-sector model, then these prices are all the same, so you can just put zero. But instead of having the marginal return, you just take the physical increase in output.

This is not the same; I can show it very quickly. This is output y , physical capital resources – say, oil or coal – and these are my production figures, θk . This is a simple capital resource model. The return on capital is this here. So this is my physical return and this is my effect on capital prices if I have a multi-sector economy. What I know is that when I deplete my oil, then the resource use is going down, it's decreasing. The capital accumulation makes my k grow. So the relationship between r over k is decreasing. So given alone, if I have a production economy and the θk is fixed, then my marginal return will decrease and I'm having a decrease in growth rate. If I have a production function and can input substitutions, then this θk , the input of capital will increase over time and the share of resources will decrease. So this is a demand side effect. This could be a solution, but it actually turns out that this is not what we find in the data. Usually and what we are applying in these models is poor input substitution, not good input substitution, so to hope for this effect is actually kind of dangerous.

But this is the old effect. This is only the demand effect. But what we also have is the supply side effect and the supply side effect accounts for the fact that capital will become cheaper over time. And why is it becoming cheaper? First, it is becoming cheaper because of policy but also because of knowledge spillovers. Actually, in the knowledge sector and research labs, you profit a lot from research and can have it done by others. This makes the future research cheaper and this is a very powerful effect.

So this is why I say that we have to get these efficiency issues right and we have to look into the dynamics. And if we go to a multi-sector economy, I mean this all not present. If you take a one-sector economy or a two-sector economy, then you find that sustainability is feasible even if you have poor input substitution between resources and capital. And this is something that has not been acknowledged broadly in economic literature yet.

This is also important for climate policy because what we're doing in these models usually we have poor input substitution, but we have many sectors. So then you shift out the sectors and go into a more into research and you can still save the economy and this would also moderate the cost of climate policy at the same time.

So if you have a multi-sector economy, it could transition to a higher equilibrium by having these sector changes, even if the input substitution is poor. So this could be if the resources are reallocated towards dynamic sectors – what we call high-tech sectors – so if you have more computer industry, have more IT, more innovation, then you can get to a higher equilibrium path. But on the other hand, it could also

happen that the resources are reallocated to stagnant sectors, like beer production. So a country produces beer and nothing else, then the innovation will die out in the end and you can drink up your beer but then you're done and consumption will go back to zero. So it's about sector change here, it's not about input substitution.

Another issue now, we have talked about this capital π , another thing is about d . So what about the impact of climate change on this long-run development? Many people and some models argue that climate change has effect on utility, which I had in the beginning, the u . This might be correct, but it's not the whole story. The things that are having an impact on your u is just noise. If it's noisy then you're disturbed for a while, but when the noise is gone you're working well. That's not climate change. And in the same, you can say it has an impact on annual productivity. It has a drop in GDP for one year but when climate change is gone, everything is fine again. Again, I think this is not correct and I have some drastic pictures here to show. I think climate change has an impact on your capital stock. It's destroying property capital. And major weather shock is destroying property capital, of your infrastructure, of your transportation facilities, of whatever you have there. The difference is when you have a climate shock, you cannot restore it within one period, you have to build up the capital stock again, and this takes several years at least. And this is why your growth rate is affected by climate change.

So again, we have the impact on one stock, on capital, and then on the other hand, what we should not forget is that climate change is stock pollution. We accumulate this stock in the atmosphere, which is there for a very long time. Part of it is absorbed by the ocean, but part of it is staying there for about 30 years. So it's not like regional pollution, which is disappearing when you have better policies – it's there for a long time. What does this do in my model? As you see, I'm not now affecting my productivity, but it's about my depreciation rate. You can see that the growth rate in the economy is the difference between the red and the green. Now I'm decreasing the red and the green, so I have more depreciation of capital, and this effect on the economy – which was growing before – is now stagnant, it does not grow anymore. This is of course something that we would not like to see.

It could even be worse for an economy, which is really vulnerable to climate change. It could be stuck in a poverty trap. This is a representation of such a poverty trap, this is what we are saving and this is what I have to use for depreciation. Now if you're very vulnerable, in the low stage of capital accumulation, so you're very poor and the climate shocks hit you constantly, then the depreciation is higher than what you are able to save and invest. Then whenever you're below this threshold, which is the stable

equilibrium, you will always fall back to zero. This is a subsistent economy, you cannot grow. And only when you pass this are you able to accumulate capital. So this is a representation of a poverty trap. Usually the productivity is not linear and then the depreciation is there but in case of climate change, it can be like this. Then you're very vulnerable, poor, and you cannot protect yourself. You do not have the needs for adaptation so you're stuck below equilibrium and you always go back to zero.

What we also have to observe is that we have lags in emission diffusion. This is also what we have to do in our models. And what could be, if it's not that serious, is that this here is that at least we have a delayed income convergence. Now, what is this? We wanted to have the poorer economies catching up with the richer economies. So here is a rich economy and a poor economy. Again, the same logic as I had before with my growth rate. You see that the rich economy in this example is not affected by climate change, so this economy can manage climate change. This would be like Sweden or Norway where they're still growing at the same rate. But the poorer economy, which had a higher productivity before climate change was able to catch up and had a higher growth rate which would be a policy goal. But now because of climate change, the depreciation is getting higher, more severe, and that means that the growth rate is decreasing or is lowered so that in the end you do not have convergence, you have divergence of income. So the world will become even more divided because of climate change.

Another issue is uncertainty, and here we also have to be very careful in modeling how to do this. What should be the conclusions for policy? We want to avoid uncertainty, we are always risk averse. In climate change, we don't know many things about the long run and how the economy will evolve and develop. We have many uncertainties in the ecological system, we have the IPCC with very clear information but still, well, they are also open about it, that there is a variance of possible outcomes. And what is also harming for the economy usually is that we have uncertainty about policy. We don't exactly know what the climate agreement will look like in Paris. We don't really know what our governments will do in the future, and for companies that are investing, this is a big issue.

And when it comes to climate change, it is clear that we have uncertain size, kind, arrival, and frequency of the disasters, which are coming. We also have two different kinds of events that could be. We have things that come more or less frequently, recurring events, like climate shocks, which come about every 10 years, and then we have the really severe events, which you could call tipping points. These tipping points usually come from natural sciences; it is something like irreversible development. Say, if a species like the polar bear is disappearing completely and it will never come back, which is a tipping point in

ecology. What if in the Alps I have no more glaciers? If the ice is melting, they will not come back. This is another tipping point. Now what's a tipping point? Economists always use this in their models and it's not really clear what that should be because one may argue that this is a drop in 30% of GDP or 30% of capital stock. But if you have a drop of 30%, you're still left with 70%, so although this is a disaster, you're not dead, you're there. And then what happens after this? Actually, this is an open question in climate modeling.

In any case, in any kind of disaster we are assuming that we have to think about now, with increased uncertainty, what is our optimum growth? And what is our optimum abatement policy for the whole world? So this is actually what it looks like if you have these recurring events, these climate shocks. So you see in the equation that you grow, but every time you have a shock, you go down because some part of your capital is destroyed. This is how the story looks like. And of course we have to find out how big the jumps are. This is actually a function of the stock of pollution that we have in the atmosphere. And then you should also know how frequent this is, so this is the lambda arrival rate. You show know the arrival rate and this can be done, although this is tough modeling and complicated math. But what we find out is that when you include uncertainty, then you will conclude that you will have more stringent climate policies, which are warranted, because you want to avoid uncertainty. The economy does not like uncertainty. And we can also have closed form solutions on how the optimal abatement share, how the optimal climate policy should react to all of these different parameters. If the arrival rate is increasing and all of these things are increasing, then you should react with your optimal climate policy.

So we can do modeling when we have closed-form solutions and I think for these specific issues, like uncertainty, it's crucial to have the basic insight. And then of course we can translate it into the price of carbon per ton to find out the optimal carbon price, and we found out that the optimal carbon price should be much higher. So it really is about the fact that we should have more stringent climate policy. The effect that you are often observing is another one of uncertainty in policy. People think that if I'm uncertain about so many things, I'm just stuck with what I'm doing. And then this is why I have to refer quickly to our attitudes and to our lifestyle because this is what we call the emersion of the doubts. If you are doubtful and people tell you 'everything is uncertain. Just do nothing. That's the best way of living', then you cannot deal with this uncertainty in a rational manner. But if a catastrophe nears, like people get bird flu or swine flu, then people react almost in panic. So we should not react in panic, we

should not react not at all; we should have some rational approach to uncertainty. So it's really about how to confront this uncertainty in a rational way.

But I wanted to switch to the second topic, which is probably even closer to your field. It's about equity. We are concerned about equity, especially in climate policy – it's a lot about equity. So in general when we talk about sustainability, it's about distribution between the generations. We don't want to have future generations, which are poorer than we are now. We want to have increasing circumstances for our loved ones. So this is the sustainability issue. And climate policy is a really big issue in terms of equity, why? Because if we have no climate policies at all, then we will have many poor countries, which are highly vulnerable and they will lose a lot. So if you look at the recent climate shocks in the Philippines or Pakistan, I mean, they lost a lot and if you don't help them, this will be very difficult development for them.

On the other hand, if you do climate policy and you do the two degrees Celsius target, which I'll show you in a minute, then of course several countries will be better off. They have to do something, they have to change. And they will then think, well this is very costly to us so then they think, well, everybody should do an equitable share of this climate policy. This is where you have to find the balance. That is the task at the COP in Paris this year. And in general, when you do climate policy, we also talk about world income distribution. So we think about ethics in general and we know that people are concerned with the income distribution. And if you increase the carbon prices because we think this is the best way to proceed then people will say, 'is it not hurting the poor? Is it not unfair to the poor?'

There are broad international studies about this. There are many, many different empirical estimates and they have found, especially for less developed countries, that it's not at all hurting the poor the most. It's the middle classes and the high-income classes because those are having the biggest cost. In other countries, it might be a distribution issue but what the conclusion is out of this literature is that you can always design a tax system overall so that you have a fair distribution. So you have income taxes, you have taxes on property, you can design a whole overall tax system if you take the carbon tax isolated, then it might be a distribution issue.

Again, what we want to do in a future climate agreement is to have everyone is included. Now, what does this mean? First of all, those countries, which have a lower living standard at the moment, they want to have what they call the right to development. They don't want to have a problem with

development because of climate policy. If they should do some climate policy themselves, then we should probably help them. Like give them some support – technical support, capital support, financial support – so that they can do this. Because the distribution issue is that big, it has been suggested by several economists that if it's just about distribution then we can probably just give money to the less developed countries and not do climate policy, because some figure that if the climate policy is so costly then why not just redistribute world income and then we are fine.

Actually, I have a paper on this and we found out that that's not a good idea. We should still do some mitigation, but we can complement with financial aid. And the results look like this. So if you compare – this is the log of development consumption, a North-South model – rich and poor countries. This is for the mitigation and this is for development aid. What happens if you start your climate policy here, or you start it here, in both cases of course North will lose because you have to do something. You either have to give development aid to the poor countries or you have to do some mitigation policy. In equilibrium, it is that you have a drop that is a bit smaller. By climate policy, you have growth effects. So actually as a North, you have the ability to gradually catch up with your previous development. While the development, in every period if you have to give a part of your money to the South, you will have no growth effects – so this is the less preferable option.

For the South, we have calculated two variants. On the left hand side, the South, again, this is the development, this is the mitigation, and in the first case if you receive development then you have an increase of income and consumption but you have no growth effects so you will have the same growth rate as before. This is one option. In the other option, it is also clear that the climate mitigation policy is the better one. And in this case, there is ambiguity but with some numerical simulation we can see that the policy mitigation is actually better.

The final and major issue is about the world carbon budget that we have to allocate to different countries. If you believe in the two degrees Celsius target, which has been confirmed several times at the COP, then we have a limited amount of tons of carbon, which we can use up to 2050 or 2100 and we should distribute to different economies and different countries. Now there are several proposals on how to do this. This has been the Indian proposal – equal division of carbon space. This would say that everyone has the right to pollute and everyone should pollute in the same way – very simple. Another is the American proposal that says we should implement a common price and every country is allowed to use the tax revenue in its own country. So this is very close to what we call “grandfathering.” You do a

climate policy, but the budget, allocation, permits, and use of carbon space is in your own country. So these are kind of extreme proposals and I have proposed something that is a compromise. I have taken four major equity principles, which I will explain in a minute and if I base it on these four equity principles that are generally agreed upon, then I will come up with something that is in between the two.

And also, we have to look at several site conditions. For example, when do we start? What has been the past? Do we ignore the past? This is what the Americans would like to do. The Indians would like to back to 1850, which I do not think is sensible or feasible, especially not for India because the British would have to pay which does not make sense. So I think that 1990 would be a good start of responsibility – that we have to think about foreign trade – should producers or suppliers have to pay? And we have to think about future population growth. So these cycle additions have to be taken into account. In general, we have to find consensus about these things in a very short time period. So in Paris at the end of this year should be the final agreement on this burden sharing. I don't know if you know the story of the Little Prince, so this is a recent adaptation. This is when we run out of time, so there's a distortion of time, so the clock master is responsible of the time and the planet has disappeared – we just don't have the time.

So maybe to find consensus about these difficult things might take time that we do not have. But if we don't have the pressure about time restriction then it may be delayed forever. We have done this now – I think in Paris this is the 21st time so why should we do this forever? We should stop these meetings. We should have a solution. And the procedure now is the so-called Pledge Review. So there was a lesson from Copenhagen – if people go to the climate summits and they get excited about a solution so they sign a treaty, but then they go back home and the whole parliament and the whole government say “no, we are not going to ratify this.” So then you say – okay, every country should contribute what they are able to contribute. And then they bring in the pledges. These are now all collected in Geneva. These are now at the UNFCCC. You can see it on the webpage where the pledges are.

And now should be the review phase, but the problem with the current procedure is, as I see it, is that there is no real review – no one is doing this. So we thought that we could provide something to show how the review could be done. And this is why we developed the Climate Calculator. You can find it on this web address/URL. We try to calculate the equitable contribution of the different countries. Now of course we have several options here – you can choose what you think is the right measure to do. You can choose at this Climate Calculator how stringent you want to have the climate policy target because

there is uncertainty. You can be very uncertain that you will reach this two degree Celsius target – so you might be a bit less strict or even be very loose and you can choose basically the level of carbon budget. You can choose the number of countries, which should be included, and then you can say how important are the major equity principles – for example, capacity – if they can contribute more. Then the cost sharing – some say the countries that have the higher cost policy should do less. Or contribution to overall technology, if you contribute a lot to technology development, you should do less. Or, also, what I found interesting is technology development, and that's the problem with the Indian proposal, not every ton of CO₂ is the same if you have emitted it early then you did not have many options in technology and just had to use oil or coal. Today, you have many renewables, you have many options, and so later emissions should be counted less than earlier emissions. And then of course, how much you want to count for the tax. The calculator provides for every country if you want to play around. I invite you to do this and give me feedback if you like it and what you take out of this. Then you can see what different countries should do and you can compare what different countries pledge. What you will find out at the moment is of course that the pledges are by far not sufficient. They will never meet the two degrees Celsius target based on the pledges at the moment.

So it's really about the review and it's about the guidelines. It's about the general principle of how you want to do climate policy, how you want to do it equitably to make sure that every country has a fair share and not that every country is doing whatever it wants. Everyone thinks they know what is fair for their contribution, but some people say that they pay very little because of many, many different circumstances, so it cannot work. You have to have general metrics and a general approach to this. So this is how it looks like. Actually, we have an increase in the design, it is now much better so you can choose here the different things and then you will get the results for every country.

In general, and I think at this institution it's clear, that institutions are key. We should concentrate on the right policy issues; people tend to mix it up now. This year we should hopefully get this right.

Let me talk quickly about institutions. There is a book by James Robinson that says nations fail because of bad institutions. And now, what about the world? We only have one world. If we fail, then we are not successful. But what struck me when I read this book was that what they call successful countries comes to the inclusive institutions. There are those countries that use their natural capital, the atmosphere and the natural resources very intensively. So they have been inclusive on a country level, but very extracting on a world level. And the countries, which are less developed, which of course do very poorly in terms of

economics, they have actually saved the climate and the natural capital because they didn't use it – they had no possibility to use their natural capital. When you look at climate pollution, they are not really harmful.

So I thought that maybe we should have more of these inclusive institutions. We should not only look at physical capital or knowledge capital, we should also look at natural capital. We should also have inclusive institutions that are saving on natural capital – not polluting the atmosphere, not polluting the globe. So this is what I would call super-inclusive institutions. These would be institutions that save all of our capital, all of our investments. So I think we cannot just concentrate on manmade capital, we have to include the natural capital as well. This is also what is important for sustainability discussion.

Let me talk quickly about lifestyle. Some say, why as an economist do you talk about lifestyle? I think that this is crucial. We all have our own daily life and some people are just reluctant to change this and they think that it has an effect. So this is a nice quote from a French policymaker who said, "Everybody talks of progress but nobody gets out of their routine." So that doesn't work, and very often you have inconsistent messages. In Europe, everyone thinks everything's wrong with the Euro and everything wrong with Greece and everything wrong with the refugees, but no one has a solution that is good. So they want to change everything, but how? And everything else should change, but that doesn't work.

And another thing with climate policy is that people now, they really insist on national sovereignty, on national circumstances. I think this is not how it works, it is not helpful, because every country can bring up some points as to why there are special – they have high costs, or the American congress doesn't work as it should, and whatever voters do not agree. And some say national sovereignty is even like an equity principle and I think this is not true. I mean, if you look at equity on a global level, then everybody should have the same rights and these natural things are not very important. Otherwise, we will not be able to form a global climate policy. But even more on a personal level, if you look at your personal life, I mean, what we know in economics are these things – we have habit persistence, imitation, status seeking – these things are there. And there's actually now an interesting discussion in Europe that we should ignore this and we should reduce envy and jealousy, of course, but this is part of human life.

So what would be needed, I think development similar to our smart phones. If you think about our smart phones, they have developed so fast. It has complemented our life. It's given us a sped up moment and changed the direction of development. The use of carbon should have something similar. If it's just

linear, then you will have a really hard time to redirect your long-term development. If it is somehow helping your development by creating technologies, which is attractive to people then it can be much easier. And of course if you imitate people, if your peers change your lifestyle then you will do it as well, so our peers have become increasingly international, like movie stars, we look at everybody worldwide. It hasn't always been this way, when I was young I was just looking at my own neighborhood, so that has changed a lot. So these things can add up to very good development or they can also make us stop if our peers don't change then we also won't change. This may be a bit far-fetched, but in the end, when we look at cost of climate policy, when you change your lifestyle according to what we have now, we can also think about deeper values in life, then the costs are maybe also reduced.

Many people are still concerned about population growth. And they still, it's not the economists, but basically, biologists still have concerns about things like population growth. We have to acknowledge that this Malthusian trap has disappeared. Now that productivity has picked up, this has disappeared. So I think rather now, we are dealing with demographic transition. People have less and less children, they invest more in education, which is good. On the other hand, we get older and older. So I've just come back from Japan and it is very visible – the problem now is not that we have too many people, the problem is that we have many, many old people, and I think that we should change our attitude there. So this is why I call my new book, "Greening Economy, Graying Society". I think we have a lot of changes in terms of greening, but we have to deal with this graying, with this getting older rapidly. And it used to be, I mean, we have the retirement age in our country at 65 and people died around 71, so 6 years of retirement. But now people live to 92 or 95, so you sit around for 30 years even though most people are still active and it doesn't really make sense so we have to change that.

We have all see the population dynamics, so we can all transition to a good equilibrium, but we can also have a transition to a bad equilibrium, we just have to guide it the right way in terms of institutions.

Here is the reference to my book. It is not commercial because the book is free. You can download it and read. It has no equations because I tried to write for the general public. You just have to check that this all is still correct because we changed our webpage just recently but actually, you will find it at this one.

So my conclusions are the following. We need efficient solutions and we need equitable solutions for climate policy. And to make sure that these efficient solutions are also implemented at the climate negotiations, we need to stress that we have growth dividends of climate policy and we have the

dynamic effects and we need to communicate that then properly include it in the climate policy. We want to make sure that all of the benefits that we want to do with climate policy are included. Actually, I didn't talk about regional pollution and I didn't talk about health effects. I mean, being in Beijing, if I am allowed to say so, I had a little bit of problem yesterday with breathing. So you have additional site benefits of climate policy, which of course you have less to pay to the old countries. But when importing oil - we are a small country and each year we pay \$10 billion for the oil bill and this is a lot of money.

We have to stress this – the burden sharing. We have to come up with solutions, which everybody thinks can be considered fair. If every country brings up it's own pledge and one country says, "I'm going to peak in 2030" and another country says "I'm going to increase my efficiency by 45%" then the third country says "I'm going to decrease my CO2 per capita." This is not comparable. You don't know exactly what is the effort of each country. You have to make it comparable. Then we have to make sure, because we are uncertain, that we should do more and not less. Also, this is a political message. In the end of course, we have to focus this year on climate, but we have many other problems, like we have terrorism, we have refugees, we are well aware of that. Actually, we could have more immigration if we have more climate damage so we really have to get the issues right. And if you are pessimistic, as many people are, I mean, what gives a little bit of hope for optimism is that we have something that could develop momentum. If people get attracted by green technologies, then this will really work well. This will give momentum then we will have a speed, which will help. And also, I mean, because all of our development is driven by the past, by initial allocation of capital and economic structure. This is not a famous model – history vs. expectations. The more you have expectations for a green future, the more better development expectations. And with this, I wanted to thank you. And if you ever thought about going to Europe, in 2016 we have a fascinating conference for EAERE in June. Thank you very much for your attention.