

THE BROOKINGS INSTITUTION

WEBINAR

REGULATORY RESPONSES TO CLIMATE CHANGE:
RECENT RESEARCH INSIGHTS

Washington, D.C.

Tuesday, October 19, 2021

PARTICIPANTS:

SANJAY PATNAIK

Fellow and Director, Center on Regulation and Markets
Bernard L. Schwartz Chair, Economic Policy Development
The Brookings Institution

SIMONE BORGHESI

Director, Florence School of Regulation Climate, European University Institute
University of Siena

MEREDITH FOWLIE

Professor
University of California, Berkeley

JOHANNES STROEBEL

David S. Loeb Professor of Finance
Stern School of Business
New York University

* * * * *

P R O C E E D I N G S

MR. PATNAIK: Hello. And welcome to this event of the Center on Regulation and Markets at the Brookings Institution. My name is Sanjay Patnaik and I'm the Director of the Center.

It is my real pleasure today to welcome three distinguished speakers from academia who will share their most recent research insights on regulatory responses to climate change. We will have about an hour of presentations and then Q&A with a lot of very engaging audience questions, I hope.

First, I would like to introduce our first speaker, Professor Johannes StroebeI who is the David Loeb Professor of Finance and a fellow at NYU Stern School of Business. Professor StroebeI conducts research in climate finance, household finance, social network analysis, macroeconomics, and real estate economics. He has won numerous awards and he is also a member of the Climate Related Market Risk Subcommittee at the CFTC. He got his Ph.D. in economics at Stanford where he also had to grab the Cohagan (phonetic) Fellowship at the Stanford Institution for economic policy research. Welcome, Johannes and thank you so much for being here today.

MR. STROEBEL: Thank you so much for having me and for putting together this great event. So, I'm going to be spending a bit of time talking about the interactions of climate change and financial markets, you know, in a new research field that, you know, we've termed climate finance.

And the motivation for this research field is that in the past few years, the surge of interest in better understanding the interaction of climate change and financial markets. And what I want to do in today's presentation is just to take stock a little bit about what we've learned from the research efforts, what we still need to know. So, what are a lot of the open questions we have? And how the insights that we have produced so far effect financial market regulation both sort of what we've seen already and prospectively what types of regulations we think we see coming down the road.

For those listeners who are interested in sort of a more detailed treatment of some of the topics that I'll only be able to talk to you about briefly, we've recently written a review article in the annual review of Financial Economics where we summarize some of these insights in more detail.

So, the starting point for this research agenda has really been to try and study the extent to which climate risk is already priced in asset markets today. And most people that think about this question start from thinking about classifying assets in terms of their exposures to different types of risk.

So, when you think about the ways in which climate change can affect asset values, there's at least two types of categories of risks you want to think about.

One of them is physical risks. These are the physical manifestations of climate change that can affect asset values. Think about rising sea levels or wildfires, et cetera that have the ability to affect the evaluation of real estate assets and others.

And the second category is a whole range of transition risks. So, these are, you know, risks to asset evaluations that come alongside the transition to a low carb or net zero economy. These could come from regulatory interventions such as potential carbon tax or the like, but they can also come through technological developments, et cetera.

Once you classify assets into these, you know, in terms of their exposure to these different risks, you start realizing that depending on the asset that you look at the most important risk source varies. So, when you, for example, look at real estate assets like I've done in a paper with Stefano Giglio, Krishna Rao, Matteo Maggiori and Anglos Viva (phonetic). You realize that physical risk exposure through things like rising sea levels or wildfires are probably the most important risk category that you would expect to be priced in real estate asset and also real estate related assets. Things like rates or mortgaged back securities or other assets where the payoff depend on an underlying real estate evaluation.

When you think about equity markets, you can probably find that the largest sets of exposures are to transitional regulatory risks through the carbon intensity effects. For example, you might think that, you know, the oil companies are substantially exposed to transition risks in case we're going to get a carbon pricing system somewhere that would, you know, harm the relative competitiveness of those firms relative to other energy producers.

In the municipal bond market, this is, you know, a market way over a trillion dollars in the U.S. You have both physical and transition risks because of the location of the tax base, right? So, if you're municipality borrowing and you're in an area that's going to be exposed to rising sea levels that's a physical risk to the muni bond market but also if you have an economy that's very hydrocarbon dependent, you might see transitions and you're going to get the same thinking about sovereign debts.

Physical risk, some countries like Bangladesh and in Fiji, et cetera, that, you know, have

a substantial part of the country line below the sea level are exposed to physical climate risks. Other countries with very, you know, oil dependent economies like the UAE and Iraq, you know, those sovereign debts will be exposed to transition risks.

So, you can see that, you know, across essentially all assets of classes out there, a combination of these physical and transition risks mean that asset evaluations will end up being exposed to climate risks.

The next problem is to actually measure these exposures systematically. Now, with something like physical risks, it's a relatively more straightforward effort. What you need, and I say relatively more straightforward. What you need is you need a combination of being able to geolocate the asset, which is a quite easy for real estate assets because they're tied to a specific location. So, you kind of have a sense about where in space those assets located.

So, equity, it's a little harder, but you can get data on the location of production facilities, et cetera. And you're going to combine that with models of the physical effects of climate change. So, to give you one example in a recent paper where studying the pricing of physical climate risks in real estate market, you're kind of combining, you know, the transaction prices for, you know, different properties. Some of which, you know, in Miami, some of which, you know, end up lying in flood zones, other ones do not.

And you're going to get these sorts of models of physical climate risk from providers like NOAA and others out there that will tell you, for example, you know, which properties are likely to be flooded if sea levels rise by six feet or more or something.

So, measuring exposure for physical risks is relatively straightforward from that perspective. Measuring exposure to transition risks, I think is somewhat harder and because it depends a combination of a variety of things including understanding the business model of terms not just today but also by how firms, you know, are planning on adjusting their business models down the road.

Think about two other companies. One of which is doubling down on oil drilling while one of them is, you know, promising to transition to become, you know, a much sort of renewable focused company. Both of them might have some similar carbon emissions today, but their exposure to transition risks is going to be very different.

How can you try and measure even, you know, exposures today? Well, some firms disclose information about their carbon intensities. There's also publicly available information of things like ESG scores and researchers have tried to, you know, become fancy and tried to do texture analysis of 10K statements while listening into earnings calls, et cetera, to try and come up with a measure of which firms are, you know, have business models that are substantially affected by these transition rates.

But fundamentally, measuring transition risks has enormous data challenges. And here, we come to the first part where I think what we've learned in this research field, I think has the ability to influence where regulation is going to go into the future. Because any asset manager you talk to basically spends, you know, a lot of time complaining about the fact that they can't measure these risks well. Why? Because the underlying portfolio companies, the underlying companies that they would like to invest in aren't yet making the disclosures in a systematic and comparable way that would allow, you know, a Black Rock or a Vanguard, whoever it would be, to decide which firms are more exposed and which firms are less exposed.

And so, we're going to see, you know, regulatory action by the SEC in this space requiring firms to make disclosures in this direction. And we're going to, I think see this relatively imminently. So, here's from a speech by, you know, FCC Gary Gensler, in July where he promised.

He said, I've asked FCC staff to develop a mandatory climate risk disclosure rule for proposal by the end of the year. So, I think we're going to see that over the next weeks. We're actually going to see that sort of proposal to come out. What might such disclosures look like? There's going to be an important focus on consistency and comparability, which is going to replace that mismatch of ESG provider scores, et cetera, that we have today.

So, I think, you know, financial markets are asking for this type of disclosure such that they can start managing climate risks in their portfolio. And I think we're going to see regulation that helps with that. The EU is a little bit ahead of the U.S. in this case. And so, the EU has introduced taxonomy, which is a classification system that goes through a whole range of economic activities, classifying them into being environmentally sustainable or not.

And it is now building, you know, a reporting requirement on top of this taxonomy which, you know, would allow companies, investors, and policymakers in their own words with the appropriate

definition of what you can even consider to be environmentally sustainable or not. So, it's very much a top-down approach of really going through sort of relatively, you know, sort of carefully specified economic activities and deciding, you know, what's sustainable and what's not.

That's obviously also potentially problematic and we're seeing a huge fight right now about whether or not nuclear power should be declared a sustainable business activity or not. That obviously has, you know, large implications for countries like France where nuclear power is big. Or countries like Austria are opposing the inclusion of nuclear power as a sustainable business model. I'm sorry, as an environmentally sustainable economic activity.

But, you know, it's an alternative approach to what I think we will see coming out of the SEC which is going to be focusing largely just on carbon emissions or something like that. But again, what that final proposed rule will look like, I think is yet to be seen.

Okay. So then when you can measure these exposures, there's sort of two approaches you can take to try and assess whether or not these exposures are priced. And one of them is what you would want to do if you would want to compare the expected returns on what the price is of two different assets that are almost identical. Except that one of the assets is more exposed to either physical or transition risks while the other asset is less close.

Now, that type of comparison is obviously very hard because energy firms don't just differ from other companies because of their carbon emissions, but they also differ on a whole range of other issues. Similarly, real estate properties that are more exposed to sea level rise also differing on other dimensions. For example, they are more likely to have a nice beach access.

And so, this type of just simple comparison between the prices of more or less exposed asset haven't really led anywhere in the future. So, what the focus has been of research efforts has been to assess the returns of more or less exposed asset when there's news about climate change or when there's an increase in attention to these type of climate risks.

So, in a paper with coauthors, we've, you know, tried to do this in real estate markets. And we've tried to measure time bearing attention to climate risk and housing market from the textual description of property listings. You know, in some years property listings talk a lot about, you know, this property is not in a flood zone. It's high and dry, et cetera. In other years, they do not.

And what we find is that the gap between more or less exposed properties goes up in periods when people pay more attention about climate risk. We find similar results in the equity markets when there's news about climate change that pushes the price movement of more or less exposed firms in opposite directions again showing that climate risk is already priced in equity.

Now, are these risks adequately priced? There's one thing to show that they're priced in a nonzero way, but there's some pricing, but are they adequately priced? Are they fully reflecting the true risks out there? And that's really the research frontier. Honestly? No one really knows.

Now, what I've done with some coauthors this summer is we surveyed a large number of academic economists, regulators, and financial market participants. And we just asked them for their perception.

We asked them in the stock markets most familiar to you, how do prices currently reflect climate related risks? About 15 percent did not have an opinion. Twenty percent said that prices currently accurately reflect climate risks. Only three percent of people said that they over reflect climate risk. Sixty percent of respondents felt that even today in the stock markets that they're familiar with, climate risk wasn't fully reflected in fact.

Now, that doesn't mean that they're correct, but it gives us a sense of, you know, market participants were thinking about this every day. What are they expecting prices to do in the future? Because one important aspect if prices don't currently reflect climate risk, they might have to adjust in the future to reflect these more accurately.

But I think this is really -- and as I mentioned where we need a lot more research. And I think someone, you know, anyone who claims right now to know if prices accurately or not accurately reflect climate risks, you know, is probably overstating their case.

So then when we understand that we have these climate risks and how do we manage or how do we hedge these risks? And I want to think about this question from two different perspectives. The first perspective is that of an individual asset manager. Take a Black Rock or an AQR or even just a retail investor who's looking at their portfolio who realizes that climate risk is investment risk and who's thinking about what to do with their portfolios, you know, to manage this risk.

The second question and it's obviously important from a regulatory perspective is that of

a prudential regulator. Someone like the fed who has to ask the question whether climate risk doesn't just present, you know, a risk for some firms to lose some money. But whether or not it might even present a risk for financial stability.

Now, how would a mutual fund's manager or an asset manager, how would they go about hedging climate risk? It's actually not obvious. It's quite difficult. And why? Because we really don't have a whole range of good insurance or derivative contracts at the moment. There's a whole range of reasons why these markets don't yet exist. And I'm happy to discuss those in the Q&A if you're interested.

But I think one important thing to just point out is that my personal view is that the derivative markets will play a very important role in the transfer of climate risks from, you know, people that are worried about these risks to people that are more easily able to bear those risks and the CFDC and the Chairman Behnam is taking a whole range of steps in this direction.

You know, in March, you know, he put together a group focusing on the derivatives market role in addressing climate related risks. And the idea of this group as highlighted here is to accelerate early CFDC engagement in support of industry and market driven processes in the climate and larger EHD states.

So as always innovation is not going to come from the government. It's not going to come from the regulator. It's going to come from the private market. There's a lot of demand for these types of, you know, financial instrument that might allow the transfer and sharing of climate risk, but it's great to see that regulators, you know, are aware that they need to play a big role. They need to create the regulatory environment that allows this type of financial innovation to happen because, you know, there's certainly a lot of need for it.

So then in the absence of, you know, large specialized, you know, assets that allow us to hedge and transfer climate risk there's a research agenda that, you know, I've worked on with a number of coauthors to try and see what we can do in terms of thinking about, you know, portfolios that might allow you to hedge these risks using publicly traded assets. So rather than sort of specialize the derivatives contracts. Trying to say, what can we do by just looking at, say, the universal investable stocks in the U.S.?

And so, we have a first paper where we said, look, if you want to construct a long-run hedge against climate risk. This can be replaced by dynamically hedging the news about climate change. So, if you can construct a portfolio that does well every time you get bad news about climate change then sort of cumulatively this portfolio will do very well if climate change gets very bad and will therefore have this hedge portfolio.

Now, you know, how do you go about measuring news about climate change? We have a bunch of approaches using textural or sentiment analysis, newspaper coverage, et cetera. So, without going into the details, but puristically you can think about every time the Wall Street journal presents to its readers some bad news about climate change, you're looking for a portfolio that does relatively well in those periods.

Now, how do you put together a portfolio like that? Well, there's a bunch of approaches you can take. One of them is what we call a narrative approach. So, you basically take an X onto view on which businesses will do well and which businesses will do badly when, you know, we get news about the increased likelihood of, say, some of these transition lists. And here, we're back in the other -- you know, in the problem we had before.

You can try and do this on E scores. So, you can go along the green firms, and you go short the brown firms, right? And so, you would think about green firms should do well when we get bad news about the climate change because it makes, you know, regulation more likely and that regulation should help with these firms. But we're left with the low quality of these exposure measures, which hopefully will be solved by some of these disclosure requirements, but so far this is not working very well.

The alternative is to use what finance economists call a mimicking portfolio approach, which is to regress news on asset returns in the past. So, I'm basically trying to see, well, I can look at this climate news series that I want to hedge in the past. And I can try and see which stocks did well in the past when we saw news. And then I'm going to assume that those stocks will continue to do well going forward.

The problem with this approach is that we only have very short time series. So, you know, this type of approach suffers from an over 15 problems where we have many, many more stocks than we have time periods in the past where we think climate risk was priced and so this approach

doesn't work.

So, one new approach that I've been working on with some coauthors is called a quantity-based approach. And the quantity-based approach starts from the inside that comes from the science literature that this is not something that, you know, financial economists have worked on.

That realizes that local extreme heat events shift local attention and local climate change beliefs. So, you know, if Seattle has just lived through an extreme heat wave, there's strong evidence that people living in Seattle are now worrying more about climate change and they believe more in climate change.

And so, what we ask is trying to figure out what industries or what stocks do mutual fund managers disproportionately buy and sell after experiencing one of these local extreme heat shocks? And then we'll try and see if we can form long/short portfolios on these industries.

And what we find is that if we do that those quantity-based hedge portfolios substantially outperform other approaches to people that have used the narrative approach or, say, the mimicking portfolio approach that I've just talked about to try and figure out how to hedge these climate risks.

Lastly, we want to ask -- no, not just from an individual investor perspective, but now put yourself in the perspective of a banking supervisor, right? Who's trying to not figure out, well, can some investor lose some money when climate change materializes? Which is an important question for the investment community but doesn't itself have to be a systemic financial problem.

In order to answer that question, does climate risk affect bank health, and financial stability? You need to answer a bunch of questions. Who holds physical and transitional climate risks eventually? How do bank loan portfolios change in value alongside reasonable parts of climate change? And so, we have a bunch of approaches here, you know, that we call stress testing or scenario analysis.

What we're trying to figure out, you know, how do bank portfolios develop under some assumptions about, you know, the part of climate change? That is obviously an important question here about which types of scenarios would you consider? But I think we're going to see more of this type of behavior going forward in Europe. This is already happening.

So viz a viz being, for example, telling banks to map climate risk into their trading and loan books, you know, in a sort of stress testing style scenario. And we're going to, you know, we had an

economy wide stress test that ECD conducted this year. That from next year onward, we're going to see climate stress test of bank portfolios going forward in the EU.

And in the U.S., we're going to -- I think this is going to move slower. So, you know, we're still in the space where, you know, the tech government anticipates new guidance from climate change for big banks. I think we'll see some activity here, but I think it will take a while before, you know, the types of stress testing that we're doing in Europe is going to play a role in the U.S. also.

In particular because I think in Europe very quickly these types of, you know, learnings from these climate stress tests will start effecting capital requirements for banks, et cetera. I think that's something that we're probably, you know, away a way in the U.S. and may never get there.

So overall, I think climate finance, this studying of, you know, the interactions of climate change in financial markets is a really exciting field with lots of open and interesting questions. We have a lot of regulatory bodies, economic regulatory bodies. We talked about the SEC today. We talked about the CFDC today. We talked about the various banking supervisors all thinking about this. All trying to make sense of this.

I think we've made some progress. We now understand that climate risk effects asset values. We've made some progress in terms of how to mitigate, how to share this type of risk. And I think we need to make a lot more progress on the disclosure side, so we have better data and then eventually we need to make a lot more progress trying to understand not just if this is an investment risk, but if this is a large enough investment risk that it also presents a financial stability risk. And I'm going to end right here. Thank you very much for listening.

MR. PATNAIK: Wonderful. Thank you so much, Johannes. It's very interesting and I think climate risk is really one of the biggest issues that we're facing today. And a lot of companies and governments ought to think about it.

Great. So, our second speaker is Professor Meredith Fowlie who is a professor in the Department of Agriculture and Research Economics and host a class of 1935 endowed energy at UC Berkeley. She is a faculty director at the Energy Institute at Haas, and she also has a research associate at the National Bureau of Economic Research which she called on Environmental Energy Economics program.

Professor Fowlie has worked extensively on the economics of energy markets and the environment. And her research investigates market-based environmental regulations, the economics of air pollution, electricity market regulation and income greenhouse gas regulations. She also currently serves as a governor appointed member of California's independent emissions market advisory committee and she will talk today about the electricity sector regulation and how we can facilitate the clean energy transition. Thank you so much for being here today. I give it over to you, Meredith. Welcome.

MS. FOWLIE: Thank you. And thanks for the invitation. It's a real honor to be here especially with Johannes and Simone. Johannes is a difficult act to follow, but I'll try.

So how I'm going to use my 20 minutes? When you think about the regulatory response to the challenges posed by climate change, I think the first types of regulations that come to mind are some of the regulations that Simone is going to talk about, carbon pricing and direct emissions regulation. I think increasingly we're thinking about financial market regulations. Some of the interventions that Johannes was talking about.

But what might not be top of mind is good old fashion, natural monopoly regulation. We don't usually think about this as like a key lever we have, but I'm going to try and change that thinking because I think it's got an underappreciated role. And to sort of elucidate that point, I'm going to be drawing from California where I live.

But I think it's an important state to think about. It's on the front lines of connotation/adaptation with its rising sea levels and wildfire. And it's also been on the bleeding edge of climate change mitigation with some higher levels of policy ambition than we're seeing in other states and even in parts of Europe and the rest of the globe.

So, I think I'm going to start with what I think is a noncontroversial observation, but I'd be curious in the Q&A if people disagree. From my perspective, I think the most promising path to deep decarbonization runs through the power sector. So, the game plan is green the grid. Invest in more clean renewable wind, solar and electrify a lot of things from transportation to buildings to some industrial applications.

So, if we think about taking that path, it's going to require massive capital investment in

new electricity generating technology, supporting infrastructure, grid modernization, charging stations. And it's also going to involve shifting consumers away from natural gas and gasoline towards electricity.

So, I think the point I want to make today is how we finance this transition is going to determine how much it costs and who pays the price? So, it's really exciting when we think about climate action to think about reinventing how we produce electricity and consume it and move it. And solar panels and wind turbines and grid modernization and battery storage. Not quite as exciting to think about how we pay for this and in particular how we regulate it.

I think it is really important to think about innovation in this space. So, my point, if you take anything away from my 20 minutes today is that energy rate reform and how we regulate natural monopolies like electricity and natural gas is really going to be key to an equitable and efficient clean energy transition.

I'm going to talk in particular about research we're doing that focuses on electricity, but we've got related projects on natural gas and even wildfire insurance. Really thinking about how we regulate these natural monopolies and how those regulatory incentives impact how we're responding to the climate challenge.

So, what I wanted to do today is start with two very quick slides reminding you of ECON 101 as it pertains to natural monopoly regulations. So, for people who took undergraduate economics hopefully this is a fond memory. If not, I'll just go over the basics because I think it's important to motivate sort of the fundamental economics of these regulatory questions and challenges before we go to the real world and see how we're actually pricing energy.

So, I'm going to focus on California and think about both, you know, how the current regulatory regime departs from how an economist would prescribe and thinking about more of the reinvention and innovation that we could see in energy price regulation.

So, my point of departure, energy utilities so electricity, natural gas are textbook natural monopolies. So, they have high fixed capital costs, large economies at scale relative to demand. It doesn't make sense to have many companies running distribution lines down your block. We want to leverage economies of scale and have single or a few number of firms supplying the market. But of course, if we're going to create a monopoly, we're also going to need to regulate it to make sure that

prices are fair and efficient.

So, this is a graph showing U.S. utility capital expenditures, electricity and natural gas in recent years and you can see they're growing. And they're expected to continue to grow. So, in this country, in the U.S., and in other countries across the world, you have the public utility regulators who are setting the retail rates to allow these utilities to cover their costs and are in an authorized rate of return on their underappreciated assets.

So, under a linear pricing model or the simplest possible way we could regulate these utilities, you charge a single price per kilowatt hour or per unit of natural gas which is set above margin cost to recover those fixed percent costs. Alternatively, you could have a two-part tariff, right? So, you could set a price closer to marginal costs and recovery additional costs through fixed costs, institute fixed charges.

So, if an economist called the shots, and we don't at the PDC. We would set electricity rates at social margin cost, right? So, when I run my dishwasher, I use about a kilowatt hour of electricity. So, what does that cost society?

It costs us -- we've got to use the fuel to generate the electricity. There's emissions associated with the generation of that electricity. If I'm running my dishwasher on peak, which I shouldn't be, maybe there was a marginal increase in capital cost for a distribution system infrastructure generation capacity to support that demand.

So, we want the consumer to see that social marginal cost so they can make efficient tradeoffs. Under a linear pricing or recovering -- charging a single price to recover all costs, we're going to see that that price is well above social marginal costs in many parts of the country.

So, what a part of the agenda that I'm pursuing and other of my colleagues in energy and environmental economics is to ask the question, how do the electricity prices we see compare to this economist prescription of setting price equal to social margin cost? This is a map that I'm taking from a paper that was recently written by two of my colleagues, Sevren Bornstein and Jim Bushnell. And what it is showing you is this comparison.

How do the average retail price that American consumers pay for their electricity compare to our best estimate of the social marginal cost? What it cost society to incrementally increase

electricity consumption and production? And you'll see there are red parts of the country. Those are parts of the country where the prices consumers face are too low relative to social marginal cost. Red in those parts of the country particularly because in those parts of the country the grid tends to be less or more carbon intensive. So a kilowatt of electricity generates more carbon per unit.

I want you to focus on the deep blue part and in particular the state where I live, California. In California, residents, retail consumers are paying prices that are well above the social marginal cost. So, we're going to dig into that and sort of think about the implications for the carbon transition both as it pertains to efficiency and equity.

So, what I'm showing you here is retail electricity prices per dollar per kilowatt hour paid by retail consumers. And each bar is showing you the range of retail prices across utilities in the U.S. And what I've called out in red, green, and yellow are the prices paid by California consumers. And you can see that California prices are consistently above the national average and increasingly out of line with the rest of the country.

And this is creating real tensions in California. Again, I'm focusing on California, but I think California is several steps ahead of other states in terms of its climate policies and related activities. So, I think there's things to learn from the California case. And in the California case there is a tension between pursuing our ambitious agenda as it pertains to that climate change and that adaptation and mitigation and our moral obligation to keep energy affordable particularly for low-income households.

So, the work that we're doing which is in progress. We've released a policy paper and there will be a more detailed paper out in a couple of months. First, asks the questions why are our rates so high? And the punchline is going to be that costs that are not going forward at an incremental cost are being recovered in a per kilowatt rate. Who's paying these prices? Increasingly, it's households that can least afford it. And can we think of alternative rate structures that would improve outcomes both on efficiency and equity grounds? And I think the answer is yes. And I'm going to proposal an alternative and invite people to get back to us with their thoughts.

But I want to first start by saying we're not with this research agenda weighing in on whether these costs are appropriate. I think it's important to keep in mind, California is a big state. Our high cost may well be justified in a state that's on the front lines of climate change. The utilities are going

to spend over \$10 billion in 2021, 2022 in terms of basic – wildfire adaption. Making sure that the grid is more resilient in increasing wildfire risks.

So, these costs may well be necessary and legitimate costs as we try and make progress with respect to our climate change adaption and mitigation goals. What I want to focus on is how we're raising the revenues to cover these costs.

So, the first step, we're going to -- we've taken our work. And I don't want to dive into the details in this 20-minute presentation, but I think it's interesting to see our best estimate of the social marginal cost of consuming a kilowatt hour of electricity in California. And the number you might want to focus on, this is from utility, but we looked at across California.

These marginal costs are coming down because we're greening the grid. The grid is getting cleaner. And our best estimate is in 2019, the average across hours of the year. Social marginal costs of consuming electricity were about eight cents per kilowatt hour. So, hold that in your mind. What are we actually paying? So, what we're showing is over time that red line is our best estimate of the social marginal cost, the efficient price that would signal to consumers what it actually cost society to incrementally increase electricity consumption.

Households like mine were paying upwards of 25 cents. Like more than three times the efficient price of electricity. The green line is in California, we have a subsidized electricity price for low-income consumers. So about 23 percent of California households are eligible for this low-income subsidy even though subsidized households are still paying twice our best estimate of the efficient social marginal cost.

So, what explains that big gap between retail price and social marginal cost? All sorts of costs that don't scale with usage, but that we're recovering in our per kilowatt hour rates. So, the cost of legacy costs of building power plants, transmission and distribution investment costs, wildfire mitigation costs, public purpose programs.

So, in this short presentation, I won't step through every step of this graph, but this is our graphical summary of why am I paying 25 cents a kilowatt hour when the social marginal cost is eight cents a kilowatt hour? The lower staircase up to the social marginal cost decomposes the social marginal cost into fuel costs, emissions and what have you. The staircase above the eight cents is explaining how

we get to the retail price. And it's sunk legacy investment costs per generation transmission and distribution. That distribution box is capturing some of the wildfire mitigation costs that utilities are having to incur to deal with or to be in the business of supplying electricity across a vast state as wildfire escalates.

And finally, in this short presentation, I'm not going to spend much time on it, but I do want to highlight the brown box which is showing you the effect on consumers' electricity prices of how we subsidize when we've talked solar. So, there's a lively debate in California and across the country about net metering.

When I put solar panels on my roof, I avoid paying 25 cents, the true social cost of what it is only eight cents. So, by incentivizing rooftop solar adoption in this way, we are shifting some of that fixed cost recovery obligation away from households like mine with solar on my roof to households who don't have solar on their roofs. And those tend to be lower income consumers.

So, as you can see real tensions in California brewing and potentially in other states as we try and sort of reckon with how we're paying for the cost of electricity supply, generation, and transportation. So, the key takeaway that I hope to leave you with is the way we regulate electric utilities and the way we allow utilities to raise revenues to cover the cost they are incurring. Effectively taxes electricity consumption to pay for grid modernization, rooftop solar subsidies, climate change adaptation.

This has an efficiency implication, right? If we think electrification is a lynchpin of our climate mitigation and deep decarbonization strategy, we're putting a barrier in that path by burdening electricity prices with costs that are not going forward incremental expenses as applying electricity.

And there's also an equity element that I think we should have top of mind particularly given the concern with making sure that the energy transition is an equitable one. So, what I'm showing you here is a quick summary of household's response to consumer expenditure survey in 2017, 2018. So, I'm focusing on California households just so we have a -- it's more relevant to the material that I've just been discussing.

And what I'm summarizing is household's response to questions about income and expenditures. And we've summarized it by income quintiles. So, one is the lowest income, five is the highest income category. So, for example, that blue line is showing you what you probably already know

which is income is unequally distributed across California households. So, the average income reported by the second lowest income category is about three times the average income reported by the first.

What I want you to focus on though is the green line and how flat that line is. And that's showing electricity expenditures, right? So, although higher income households do consume or spend more on electricity, they spend a much smaller share of their income on electricity as compared to low-income consumers. And that flat line is flatter than the lines that correspond to other consumption that are subject to the sales tax.

So, the punchline from this picture is that raising revenues for climate change mitigation, adaption, public purpose programs, large investments by taxing electricity is one of the most aggressive ways we can raise these revenues. More aggressive than an income tax, more aggressive than a sales tax.

So, this leads me to the final point and emphasis of our research agenda and research agendas of others in energy and environmental economics is can we rethink how we regulate natural monopolies given the efficiency and equity of implications of how this playing out as investment costs escalate in electricity, in natural gas and related industries?

And so, in our work we've been sort of thinking about this plight of a policymaker. You're regulating a natural monopoly. You need to guarantee or assure that the natural monopolist can recover the cost of doing its business. So as an economist, we want to set the per volume metric price equal to social marginal cost so consumers can see what it actually costs to consume electricity.

For now, we're going to -- today I'm going to focus on a proposal that holds the revenue requirement constant. That is we continue to assume that we need to recover these costs in electricity rates. I want to make a side point which is we see a case to be made for taking some of the cost we recover in electricity rates out of the electricity rate base and pushing it onto the state budget.

So, for example, in California if you are managing vegetation close to the electricity grid, those are costs that are put in electricity rates. If you're managing vegetation that's far from the electricity grid that's on the state budget. That's a state cost of adaption to wildfire risks. So, I think we should be potentially revisiting some of the costs we're putting in the rate base given the equity and efficiency implications of how we're paying for energy.

But for our purposes today and in my last two minutes, I want to focus on a proposal that continues to recover the cost of recovering in rates. But here the aim is to shift some of the cost burden off of lower income households working within administered of legal and political limits that we surely will need to work within in reality. So, let's go back to that natural monopoly regulation 101, where I said, you know, one option is linear pricing, which is effectively what we're doing in California and many other states where we recover all the rates in a per kilowatt hour charge.

Another is a two-part tariff that sets the rate per kilowatt hour at the efficient social marginal cost and recovers the remaining cost in a fixed charge. Going back to my utility in 2019. If we all paid eight cents per kilowatt hour, there would be a significant chunk of cost we'd still need to recover. If we recover those in a fixed charge that was equal across all households, it would be a \$75 per month fixed charge.

But what about if we thought about, well, we can use this rate design feature to try and make cost recovery more equitable. And so, what this picture is showing you is what if fixed charges increased with income in a way that was commensurate with the sales tax, for example? That was the yellow staircase.

So here everyone pays the efficient price. Lowest income households pay no fixed charge. Households like mine pay \$150 per household. So, this is an alternative way to recover rates that is an improvement on efficient grounds. We're sending a more efficient price signal. People see what it actually costs to consumer electricity and improves on equity grounds in terms of shifting more of the cost recovery burden onto households who are in a better position to pay.

So, in summary, lots of parts of the country retail electricity prices are set above marginal costs to raise revenues for needed capital investments and legacy costs. These costs are going to escalate. When you look at, you know, no matter which report you're reading, when we think about what it's going to cost to modernize the grid and invest in more renewable energy and the infrastructure, we need to support it, these costs are going to increase.

The way we currently recover these costs in electricity rates amounts to a regressive tax on energy consumption. This has negative implications for efficiency. It's going to slow -- you know, who wants to electrify with electricity prices this high? And it's going to be harder to get people out of their

gas-powered cars into electric cars swapping their natural gas water heaters for electric water heaters.

And it also has equity implications, which need to be front and center as we craft our climate mitigation plans and goals. So, I think an area of innovation that we don't talk about as much as we probably should is thinking about innovating and how we regulate natural monopoly pricing. Changing the way that these escalating sector costs are recovered could help us ensure that the clean energy transition is efficient and equitable.

And so, as researchers we're involved in academic research in this space, but we're also part of the policy conversation in California where I think the tensions are so palpable that people are realizing that we need right reform of some form and the conversation is trying to how we can rethink regulating not only electricity prices, but also natural gas prices.

Finally, we're also working on property insurance, wildfire insurance. Asking similar questions as wildfire risk escalates. How is regulation helping or hindering firm's abilities to change premiums to reflect changing wildfire risk profiles? So, I'll stop there and look forward to questions and conversation.

MR. PATNAIK: Wonderful. Thank you so much, Meredith. I think you raised a couple of really interesting points because if we want to make a transition to a low carbon future based on electricity, we need to make sure electricity grid, regulation and energy systems can actually take it. So that's a wonderful point.

Great. So, our last speaker is Professor Simone Borghesi who is the Director of the Florence School of Regulation, the Climate Division at the European University Institute. He's the president elect of the European Association of Environmental and Research Economists and the Secretary General of its Policy Operation Committee. He is also a full professor of economics at the University of Siena in Italy.

He has been president of the Italian Association of Environmental and Resource Economists and he got his Ph.D. at the European Research Institution in 2001. He worked at the IMF in Milan and he was a visiting scholar at INRA at the University of Cambridge. The EK of Zurich and he currently also directs the EUI the LIFE DICET Project on deepening international corporation while administrating which is especially important given that the EU has been a pioneer in common pricing and

emission creating specifically and he's going to talk about that today and what lessons we can learn from the EU from that. Welcome, Simone, and thank you so much for being here today.

MR. BORGHESI: Thank you. It's a great pleasure. A great honor to be with you today. As you said and as the title suggests, I would like to convey some of the lessons that can be learned from the European experience in emissions trading system and also of the research in this area.

For this purpose, I will start by providing the past and present of the ETS, which I will describe as a living creature. You will see why I said it. And then we will move onto what I think are the open issues and the next challenges that the ETS will have to face in the future. In particular, I will focus on carbon linkage risk and its possible solutions and will conclude with some lessons.

So just to make sure that we are all on the same page, let me start by very briefly describing the functioning of the ETS. As you all know the ETS is the cornerstone of the EU climate policy. It's a carbon price mechanism. So, it ETS a price on greenhouse gas emissions to cost effectively control and eventually eliminate emissions.

It's a cap-and-trade mechanism the government says. The cap, the quantity, the total number of emission allowances and then market operators trade allowances. And the interplay between supply and demand determines the carbon price.

Born in 2005, the EU ETS was divided into four phases of increasing length. The pilot phase in 2005-'07. Then 2008-'12. '13-'20, and 21-30. That is the current phase we are in which covers the whole decade. And while phases became longer, the stringency also increased over time. The quantity falls by a linear reduction factor that increase over time was minus 174 percent in the period of 2013-'20 and it was increased up to minus 2.2 percent from this year. And actually, there is already a plan to further increase the linear reduction factor in the future.

The system covers now around 40 percent, yes, of the European greenhouse gas emissions more than 10,000 heavy energy using installations, mainly power stations and subplants that are located in 30 countries. But where are these market operators located? And whom do they trade with?

To provide an answer to this question, I want to show you a diagram which comes from a paper that I wrote with a colleague which shows you the EU ETS as a network. Basically, each node in

the network corresponds to a country. Namely, to the set of market operators which open up an account in that national registry of that country.

The size of the node is proportional to the in strength which is a measure of the incoming links. In other words, the number of allowances that are purchased by the operators in that country. And the color is related to the page rank which is a measure of network centrality ranging from blue for low values to red to high values.

So as expected, we can notice that the biggest nodes, the biggest hole in the network also more red. Why? Because these countries are more active in the network and therefore are also more central in the network. However, this is not always the case. If you compare Netherlands and Spain, for instance, you notice that they have similar size but different colors. Netherland being much more central.

Indeed, the centrality does not depend only on how active you are in the market, but also on who do you trade with? So, if you trade with other countries that are very central in the network you become central as well. Indeed, from this visual representation, you can notice that there are five countries that emerge as particularly key in the network. Namely, France, Germany, Great Britain/U.K., Denmark and the Netherlands.

Obviously, these were a representation based on the first phases. But we all know with brexit things changed. And so, the question that I wanted to address is what happens if we take out the U.K. red hole? How would things change with breaks? For this reason, we -- with the same colleague -- we wrote a full out paper I would say, entitled, *With or Without U.K.* in which you look at we look at the structure after brexit. What would be the impact of brexit on the direction of the flows of the transactions?

And we tried to provide different scenarios depending on the possible reallocation of the transactions that involved the U.K. partners. What we find, obviously, it's based on backward analysis because we don't have due to the embargo on the data, the real time data. But what we have based on the past is that we can expect the network to become more homogenous because of the reallocation of the transaction from the U.K. to the other countries. But still characterized by a core periphery structure in which a few large nodes remain, and the others are at the peripheral at the margin of the network.

And this analysis shows that the structure of the EU ETS of the view changes over time

as sort of a living creature. And indeed, the more I studied this topic, the more I see the ETS as a living creature. As a living creature, it comes to life, grows, learns and teaches and sometimes it gets married like in the case of the linking with Switzerland or divorce like in the case of Brexit.

As I said it came to life in 2005 and from the very beginning it was clear that it was one of a kind. The first transboundary cap-and-trade system and there world's largest carbon market at least until the Chinese market will become truly operational. From the very beginning, the system started growing, adding new sectors petrochemical , aluminum, and ammonia, and gases, nitrous oxide and perfluorocarbons under the EU ETS. And as we will see in a second, it keeps growing and adding new sectors.

And as it was growing, it was also learning. And the learning was actually a continuous learning process as witnessed by the number of reforms that EU ETS went through. After the initial 2003 directive, there was a revision. A new directive in 2005. Then in 2014, the backloading and short-term intervention to reduce marketing imbalance. The market stability reserve in 2019, a long-term intervention aimed at stabilizing the market with predefined automatic supply changes. The revision for phase four and currently the 2021 review under the 54 55 measures.

Not only the EU ETS learnt but also has been teaching to the others. It has been a pioneer and often considers the prototype for all its followers. And the followers have been quite many. This image from ICAP shows the extension of the ETS' around the world. In blue, you have the jurisdictions that adopted an ETS. In green those are where the ETS are under development. And the yellow, those were -- it is under consideration.

And as you see, starting from Europe, ETS has extended, spread to Quebec, (inaudible) on the eastern coast of the U.S., California, Mexico but also eastern to Kazakhstan and South Korea, New Zealand and last but not least China where this set of pilot projects and with a nationwide ETS that is growing, has been just born.

Each ETS has its own structure, has its own rules, has its own applications. For this reason, we wanted to see how the systems can be aligned. And this is the object of the project that I'm currently directing at the European University Institute namely the LIFE DICET project where they're letting acronym DICET stands for Deepening International Cooperation on Emission Training.

The project involves the regulators of the main ETS around the world, Europe, California, China, New Zealand, Quebec, and Switzerland with the objective of aligning this ETS' and possible integrate them in a larger maybe in a future global carbon market.

Each ETS has its own story and as a living creature also the EU ETS had its ups and downs, which are here. Well represented by the carbon price intertemporal trend. The diagram shows that trend of carbon price in Europe from the beginning of phase two up to basically today. And as you see, you can easily read the financial crisis, 2007, 2008, which caused a falling price.

Prices remain very low below five Euros per ton of CO₂ for a long time until the end of 2017 when the announcement of the market stability reserve and of a more stringent intervention by the regulator led to a new rising price which continued despite the pandemic crisis, despite the lockdown. And the price is now about 60 Euros per ton of CO₂. I think yesterday was 58 something.

A similar trend can be observed also in the other measure ETS. New Zealand, California and Quebec which join linked their ETS in 2014 so they continue with just one price, one line. And Switzerland will join the ETS at the beginning of 2020 and so, its price is rapidly converging to the European one.

If you will look at these trends, you notice that they are somehow similar but there are still large differences in terms of carbon prices. With the carbon price in Europe being much higher, almost 50 percent higher than in New Zealand and almost three times higher than California and Quebec. And this difference is even larger if you look at the Chinese pilot projects which show large transactions because they are all in their infancy if you want. But with prices that are all around five dollars per ton of CO₂. Only Beijing being above 10.

So large differences. So, what we have is an increasing price in Europe and increasing gap with respect to the other ETS's. This brings me to what, in my view, are the next challenges. Namely, this trend may provoke concerns in terms of competitiveness for European firms and distributional concerns because of the possible regressive effects of the increasing carbon prices.

In my view of the two major challenges that the ETS will have to face in the future together with those that come from its continuous growth. The extension to new sectors. The maritime which is about to enter the current ETS and the buildings and transports that are planning to set their own

ETS in the next few years. Hopefully, and possibly converging with the EU ETS in the future.

Now, due to time constraints, I want to focus on one of these aspects. I will focus only on the first one, on the competitiveness issue and of the possible risk of carbon leakage. We all know that unilateral policies like the EU may provoke carbon leakage. Namely, the delocalization of the political activities. To be honest, so far, the literature shows very little or no evidence of carbon leakage. No evidence in the Dechezlepretre study and very weak evidence for instance in a study on German firms by Koch and Basse Mama or in other studies that I conducted with Karen Frank, Gavoni Marine (phonetic) on the China firms.

But this is true, or these studies were based, including mine, on a previous period when carbon prices were low as we saw. What will happen if carbon prices keep rising as we can expect if we want to achieve climate neutrality by 2050 or by 2060 in the case of China?

So, this rise, the issue of how to safeguard international competitiveness? And in my view, there are three possibly ways. The most commonly adopted way is free allowance allocation. This has been adopted in mainly all ETS's with free allowance to installations of sectors at risk of carbon leakage. However, here the problem is how to define the sectors at risk of carbon leakage and what is the optimal level of allocation that we should give?

According to some studies, for instance, Martin and others, these criteria were too generous in Europe, which led especially at the beginning to windfall for profits and reduce incentive to innovation. For this reason, the European commission is planning to phase out free allowances and looking for alternative solutions. And one of this is certainly linking the object of the LIFE DICET project.

Linking leads to price convergence and cross the linked ETS's. So, it automatically reduces the incentive to localized to the other jurisdictions. However, the problem is how to align the various ETS's. What, for instance, is the maximum price differential for perspective linking? What is the maximum size differential? Or which are the features that may prevent linking? For instance, how can we link a system that has an absolute cap with a relative cap like the Chinese one?

These and other questions are the object of our project. Linking in my view is an interesting perspective, but it takes time because in these two built up mutual trust and this takes time. And since we don't have much time given the urgency of many climate problems, Europe is looking for an

alternative solution. And this is how the carbon border adjustment mechanism came about.

Certainly, it is a reasonable mechanism because it tries to create a level playing field. However, the problem here are how to implement it. How to avoid possible retaliation problems because in my view we should avoid absolutely trade wars and bigger thy neighbor policies especially in a period of reorganization of pandemic like the present one.

As you notice all these solutions to safeguarding international competitiveness imply strategic component across or between the regulator and the firms across ETS or across countries. For this reason, I think it is very useful to adopt the game theoretical approach. And this is what we try to do with some colleagues in a paper entitled, *Should I Stay, or Should I Go* in which we consider a set of firms that have to decide whether to stay or localize, and in which their decision depends on what the others do.

So, we introduce the possibility of mimicking the other, imitation processes. And when we do that the design of the ETS affects the share of firms that are localizing, creating interesting nonlinear affects. I don't have the time to discuss this in important details, but I just leave you the link in case you want to access the paper. Actually, free accessible until the end of November.

Now, I think my time is getting to the end so let me use the few last minutes to discuss the lessons that in my view emerged from the European experience. First of all, research lessons. There is large room for more research in game theory, in network studies, in empirical analysis of this. So different instruments that can help understand more for the future.

Secondly, policy lessons. I think for policymakers, one of the lessons is that emission to the system is a living creature. So, the EUS is a living creature, but also the other ETS in the sense they go through a continuous learning process and obviously for economists' credible commitments are of key importance and this is very clear when we look at the effects that the announcement of the markets of a user, of the European deal had on the European carbon plans.

High stringency led to higher carbon prices as suspected. On the one hand, this can have a higher impact on firms and households, which raises a problem of social acceptability for the future, which I think is very important. And I am happy to discuss it further in the Q&A.

On the other hand, higher carbon prices imply a larger incentive to innovation, larger

incentive to behavioral changes and also larger auction revenues. More than 57 billion Euros in the year 12-20. The use of these revenues in my view is of key importance to mitigate the losses and fund carbon innovations through the innovation part of the modernization fund. So much of the success of the EU ETS in the future will depend on how the option revenues will be used.

Finally, the title was a bit patronizing in my view, *Lessons from Europe*. To be honest, I think there are lessons to be learned from Europe and lessons to Europe. So, in a mutual learning process. For instance, California-Quebec linking was an interesting lesson for the linking agreement that has them or it wants to establish in the future.

And also, the full price which is missing in Europe could be a lesson to think about for the future. And finally, the CBAM, the CBAM itself can be a lesson in both directions. It can be a lesson for the others if the others will follow the European example. But in any case, we can expect that Europe will have to learn from the other, adopt to the other and interact with its trade partners if it wants the CBAM to work. And on this note, I think I will stop here and wait for your questions and discussion. Thank you.

MR. PATNAIK: Great. Thank you so much, Simone. That was very interesting especially given that the EU has really been a pioneer in climate policy and carbon pricing.

So, I'd love for all of you to unmute please and we're going to talk about different questions that we got from the audience and also kind of like the roles in terms of your presentation.

I want to start with Simone. Can you talk a little bit about the carbon border adjustment tax that has been discussed in Europe? What are some of the latest developments that you see? How likely it is that it will come? And what form will it take?

MR. BORGHESI: Well, that's a very good question. I remember discussing this point a few months ago with Robert Stavins (phonetic) who told me, are you kidding me? Are you sure that Europe is going to do that?

Well, let me say how I see this. It's a very risky move, I must admit. But at the same time, it's a game changer, which somehow pushes and speed up the process. I think that's the intention that Europe has in this case. Whether right or wrong, I think it's producing some effects because I'm reading on the news that Russia is starting to think about a carbon tax. I'm reading the news that U.S. is changing attitude. Actually, to be honest, the U.S. already has thought about a CBAM in the past. So,

Canada is considering that.

So, you know, somehow it creates the structure for carbon club or carbon coalition, whatever you want to call it of the kind that probably Norhouse (phonetic) had in mind years ago. So, it can help push things ahead or it can be just an instrument to go on. I mean I had the impression that Europe maybe doesn't want to use it at all. And it just a strategic move of the -- I can't tell. It's just my impression but certainly the great challenge is how to make it WTO compatible. And I think Europe is moving in the right direction, to be honest, involving its trading partners in a dialogue before implementing any CBAM because the CBAM is going to implement if any in 2026, say. So, I mean there is time to think about it and also excluding export rebates which was probably one of the most critical aspects in the original proposal.

MR. PATNAIK: And I think you're right. I mean I think it's a really important signal, right? Especially a signal towards markets like the U.S. that have for years faithfully implement any carbon price.

Meredith, I'd love if you could weigh in a little bit on that because I think there has been some thinking on this in California, right?

MS. FOWLIE: Yeah. So, California has a water coverage adjustment like a real live water coverage adjustment, which I think not everybody appreciates. And I think there is some interesting lessons to learn from it briefly.

So, it's only in electricity. When the Cap-and-Trade program was set up, a majority of the emissions from electricity consumption in California came from outside so it was clear that something needed to be done. So how it works is we tax emissions in California directly and then effectively sort of stand on the border and try and price the carbon that's baked into electricity imports.

I just want to pick up on something Simone said. And so, what I think the lesson that is most interesting to me is that it really elucidates a tension between needing to be careful about protectionism or perceived protectionism because you could just stand -- the original plan was to stand on the border and just charge an emissions rate. But when that emissions rate is not zero that means a wind turbine in Nevada is not happy because a wind turbine in California faces no compliance charge, whereas a wind turbine in Nevada is being penalized by this average rate.

So, what California did was set an average rate but allow outside zero carbon resources to opt out and demonstrate that they're zero carbon. But the problem there is that it does not solve linkage problem because there is enough out of state zero carbon resources such that we're seeing reshuffling. All the zero carbon resources are being put on paper, sent to California, but we're not shutting down coal plants. We're just rearranging supply relationships.

And so, our research has been a little bit -- I mean I think it is important -- it's a really important proof of concept. You know, it's showing some of the real-world complexities of implementing this. And also, showing that this is a difficult challenge to strike a balance between the WTO agreements or concerns about trade protectionism and really mitigating the linkage problem.

So, it's a work in progress and one worth watching as we try and learn from the experiences of other jurisdictions.

MR. PATNAIK: And I think you raise a very important point which is kind of like the fine line between protectionism and doing the carbon point adjustment because I think we see a lot of proposals now in the negotiations in Congress to put a carbon border adjustment tax in the U.S. without having a domestic carbon price. And that doesn't make any sense.

It is going to be very difficult to ascertain the proper price. And as a signal, it is very difficult, right, to say well we have these bunch of regulations and based on that we indirectly calculate a carbon border tax, so we don't have carbon price.

So, I would like to stay on Meredith. I want to talk a little bit about California has started to experiment already many years ago with hydrogen powered cars. And so, I was wondering, do you know a little bit about what the thinking is on hydrogen combined with electricity. Are there any new developments that we have seen?

MS. FOWLIE: I'm afraid I don't know. That's something I don't know much about. I know that they probably have -- yeah, there is some policy in place there. What I'm more familiar there's a real push towards electric cars and the kinds of infrastructure one would need to help, you know, convince consumers out of the gas cars, but unfortunately, I have not been following the hydrogen powered car development.

MR. PATNAIK: No problem. Let's move onto Johannes. So, we got a question from the

audience which is on kind of like the securities markets and especially in the mortgage space.

So, what do you think -- what is some of the frameworks that are being used to price climate risk in those securities markets and especially in the mortgage space? And I'm curious because in your presentation, you mentioned kind of like a lot of those assets they'll price the climate risk in yet. What is your expected timeframe that investors that are kind of like market actors with stock to price it in actually?

MR. STOEEL: Yeah. I mean so particular for mortgage-backed securities, which I think are the largest sort of group of you know, of asset that trade, that, you know, have the mortgage markets, you know, in the background.

One of the challenged pricing climate risks there is that the largest part of the U.S. mortgage market, as you know, is these government sponsored enterprises, Fannie Mae and Freddie Mac, guaranteeing the default risk on these mortgages.

And if you think the fundamental way in which, you know, climate risk is priced in mortgage markets, it would come through default risk price. And so, you know, if your property gets flooded that makes it as much likely that you'll repay the mortgage.

And so, we see that there is a lot of -- that sort of guarantee being exploited by mortgage lenders. So, for example, there's research that shows that, you know, if you're a bank and you originate mortgages. If you become more worried about climate risk, you're actually more likely to incent those mortgages and package them in precisely these GSE insured mortgage back securities. So, it's shifting of the risk essentially to the government.

And the big problem there is that the government isn't pricing this risk. So, the G fee which is this fee that, you know, Fannie Mae and Freddie Mac receive for taking this, you know, default risk out of these mortgage-backed securities is constant across space. So, it doesn't vary, you know, between, say, a coastal property in Florida which is likely to be flooded in 40, 50 years from now. Somewhere that is not.

And that has got, you know, a lot of historical reasons. There's a lot of good reasons for that. You know, the mortgage market is one where historically we've seen a lot of redlining, you know, where minority neighborhoods would pay substantially higher mortgage rates. It was impossible to get

mortgages there at all. And so, historically the government is, you know, the GSE's have been very averse to, you know, having any spatial price differences in that default guarantee.

But what it means is that this is not a risk that ends up being priced in the market, but it is a risk that is sort of in a hidden way is getting transferred to the taxpayer that is eventually responsible for, you know, for those guarantees. So that means, you know, in that sort of largest part of the mortgage market, the risk isn't priced, but it comes -- but, you know, there's a huge, implied government subsidy to sort of areas with more climate risk exposure.

In private mortgage back securities markets, you know, you can start seeing it being priced a little already today. And so, now then the question, well, what's horizon do we think it will be fully priced? That's a really hard question because, you know, it requires you to take a stand not just on an asset pricing model, but it also requires you to take a stand on what you think the future part of carbon emissions is. There's a lot of uncertainty, a lot of parts regulation can go.

You then need to make an assumption on how those carbon emissions will translate into global temperatures. You need to make an assumption about how those global temperature changes will lead to, you know, rising sea levels, flooding, et cetera. And then, only then, do asset prices start playing a role. You can then try and figure out, you know, how we're going to price these risks.

And so, there's an enormous amount of uncertainty there. What we can say is it is being priced already the same way that it's being priced in real estate markets. But, you know, is it being priced adequately? It is always adequate relative to my model of where regulation is going to go and then all these physical feedback loops about how that regulation is to say how the climate and rising sea levels. And that's just, you know, the era bands around each of these steps is just so wide that I don't think I can credibly say, I think, you know, it's adequately priced, overpriced, or underpriced.

MR. PATNAIK: That's actually really interesting. I'd love to turn to Meredith.

You have done some work on insurance markets as well in California, right? Can you tell us some lessons learned? Some of the impact that you have seen?

MS. FOWLIE: Yeah, I can't tell you lessons learned yet, but I can tell you questions asked. And listening to Johannes, I guess I would be curious.

So, one thing we've become interested in is regulation of property insurance and

homeowner's insurance in particular. And something that caught our attention is, Johannes, you were talking about these, you know, these probalistic models. And there's tremendous innovation in that space. Really trying to improve our read on current risk profiles and where we're going.

One thing that caught our attention is that the California Department of Insurance regulator, very apprehensive to allow insurance companies. The State Farms, the Allstates to base their premium on these probalistic models because they're trying to balance transparency and concerns about, you know, firms using these very hard to understand models to rationalize different pricing across properties and across parcels against the very clear need for firms to signal the real risk, the changing risk.

And so, right now as the regulations are written and a firm wants to apply to change its premium that it's charging different types of parcels, it can only use backward looking data from its own portfolios. And it seems that this could be a real -- the question is how important is that regulatory limitation? Is that limiting firms' ability to leverage innovation in the modeling space? To send better signals to homeowners that this is a risky property, and empirically it is not.

So empirically, we're just trying to better understand the relationship between our best modeling of risks and what the premium varies across parcels with different risks, so I don't know if they're parallels with what you're working on, Johannes. But it struck us that this regulation could be impeding potentially firm's ability to respond on price risk.

MR. BORGHESI: No, I think that's extremely likely. And it will be interesting to see sort of what you end up quantifying it, how big that is.

You know, for these types of, you know, climate risk property insurance, I mean the market for flood insurance, the private market has broken down a long time ago. And so, we have the national flood insurance program, which by the way is the exact same cross subsidy issues as the G fee, right? And that's something that's actually on the table right now to be changed. So, we're having discussions, you know, as we speak about whether or not over the next 20, 30 years the flood insurance rates from the National Flood Insurance program will start to approximate more the, you know, the actuarially fair rates.

The problem is that there's going to be properties where that will go up from a few

hundred dollars a year to more than \$10,000 a year, which will make it essentially unaffordable to live in some of these coastal communities.

Now, honestly, my view is that's probably where we need to go. And it is probably in the long run unsustainable to live in these communities and price signals might be a great way to tell people to stop moving there already so that, you know, by the time that these sorts of sea level rises, et cetera, materialize you're starting to, you know, you have much less capital deployed there. You have many fewer people living there.

But we're seeing the exact same issues with the wildfire market. You know, wildfire insurance, which I think is one that in California right now, you know, is a big deal where, you know, insurance companies are realizing that models in particular, the models trained on past data have sort of, you know, meant that the types of fires we've seen in the last few years have all been one in a hundred-year events so whatever the exact number is.

And so, you need to start using these more forward-looking models. I think part of the question is the pricing that those models apply, you know, are they essentially rates that no one can end up affording? So, I think there's a danger that the, you know, wildfire insurance will go the way that National Flood insurance -- you know, the flood insurance will go essentially in the absence of a heavy taxpayer subsidy. Some of these properties just become unaffordable.

So, it will be interesting to get a sense quantitatively where that ends up and, you know, how many properties will end up being in this essentially uninsurable space? I don't know if you've had a chance to look at that data?

MS. FOWLIE: Yeah. I mean I guess the only other thing I want to inject in this conversation which is really interesting is there are several things that homeowners can do to protect their home in terms of defensible space and building materials.

And so, something that I think is very exciting but still I think limited in this current regime is you can imagine, and you're starting to see some experimentation, your premiums will be lower if your community can get together and solve this coordination problem, and everyone takes the steps that they need to take such that when the fire comes, we can defend your space.

And so, right now there's a limited ability. But that's a really important margin that

homeowners do not have an incentive to invest in that if you could figure out how to convey that through adjusted premiums, I think it could be powerful so.

One thing, I should mention, and I think what you put your finger on, Johannes, is there's a real equity of affordability concern about, you know, if people are living in places that are going to become inhabitable, what do you do? Especially in California where affordability in the urban areas have pushed people out into the wilderness interface which is precisely where the risk is high. So, we do have a fair plan that is sort of a backstop so that people get pushed off. But it's just thinking about how to strike that appropriate balance between setting the right price signals and making sure that people who are, you know, really marginalized aren't impacted too hard.

MR. PATNAIK: And I think the problem isn't -- and I agree with you, Johannes. I think that it is a very hard conversation to have to say certain areas will be off limited for zoning or should not be rebuilt. But at the end of the day someone will have to foot the bill, right?

Currently, it is mostly taxpayers if something happens, right? And so, we have to I think reconsider what kind of areas we want to build in. And I think we've seen that in use play out in the debate. Like which areas should be up for zoning and which shouldn't?

I want to move over to you, Simone, a little bit on a question that is slightly related, but you showed in one of your graphs effectively that EU has one of the highest carbon prices now in the world, right? And it's rising. It has been rising quite fast actually over the last couple of months. And so, you pointed out kind of what's going to happen if it rises further. That EU is really -- I think if you look around the world, the one block that has credibly committed to really reducing emissions and to doing something about it much more so than most other areas.

And we've seen some pushback. Not too much, but some pushback in the population. So, my question is kind of like it came from the audience actually. How can the EU kind of like maintain their quality of life and still become carbon neutral? And what's the best way to go about that?

And the second part of the question is have you seen and to what degree have you seen the EU ETS being kind of like a template for other programs around the world? And the EU really with the leadership role influencing policies in other parts of the world especially the developing world?

MR. BORGHESI: Okay. Thank you. That's an interesting question that I think

Europeans are asking themselves right now in a way. It is true that there has been some pushback, but I think the framework that Europe is building tries to address this distribution aspects.

I mean the way to go in my view is redistribution to make sure that the climate issue does not become an equity issue. I mean building up on what Meredith was saying because I think that's very true. That's a big risk that would pose everything at risk, the whole structure at risk.

But, you know, Europe has also done steps in the right direction in my view. For instance, building up this social climate fund for the redistribution of the revenues coming from the ETS so that is from building a trust for the ETS's. But now they are planning to do it also more and more with the EU ETS that we have already.

So, work more on the redistribution of the revenues and consider that the revenues from the auctioning will be higher if prices get higher and higher. So, there's the larger amount of money that can be redistributed. So, we should not deny the possible regressive effects of some measures, but we should communicate to the population that, look, we are doing something, and this is the something we are doing. These are the money that we use for the redistribution to make sure that people are compensated.

And consider the second question on the leadership of the EU. Well, if you think about it, the EU is producing nine percent of global emissions. And ETS covers around 40 percent of European emissions. So, it's less than five percent of global emissions. So, if you think about it, it's a tiny little contribution. But I think in reality an important signal effect that it's an important contribution as long as Europe manages to have a leadership role.

My feeling, you know, from the perspective of EOI and of the project we carry forward is that it is working. It is producing effects on the others. And so, I think Europe has built a leadership taking advantage in a way of a period in which the U.S. leadership was lower. Unfortunately, I mean the climate topic is on the agenda again in the U.S.

So yes, I think the signal effect is even more important than the actual emissions reduction than we can achieve in Europe alone because in the end, we will achieve global targets only through a global action.

MR. PATNAIK: I agree. That's actually a good point. So, we have a few more minutes.

I want to close with one question to all our panelists with another that came from the audience.

We currently have the negotiations ongoing in Congress about the reconciliation bill where carbon prices are being considered, but the U.S. has a very kind of like spotted history with the federal carbon policy. We don't have one. It failed a couple of times so if you had to kind of like identify the largest obstacle or the way to get a carbon bill passed at the federal level in the U.S., how do you think that would be the most efficient or the easiest way to go about this?

This is obviously not a very easy question as you can see. So, Meredith, do you want to start?

MS. FOWLIE: Oh, boy. I think one of the problems has been when you talk about a carbon tax, you're leading with the pain, the cost and you're sort of -- in the background is the benefit, the carbon mitigation.

MR. PATNAIK: That's true.

MS. FOWLIE: So, you know, especially as we're pushing for deep decarbonization. I think we can think creatively and say, okay, let's make it a renewable energy standard that mimics the carbon tax more so than the plan that was on the table.

But you can lead with renewable energy which when you poll people, you know, people like the idea as they should. You know, the costs are coming down. So, I think part of it will be just how you present it. And leading with a shiny object and not focusing as much attention on the fact that we're going to have to pay for it, but if crafted well we can mitigate that price tag to be sort of -- but I'm not a politician. I'm an economist so. But that would be my take.

MR. PATNAIK: Great. Thank you. Johannes, your thoughts on this?

MR. BORGHESI: My thought is sort of related. You know, I think the first thing is you stop calling it a carbon tax. Then you start talking about a carbon dividend, right? Because, yes, it is going to cost us something, but you can make this revenue neutral, and you can probably make this pretty progressive.

I suspect, you know, if you go in the way that, you know, some parts of the world have done and basically just redistribute the lump sum or even in a sort of progressive way, you know, a large part of the population will end up being better off. And so, you know, tax always sounds like you're going

to have less money in your pocket at the end of the day.

And, you know, yes, you don't want to pay more at the pump, but in the end if that comes with a \$2,000 check from the government every year, you know, some sort of refundable tax credit of some sort, I think you could get a lot of people onboard that way. So, start talking about the carbon dividend that counts and less about the tax.

MR. PATNAIK: I think that's a great point. And I've seen models throughout the world where parties from the right and the left came to an arrangement through that. So, kind of like making it carbon neutral and maybe combining it with some kind of corporate income tax reform.

Simone is an outsider. What are your thoughts on this?

MR. BORGHESI: Even more difficult from the outside, but I can just echo what Meredith and Johannes said. And, you know, insist on the communicate part. In the end that's what they are also saying.

Don't present it as a tax. This is definitely not the way to go. But actually, there was already a statement by many Nobel prizes and the U.S. economists and economists from all over the world insisting on the carbon dividend idea that Johannes was suggesting. I think that's the right way to go.

And on top of that I think earmarking the revenues could be an important way to go so that people really see where the money goes. I know that this is controversial from a theoretical viewpoint, but I think this is how it works. How it should work. How you can get people onboard.

MR. PATNAIK: To get a proper cooperation. Well, this has been really interesting, and I want to thank all three of you for taking the time. I know you're incredibly busy, but I think this was a super interesting discussion today. Thank you again and all the best.

* * * * *

CERTIFICATE OF NOTARY PUBLIC

I, Carleton J. Anderson, III do hereby certify that the forgoing electronic file when originally transmitted was reduced to text at my direction; that said transcript is a true record of the proceedings therein referenced; that I am neither counsel for, related to, nor employed by any of the parties to the action in which these proceedings were taken; and, furthermore, that I am neither a relative or employee of any attorney or counsel employed by the parties hereto, nor financially or otherwise interested in the outcome of this action.

Carleton J. Anderson, III

(Signature and Seal on File)

Notary Public in and for the Commonwealth of Virginia

Commission No. 351998

Expires: November 30, 2024