MIKE LIVERMORE: Welcome to the Free Range Podcast. I'm your host, Mike Livermore. This episode is sponsored by the Program on Law, Communities, and the Environment at the University of Virginia School of Law.

With me today is Frances Moore, a professor of environmental science and policy at UC Davis. Her work focuses on climate economics and she was the lead author of a recent paper in nature that examined an important set of feedbacks between politics and the climate system.

Hi, Fran. Thanks for joining me today.

FRANCES MOORE: Thanks so much for having me.

MIKE LIVERMORE: So let's talk about this super interesting new paper that you published. Here's a great line from the beginning of it. I'll just read it out. And the quote is, "Climate policy and greenhouse gas emissions arise endogenously from the coupled interaction of the climate, social, political, and energy systems." So there's a lot of important stuff in there. Maybe you could help unpack it a little bit for our listeners.

FRANCES MOORE: Yeah. I mean, there's a lot of long words in there. But I think have picked out like pretty much the key sentence, kind of describing what's new in this paper and what we're trying to do. And kind of recognizing that existing modeling, by and large, in the climate space kind of takes emissions as a given, right?

So we're either asking, what will the climate system do, given this emissions pathway or this other emissions pathway, right? Or we're taking these emissions and we're saying, give me the lowest cost energy mix that meet some emissions constraint that can get us to this like, say, two degrees kind of consistent pathway.

And what both of the approaches do is they just say, OK, well, it's emissions X or it's emissions Y. And what we're trying to do here is we're actually trying to model the determinants of those emissions pathways. And so this is a key question in what climate change is going to look like over the 21st century of what happens to emissions.

And right now, by and large, we kind of don't put probabilities over those emissions because mostly we don't incorporate them into our models. And so that's what this paper is trying to do. So when it says endogenously, it means like a part of our model, like we don't impose emissions from outside of the model. Instead, what we do is we model the formation of policy and emissions. And that then links into the climate system and then there are feedbacks to more policy and change with emissions and so on as part of the model.

And so that's what the key difference is in this paper compared to what most of the literature does.

MIKE LIVERMORE: Yeah, great. And so one thing that I've always found interesting about the research in this area is there's kind of a split between two broadways of modeling kind of the climate economy energy systems. And there's one that is very prevalent in the IPCC process and amongst climate scientists.

And that's where, kind of what you were saying is, let's look at what happens to the world on a particular emissions pathways and there's different kind of scenarios. And that's about modeling how the climate system responds to what we're doing in terms of emissions. Or as you said, you what energy mix is consistent with different emissions pathways.

And that's kind of the Intergovernmental Panel on Climate Change, the folks that put out the regular assessment reports, the big scientific process. And there's a whole world of researchers and modelers who kind of feed their 8op into that.

And then there's another world, which is the economist's way of doing climate modeling. And that's like your William Nordhaus, who won a Nobel Prize in economics a few years ago for his work developing the first big economy climate model. And these are the models that feed into a different important policy process, right? This is the social cost of carbon that's developed by the US government that is used to price the value of emissions reductions when the federal government and some states now use as number two when they're evaluating policy using cost benefit analysis.

So how does the model that you've developed fit into these two broad categories of the kind of IPCC versus SCC approach to doing modeling of climate change?

FRANCES MOORE: Yeah, that's a great question. And so I've done work previously using the SCC type models, like some of my work uses versions of DICE and some of the other, which is the Bill Nordhaus model, and some other models that also do that.

This is distinct, I think, from both of those approaches. It is similar to the kind of economist world in that in the economist world, you have emissions rise to some extent endogenously because policy entered into the model as a control variable, right?

So one of the reasons economists design and use the models they do is because they ask this question about what does optimal climate policy look like? And using these models, where you're looking both at the cost of emissions reduction and the benefits in terms of reduced climate change damages, you can have this objective function that then you maximize the welfare by controlling emissions at a certain rate over time. And that's what DICE does.

We are distinct from in that we are not optimizing anything. So although kind of cost of mitigation enter into the model, we have no real-- there's no kind of centralized social planner the way there is in the DICE model, who kind of this omnipotent person who can just control the carbon price, the global carbon price every period, which we kind of know doesn't exist.

So what we're trying to do is representation of how policy arises is kind of more grounded than that. And because of that, it's certainly non-optimal. And so these carbon prices that come out of it are not necessarily optimal in any way. But they're just kind of coming through how we think, say, political processes work, basically.

MIKE LIVERMORE: Yeah, great. And I think that-- one way that I think of the work that you've done here and published in the research behind it is, in some sense, as you said, it's a third approach or it's at the intersection of these two different approaches. Because as you know, just to reiterate, the Nordhaus and the economic kind of approach to doing this modeling is an optimization modeling, right? What's the ideal carbon price kind of question is what they're asking.

And the IPCC world is doing a more predictive enterprise. What happens if we take this emissions pathway or that emissions pathway? And in some sense, it's really interesting what you've accomplished here, which is to say kind of a fully predictive model in the sense that, what's the most likely kind of suite of policies that we'll see in light of what we know about how policy is made or at least how much of that we can capture in our models?

And then how do those policies interact with emissions pathways? And this is an important move in the paper, how do the emissions pathways then interact with the climate system to feed back into the political processes to generate different policies that then affect emissions and so on?

And so it's really quite a complete way of making predictions about what our climate future looks like. It's really fun and interesting in that way.

So maybe we could talk a little bit about that feedback effect that you now have been able to capture in your model, where maybe just taking a step back, feedbacks in the climate system, we all know about. This is where when you add carbon into the atmosphere that could heat up, that will heat up the planet, which then can do things like melt permafrost, which then releases methane, which heats up the planet, and that's a positive feedback effect.

But one of the feedbacks that you're interested in is the feedback where effects in the climate system then introduce changes into the political system. So what are some of-- what are some of those feedbacks that you're interested in?

FRANCES MOORE: Yeah. So just to respond to some of the things you said there. So I think certainly it's comprehensive in its ambition, I would say, this model. The question of whether or not we are kind of-- it's also highly, highly stylized. And so I think that because the ambition is to be comprehensive, there are pieces missing and that people approaching the problem from different areas might kind of object to some of the simplifications we have to make. And there's always kind of more we can do on that space.

I think it's also worth spending a minute on why this is something we want to do. And this is not necessarily always obvious. And so I think for me this question of putting probabilities over different emissions scenarios is really important if you approach the problem as an adaptation planner, right?

And the fact that right now we essentially don't do that at all and we say, there's no way we can tell someone about whether RCP 8.5, a very high emission scenario is less likely or more likely than ICP 4.5 or ICP 2.6. I think that's just very impractical for people trying to plan for what climate change impacts are going to look like over the next 50 years.

And I think we kind of want to do a better job of that. And if you do, then you have to start saying something about what emissions trajectory the more or less likely. And there are other ways of doing it, but this is kind of one way of doing it.

But then to get at your question, so what we're trying to do here, the reason we have a lot of feedback processes is to kind of respect the fact that there is a lot of potential non-linearities parities in the system and that we can represent them in terms of the feedback processes that lead to-- when you couple together a lot of different feedbacks, you can get quite complex kind of emergent dynamics out of a model.

And so we really paid attention to evidence for these different types of feedbacks when we were looking into the relevant literature. And we tried to capture kind of as many as we possibly could in designing the model. So that although it's highly abstract and stylized, it hopefully represents a lot of some of these key processes that are going to kind of affect the dynamics of these trajectories over time.

And so some of the examples. You mentioned the feedback from the climate system kind of back into the social system. And so this is the overarching feedback that goes across the whole model. And we call it the cognition feedback. And so this is the idea that, well, maybe people perceive climate change and that perception of climate change maybe leads them-- and this is something we vary in the model-- but maybe that perception of climate change leads them to kind of either support climate policy or undertake kind of pro-climate individual behaviors.

And so that's one of the big feedbacks that we allow for and then we allow for various types of imperfect cognition as supported by that piece of psychology literature. There are other important feedbacks some of your listeners may be familiar with, like in the energy system, for example, the feedbacks associated with cost declines over time. So kind of new energy technology.

They're often very expensive. But then as you kind of deploy more of them, the cost come down, which means you deploy more of them, which means costs come down. And this is this reinforcing feedback that's quite well documented in the kind of energy systems literature. And so that's one of the feedback we have, There's about, I think altogether, about seven or eight of these different types of feedbacks.

MIKE LIVERMORE: Yeah. There's a lot of interesting stuff there. And maybe at some point, if we have time, we can get back to. I think there's a kind of a fun and interesting philosophical question actually at the heart of your approach about modelling human behavior in in this causal way and making predictions that is pretty interesting. Actually, deep kind of philosophical differences between the Nordhaus, the IPCC, and your approach.

But just maybe to stay in the weeds of the model for a second before we zoom way out. So yeah, so I took a look at just the different feedback processes that struck me in the paper were this notion of social conformity, the idea that if a bunch of people get together and start really caring about climate change and showing that and there's a norm that develops around addressing climate change, that that could have potential tipping point effects.

And we have experience with that maybe with smoking, where a norm develops around, say, smoking indoors. And then there's kind of a tipping point where it used to be if didn't let people smoke in your apartment, you were kind of a big jerk. And now it's pretty strange if someone lights up in your house without asking.

You noted the climate change perception, is that as we start to see climate change happening in our environment, then that might lead people to care more about climate change, recognize it. Political interest is another one that you noted.

The one that, as a law professor, that struck me interesting is the expressive force of law feedback. We don't normally see that in scientific papers. So maybe that's something we can talk about a little bit. And then another important one is the temperature emissions feedback, where if you have temperature change that then leads to a reduction in economic growth, that's then going to affect emissions.

So all of these are really interesting on their own and we could spend a lot of time talking about them. Maybe we could talk a little bit about-- I'm just thinking-- well, actually, why don't you tell me, what's your favorite feedback?

FRANCES MOORE: Given I'm talking to a law professor here, it would be really interesting to talk about this expressive force of law piece of it, I think. Because that's an example where some of the challenges we had was reading some of these literature and the law literature with some and the psychology literature to some extent. And really importantly, the political science literature, where you have documented feedback that are clearly important to the system.

But they're very qualitative-- they tend to be very qualitative descriptions. And what we have to do in this model is, I mean, it's a computational model. So you have to kind of take that and you have to try and turn it into functions and numbers in some way that you can plug that idea in to your modeling of the system.

And certainly, that expressive force of law was really kind of interesting when I kind of learned about this idea. And it was clearly an important potential feedback if you have signaling power from changes in the law that feeds back to public opinion in this reinforcing feedback loop. Then that's going to be quite important in changing the dynamic-- potentially changing the dynamics of the system.

And so we wanted to incorporate that in a way that drawing on this literature for support, but very qualitative literature, mostly with some case studies maybe. But we wanted to be comprehensive in terms of the potential pathways that we were including there.

MIKE LIVERMORE: Yeah. No, I think it's great. I mean, I'll kind of offer two somewhat contradictory takes on that. So one is, I think it's great. I mean, it is-- you're right that it's a very interesting potential feedback, could be important. There are lots of my colleagues in the legal academy who are interested in the idea of this expressive force of law or sometimes kind of think of it as using law as a mechanism to achieve kind of cultural change rather than just changing incentives or something like that.

So my own personal take on this is that I'm a bit of a-- I'm a bit of a skeptic. There's kind of two different takes on expressive-- the kind of expression in law. So one is just a more kind of moral that it's really irrespective of how the law affects people's attitudes or beliefs or preferences. That the law should respect equality or something like that, like embody respect for gender equality or racial equality or something like that.

That would be one. That's more kind of a moral view. And then an alternative would be like the social scientific or the behavioral view would be when you have a judicial opinion like Brown versus the Board or Obergefell, which was the gay marriage opinion, then that affects how people view things like racial equality or marriage equality or whatever.

I think there's just a big open question on how much that works, how much that's real. As you might imagine, it's completely endogenous, right? So like there's other social forces that are acting on the court and that are acting on politics and are acting on culture. That those social dynamics could be leading to broader social change and leading to the judicial opinions, right?

And it's super hard to-- I mean, basically, super hard impossible to disentangle those. You'd have to imagine the experiment, right? You'd have to somehow have some kind of exogenous shock that led to these kinds of legal changes. And then you try to have to trace. Imagine, again, it's like just a theoretical kind of study that you would do.

So, yeah, so I think that there are just different views about that. I'm probably more on the skeptical side, on the behavioral side. I think on the moral side, that's a different question. But on the behavioral side, I'm somewhat more skeptical. It's possible. It's just very hard to know. That's the kind of thing. There's almost no way to empirically know anything.

So it's kind of based on people's views or you can do things like you can run experiments or surveys. I've seen some of this, where you kind of inform someone of a hypothetical or you just prime someone, letting them know that there's this judicial opinion that says this and then you do an A/B testing kind of thing where you expose some people to the judicial opinion and not others and you see how that-- you see if that has any effect on their views.

I think out of that literature, again, it's a bit of a mixed story. I've actually seen some work that shows that there are reverse effects. Like for example, like an interesting one would be-- I don't actually if this has been studied specifically, but you could do this, would be, is waterboarding torture, would be a question. And you could, say, expose people to a hypothetical judicial opinion that says that it's yes and see what the effects are.

But again, I think out of the literature, what you get is very, very mixed. And again, sometimes even inverted. So like Roe v Wade, for example--

FRANCES MOORE: Yeah, I was just going to say Roe v Wade, I think, is a classic example of the feedback operating in the opposite direction, potentially.

MIKE LIVERMORE: Exactly, where it was actually pretty uncontroversial, the decision at the time. And then it just kind of became more and more and more controversial. Not more and more and more, but, well, it did and then stabilized into kind of the current level. So yeah.

But I do think it's the kind of thing that's-- and this actually is very interesting. This gets us into models in general and how to read the results of a model like the one that you have is, it's a very useful thing to have in there because it's a possible pathway. And if someone believes that the expressive force of law is a real and important phenomenon, which they totally can based on current evidence.

It's just what's your model of human behavior and how it interacts with legal institutions, then they can look-- in theory, you can imagine you can kind of press that dial or not press that dial, right? Do you think it's important to do nothing? It's important-- or look at the model runs where expressive force of law is a major factor. You've turned the dial up or looked at the model runs where that's low on-- where you've turned the dial down.

And then that can tell you something about if it's a real thing, how important it is, right? And so I think that even irrespective of the kind of current state of affairs in terms of the empirics, there's value in modeling, something like that.

FRANCES MOORE: Yeah. I think that's definitely the approach we took at that. We allow for the feedback and then it could have a value of 0, and it does in some runs. And then just the fact that it's a feedback process, which is what-- that by itself creates these empirical challenges that you are talking about, where everything's connected to everything else, right?

So if you're looking at the real world, like how do you say what's the causal effect of the feedback versus not? Well, it's really hard, right? Because the original policy itself arises endogenously from the society that's producing that policy, right? But then it feeds back, potentially feedbacks in some way on that society.

And so this modeling approach allows for a lot of hypotheses around what human behavior and cognition and social interactions and how they aggregate up to produce policy, allows for you to put in a lot of different models of how that works and to kind of look at how that affects affects the emissions. And I think we don't necessarily take strong positions either way on exactly what the magnitude of some of these feedbacks are.

We have-- but what we're trying to do is, to the best we can, kind of integrate across the evidence, allowing for a lot of these interacting dynamics and say something hopefully comprehensive about what the emissions pathways look and what factors are important in driving those emissions.

So if you look at this parameter, say, the feedback, for example, and you decide, oh you know what, it turned out it doesn't seem that important after all. Well, maybe we don't need to spend a lot more of empirical effort if we're only interested in climate change, which, obviously, we're not. It's interesting for other reasons, but we might focus our efforts on kind of the other [INAUDIBLE] that drop out of being really important in differentiating these pathways.

MIKE LIVERMORE: Right. Right. Yeah. That's super, super useful. And it's the purpose of modeling exercises like this. One of the-- actually, one of the outputs or conclusions or at least tentative conclusions that you guys come to I think that's pretty interesting kind of had to do with the effect of individual behavior. I don't think this is maybe all that surprising for at least some folks who follow this conversation closely.

But it looks as though, basically, individual behavior can matter. But only kind of when it leads to broad preference cascades of some kind, right? Where my behavior then affects someone else's behavior that then affects someone else's behavior and then we reach a tipping point, norms change, and that leads into-- feeds into the political system and everything else.

So by myself, I'm not going to be able to accomplish much. And so the real question is, kind of how much does our individual behavior or the behavior of individuals who are concerned about climate change actually affect the behavior of other people? So was that a fair conclusion to come up with? And I'm just curious about that.

FRANCES MOORE: Yeah. That question about individual behavior, I think, that was part of-- we have a quite rich representation of individual behavior change in the model. And partly that reflects where some of the effort has been, I think, on the scientific side around like modeling kind of individual-- what effects kind of individual decisions do. Kind of pro-environmental behavior, there's a lot of work on that That we try and incorporate in.

But there's this tension, I think. And you saw these debates playing out, I think, in some of the popular kind of articles and things about the focus on individual behavior change versus on some kind of collective action. And what we do here is we try and we, I think, we are able a little bit to kind of resolve some of the arguments at those debates at a higher level in the sense that we find-- and this is not surprising-- just individual behavior change like by itself that cannot solve climate change, right? Because most of how we produce emissions is collective-- is a collective decision.

And so people making changes like are only able to do so much to actual emissions. But because we have a lot of these reinforcing feedbacks in the model that are all coupled together, it is possible to put the model into certain states where the propensity of individuals that support collective climate policy to kind of make costly changes in their own behavior have a feedback to their neighbors, to the social network, that persuades other people of that same opinion that we should do something at the collective level to address climate change that have an effect then on the political system.

And because there's this all these coupled connected reinforcing feedback that can create this kind of cascade of action that can lead to kind of a tipping point. And I think focusing on that piece of it that what you're doing there is like a social signal. It's not necessarily the emissions reductions themselves, but it's that social signal of I am about your values, right? And it's kind of saying, look, I am undertaking this action that's costly to me because I care about climate change for the following reasons, right? And I think other people should too.

And it's that effect that could potentially leverage those individual actions into kind of much more large scale changes. And so we kind of show that the model has this have this potential in it. Once we parameterized the model to look something like more what we think might be a more realistic set of parameters, it turns out that those states of the model where individual action is really key in tipping the whole system into the sustainable state is actually quite-- it's not so common.

So it turns out, when we actually do our real model runs about what we think how we think things might evolve, it's not so important. But I think some of that debate comes from people's intuitions about that social signaling value and that it is real and it can drop out of the model in certain states.

MIKE LIVERMORE: Yeah. Yeah. No, it's super, super interesting. And I think just to kind of get into some of the other results or insights that we might get out of the model, well, maybe there's kind of a top line thing and then we can get into the detail.

So one top line thing that I took is-- again, I'm going to kind of read a sentence and then we can unpack it a little bit-- goes something like this-- or it goes exactly like this. This is the quote. "Our parameterized model implies a high likelihood of accelerating emissions reductions over the 21st century, moving the world decisively away from a no policy business as usual baseline", which I believe is economist speak for there's hope.

And so maybe you could just say a little bit about that finding and how you kind of come to it. And then I think we can move into some more details about the relationship of these different outputs and scenarios and so on.

FRANCES MOORE: Yeah. So you're right that that is really one of the headline conclusions of our whole exercise here. And so how we get to that point is we start with this model that has a lot of potential dynamics in it that can give rise to a lot. There's a lot of potential behavior. And then we do some exercises to try and constrain some of the parameter sets.

And there's two main things. So one is that we use kind of evidence on the current distribution of opinions on climate policy. And so that comes from pew surveys from mostly from kind of US, OECD kind of set of countries. And that's a kind of key starting place for our model.

And then we also do some exercises where we kind of run the model in kind of historic mode. So looking at the last decade. And we probabilistically constrain some of the parameters based on how the output from the model matches what actually happened.

And so that helps us rein in, to some extent, the parameters. And in particular, we're able to do that in parts of the system representing the political component. Very importantly, in some of the system representing the energy system. And other parts of the model are less well constrained.

But we take this probabilistically and then we run the model like 100,000 times, sampling over these uncertain kind of parameter spaces. And then we look at what the trajectory of emissions look like under those 100,000 runs. And we find that in a large fraction of them, we see this kind of accelerating climate policy and dropping emissions. So that in a kind of central case, what we call the modal pathway, you get to global net zero emissions-- well, zero emission, we don't have negative emissions-- by about 2080 to 2019.

And so that is not a kind of quite a 2 degree consistent pathway, but it's also not far off from it. And so that would get you to something kind of close to above about 2.3 degrees by 2100.

MIKE LIVERMORE: Yes. And another point that you make in paper is this is like roughly consistent with actually the policy commitments that are on the books that we get out of the Paris Accord and the pledges that have arisen out of that. And then, obviously, there's been some talk of maybe adding, later out into the century or at some point when we develop the technology, some kind of negative emissions to keep us below 2 degrees.

So that's pretty interesting because you didn't plunk in those policies. They actually came out of your model.

FRANCES MOORE: Yeah, it was very exciting when we discovered that because it is quite surprising that we don't-- there's nothing about these policy commitments in our model area. Because policy is just arriving at an output from the model. And yet our model pathway looks very much like what the 2030, 2050 kind of emissions commitments look like.

And actually, there was just a paper, another paper in *Nature* last week showing that the long term net zero commitments that countries have made are largely consistent with a 2 degree pathway. And so that's what-- we're kind of able-- we seem to be able to capture at least some of those dynamics. Whether or not countries are actually going to meet those long term commitments, we can't say. But our model suggests that they might not be far off from it.

MIKE LIVERMORE: Yeah. Yeah, I know. That is good news. And certainly good news for a model, when you can kind of put in the inputs on one side and then you get outputs that actually match something that looks like the real world, which is pretty-- I could imagine it was pretty exciting.

Kind of on the other side, there's always some bad news whenever you do climate modeling, right? There were some model runs where you had higher temperature change popping out, something closer to 3 to 4 degrees. And it's interesting to, I think, consider the model features that were associated with kind of more or less temperature change. And so I'll just read off some of these that struck me.

So in the kind of bad world, what leads to the bad world in some sense is things like, well, what you write here is high network homophily. So what that means is that people are essentially separated into polarized camps. And so the people who like care about climate change, do take efforts to address climate change. That message doesn't spread very effectively through social networks because the social networks are essentially fractured amongst people who think alike.

High social norm effects. So people are strongly affected by the people who they're around. But they're around people who they tend to agree with. Political systems that have a bias towards the status quo.

A couple of others that I think is quite interesting also is high biased assimilation. So what this means is that people-- and there's some evidence that this is the case-- when there are severe weather events or other things like that, people view those things through a partisan lens.

So people who believe in climate change or in the US or Democrats they'll say, oh, there's wildfires, that's because of climate change. Other people who aren't big fans of the idea of climate change or consider themselves Republicans might look at the same thing and say, no, that's because we haven't managed our forests properly.

And then the shifting baselines issue, which is that's our frog in water example, where if we're just comparing temperature to the last 5 to 10 years, it doesn't really look like it's changed all that much, right? Whereas if you look over a longer time horizons, then it does look like it's changed quite a bit. And the reality is that humans tend to update their views pretty rapidly. They tend to adapt, which generally is actually probably a good thing about us. But it makes it very difficult for people to see long term trends.

So maybe we could just talk about some of those factors and how they relate to the model to then generate these outcomes of more pessimistic climate scenarios.

FRANCES MOORE: Yeah. So kind of broadly speaking, what our model is doing is it's taking in evidence, which is coming from the pure opinions of it, is that there is fairly already across the OECD kind of fairly widespread support in general for climate policies. And that's a starting point.

And so then you have to kind of-- in order to get into these like bad states of the world, you have to explain and there needs to be reasons why that doesn't translate into kind of climate policy. And broadly-- so there's several reasons why that's the case.

So one reason is that there's these kind of social set of reasons, which is have the fractured social system, where we're just going to-- this distribution of opinion is just going to kind of stick in place. And you're not going to get this like what the model would otherwise want to do, which is this kind of broad like transmission of support for climate policy as it spread through the population.

There are another set of reasons to do with responsiveness of political system. And so if you have broad support for climate policy but you have a fairly unresponsive political system, where that just doesn't matter in terms of collective action, that's another reason why you could end up in a world with not very ambitious climate policy.

And then there's another set of reasons to do with the feedback of cognition, right? So even if you're not persuaded by people in your social network, there's a pathway in the model where you could just directly observe climate change, right? And it turns out if you allow that to happen with no kind of limitations on people's cognition, then, basically, everyone supports climate policy like right away because the evidence the evidence of climate change, well, certainly, going forward, is very, very high.

But we think that there's probably quite a lot of limits to how people are able to perceive climate change given their observations of weather. And that includes things like shifting baselines, which I've done some work on before using Twitter data, where we suggested that people adjust their sense of normal on about a five year basis. And like the signal of climate change is not very high on that time frame. And then you couple that with this bias assimilation effect too and you can get a situation where people are not able to distinguish the climate change signals at all, given their observations.

And then there's one final reason for why you might end up in the worst day for the world, and that's to do with the energy system. And if you end up in a world where you just get really unlucky in terms of the evolution of energy technologies and they just don't keep evolving the way they have and like they stay really expensive. and so even though maybe your climate policy is quite ambitious, it's actually just not doing much in the energy system. That's another reason you can get these draws on the higher end of warming.

And so we kind of can distinguish those pathways to some extent by looking at the combination of model parameters that produces different combinations of climate policy and emissions over the 21st century.

MIKE LIVERMORE: Yeah. For what it's worth, I'm probably more optimistic about the technological side than the social side.

FRANCES MOORE: Yeah.

MIKE LIVERMORE: I think we have reason to be, in a sense, right? If we just look at the last couple of decades, the technology has come along quite nicely. Our politics have not come along nearly as nicely.

So I'm curious about some other-- what you think of some other potential feedback effects. And then I'm curious also where the future kind of work on this model and this approach is going to take you.

So some of the feedbacks that I've written a little bit about in this area are the ways that the climate system or changes in the climate system could kind of do harm to our ability to carry out political change. So I think one of the things that's interesting about the model that you guys have is it's pretty optimistic in the sense that, as climate damage has become apparent, that generally speaking, through mechanisms that you guys identify, leads people to care more about climate change, which is a pretty sensible thing is that people see something bad happening in the world, they care more about it.

The concern that I've raised with the co-author, Peter Howard, is this idea that in order to address climate change, you need to have a fairly high degree of cooperation in society. Because, again, no individual actor, including any individual country, can really substantially change the global emissions pathway. And so there's huge free rider problems and those aren't going anywhere. There's always going to be free rider problems. And so some form of cooperation is necessary.

And the concern is that climate damages undermine the conditions that are necessary for that kind of cooperation by just putting pressure on societies. Mass immigration, economic costs, social dislocation, all the harms that are associated with climate change, those just decrease the capacity of the state to do big projects and decrease the ability for international cooperation or the functioning of international institutions.

I'm curious whether you guys contemplated that kind of downer of a feedback or if it sounds kind of roughly plausible or something that could be potentially incorporate into the model?

FRANCES MOORE: Yeah. It's definitely something I was thinking about. I think we-- I definitely think it's true right that if you think of what the project on climate mitigation, like something maybe I have my economist hat on, but we would describe it as like providing a global public good, right? And that's really hard. And what nation states are more used to is providing public good for their citizens, which you might think of that as various types of public adaptation, expenditures.

And I think like thinking about-- we definitely talked about possible models, where I think if you have that feedback in, you would get this kind of bifurcation, potentially, where you end up in this negative feedback loop, where-- you end up in a bad feedback loop, which is a reinforcing feedback loop, where climate damages lessen the state capacity to undertake mitigation that leads to more climate change damages.

I think it's true. I think the working group and the effort that gave rise to this paper, we were interested in this question of tipping points in the social system, right? So we were looking-- we were tending to, I think, look for examples of reinforcing feedback in the positive direction. And I think, definitely, in the next extension for the model would be to look at some of these more less good examples of tipping point. And I think that is definitely one of them, this idea that you could get trapped in this constant adaptation, constantly responding to climate change impacts rather than lessening the ability to do these other types of changes.

I think the other feedback that we don't have in the model right now is that kind of negative public reaction to changing energy prices. We know that's true. We're seeing it right now. I think I would probably incorporate that as some type of reaction against rapid changes in energy, right? So you can increase energy prices, if you do it through a carbon tax say. But if you do it very quickly, there's a negative response to that that diminishes support for climate policy. And that would change-- that would definitely change our results.

So I think some of that-- that's all kind of work to be done as we kind of flesh out some of the richness, I think, of what's in this type of model.

MIKE LIVERMORE: Yeah. Great. Yeah. Look forward to-- look forward to future iterations. One of the things that you mentioned there, which is another really interesting feature of this project and something that we've kind of returned to in this podcast a few times in the past, which is, this is highly interdisciplinary work. And actually, in the paper, you even talk about there was a four day interdisciplinary workshop. That's where we kind of identified the feedbacks that we were interested in, which is very cool, I think. Because that's how the real world works. You have these workshops and you get ideas and you exchange thoughts. And then that's how you kind of build these things.

So maybe you could just tell us a little bit about that, the workshop, the idea for the workshop, the kinds of folks who were there, and what the value was of that.

FRANCES MOORE: Yeah. Yeah. So it came out of this interdisciplinary working group funded by SESYNC-- Socio-environmental Synthesis Center, I want to say, in Annapolis. And it was Brian Beckage and Katie Lacasse and Lou Gross, who are some of the co-authors in the paper, had been involved in a previous version of the working group. And this was like the second iteration of it.

And so it's an interesting mixture of disciplines of several ecologists. There were some system dynamics specialists. The style of modeling is often called kind of systems dynamics, focused on feedback loops and changes over time. And so that's definitely like an important piece of the modeling. And I think-- and then Katie Katie Lacasse is a psychologist, and there are disciplines missing from that. And so some of that was like us reading a lot into those literatures.

But I think it's hard to get these things to always work well. And I think here, there was definitely a focus early on on quantitative modeling. And so everyone was on the same page about that and willing to make the necessary simplifications and so on that come with trying to put very rich qualitative insights from some of these disciplines into a rather dry computational model in very simple functional forms. But people recognized that that was the end goal of this project, ultimately.

And because of that, we came up with some interesting work. I think next, we would like to have more disciplines in particularly recognizing, I think, political science and law as being really critical to some of the way in which collective action emerges from the space. I think, in general, the social ecology modeling-- which there's been a lot of that within ecology, so ecologists are used to thinking of how do species interact with their environment, and how do the environment then shape the species evolution, and the extension of that then to humans is a natural one.

And so you've seen some of the type of modeling work coming out of ecologists. And so I think that's why you see-- that's why we have ecologists involved on this paper. But I think bringing in more of specialists within the social sciences that are interested in engaging in this type of work, I think it would be really valuable.

MIKE LIVERMORE: Yeah. No, I mean, it's fantastic, though, what you've done so far just to bring these disciplines together. And again, as you noted, at the end of the day, for an exercise like this, stuff has to get translated into quantitative terms that can be put into a model that can generate, that they can interact with each other and generate outcomes. And so that can always be a challenge to integrate some of these more qualitative disciplines. Folks can get uncomfortable with making assumptions about what the coefficient is going to be when you parameter as a model. But I do think that that is-- it's admirable.

FRANCES MOORE: Not just the coefficient, but I think sometimes people can get very hung up on the terminology. And you get into debates about what I would call semantic debates that are not particularly substantive because semantics are important in some of these disciplines. But when you start translating these ideas into numbers, a lot of it really-- these nuances, these distinctions start breaking down.

And you have to be willing to let go of some of that and recognize that, oh, what you call this and what I call this are really, when we actually try and put it into a model like this, are functioning as the same thing. And we just have to live with that and let go of some of these more semantic distinctions. And it takes a certain kind of flexibility mindset, I think, for people to be able to do that.

MIKE LIVERMORE: Yeah. But that's also a useful intellectual exercise in its own is to nail this out and say, actually, you know what? We're talking about the same thing--

FRANCES MOORE: Yeah, exactly.

MIKE LIVERMORE: --when it comes down to it. Yeah, that actually takes us back, I think, a little bit to that initial-- or that point that I made earlier about the different philosophical underpinnings of these different approaches because you mentioned ecology and the way that we could think of ecosystems and species and ecosystems just all interacting with each other within a single kind of model.

And there's no reason, in principle, not to think about-- well, at least in one worldview, there's no reason, in principle, not to just think of humans exactly the same way, that we're conditioned by our environment. We then interact with our environment and have effects on that environment, and that feeds back to us. And what you have is almost like a fully causal model of the human climate system. Now, again, as you note, it's not comprehensive and complete and whatever else.

I mean, you're making a rough cut and an attempt to include what you think are the important features. But broadly speaking, the underlying idea is that we're acted on by causal forces. We have characteristics that then can change over time or not. But we're embedded in this dynamic, essentially, that is fully enclosed from a causal perspective.

Whereas under the Nordhaus model, what you might say, one way to interpret that, is we have a choice. There's no social decision-maker in reality. But we ask this question, which is, if I were a social decision-maker, what would be the right thing to do? It's a utilitarian worldview that says, well, this is really what social decision-makers or the people who are best positioned to-- best positioned to make social policy ought to do because it maximizes social welfare, social well-being.

And then you can think of the IPCC world as being a little bit more agnostic in terms of the ethical framework that it's using. It's not clear that they're trying to maximize social welfare. It's not really clear what their utility function is exactly. But basically, they're saying we have a choice. We can choose emissions pathway A, B, C, or D. What kind of world do we want to live in? And we have to decide that collectively.

And I think that's very interesting. So I guess I would just be curious about your thoughts. Is that something that you all considered when thinking about your model and how it different from the other models? Or is this a little bit of a philosopher's point that wasn't really front of mind?

FRANCES MOORE: No, I mean, it's definitely something-- I think your typology is exactly accurate there. And it's definitely something that certainly I was thinking about. And in particular, it came up when I was communicating about this paper. I was talking to people about it. And people would say, what does it mean about what we can do?

And it's like, well, it's not that type of model. It's very much a descriptive, not a normative model. It's telling you, well, if this is the type of world we live in, then this is what emissions are likely to be. And if this is the type of world we live in, then this is what emissions are likely to be.

And in that sense, it is very-- the goal of the modeling exercise is understanding and descriptive, primarily, and not necessarily prescriptive or normative in its intent. And that makes it different, I think, than some of these-- the goals of these other modeling exercises that do see that role as giving advice, say, to some imagined decision-maker. But the problem is that this world global decision-maker doesn't exist for these complex, wicked problems. Climate change is one example.

And I think it does-- in that sense, what this is doing is pointing to the importance-- if you take the science of sustainability and the science of social ecological systems seriously, then the driving determinant of how these natural systems evolve over the 21st century is going to be people, people's collective decisions. And you need-- you can't just exclude that from your understanding of the system.

You're taking the most important driver, and you're explicitly saying, oh, no, we don't do that. We don't model that. And to me, that's just very unsatisfying as a scientific exercise. And I think there is echoes-- I would say there's echoes here of Elinor Ostrom in the sense that she studied, scientifically, the emergence of behaviors, that these collective decisions around common pool resource management.

And a lot of her work was looking at, under what situations do you see this arise, and what situations do you not? And it was this descriptive exercise. And she was very-- she tended to be quite averse to saying, oh, well, here's what we can do to manage this type of resource. But her work tended not to be particularly prescriptive in that sense.

And I think you can see this in the same vein in the sense of what we're trying to do is we're trying to understand and predict and project the emergence of collective action around governance of various types of environmental commons in order to better understand both the processes that give rise to that type of governance as well as the behavior of what the trajectory of those systems will look like over time.

MIKE LIVERMORE: Yeah, no. That's interesting, that interesting connection to Ostrom's work because that does make a lot of sense. One feedback that just occurred to me that maybe you could include in future iterations is the feedback effect of your model into the policy process is that now it's out, people can see it. And then if people change their behavior on the basis of your paper, that, itself, is a kind of feedback effect. Maybe a little hard to incorporate into the model, but fun to contemplate.

So one maybe final question for you is again, with this predictive enterprise and with the state of modeling, obviously you're not saying what the world is going to look like, right? You're saying, look, there's some probability distributions, and we think these are some of the important features of the world that will bear on whether we find ourselves at 2 degrees or 3 degrees or 3 and 1/2 degrees by the century's end.

And so again, as someone who's been in the weeds of the model and seen the runs and done the analysis, one of the things I would be very interested to hear from you is, what are the things that we should be looking for over the next 10 years? What are the features of the social world or the technological world that we want to know about? That if X-- If we observe X, then this should give us hope that we are going to stay within a reasonable temperature change.

Or if we see Y, then it's time to move to Canada. What are the things that we should be looking for? Is it the next mid-term elections? Or is it-- Is it something in terms of polariz-- if polarization, political polarization continues along the same track, what are the things-- is it just public opinion? Yeah, what are the things that we should be looking for the next 5 to 10 years that will be a signal about what world we're most likely to find ourselves in?

FRANCES MOORE: Yeah. I think I'm probably going to reveal my economist hat, economist background here. And I would say probably something along the lines of carbon pricing because one of the common features, near-term features of these worlds that look more optimistic is you see quite rapid increase in the stringency of climate policy, what that's measured in terms of, some kind of aggregate carbon pricing measure.

And I think if you over the next few years-- we're starting to see that. The European carbon price is going up rapidly. Same in California. And but it's not just carbon pricing. It's also to the extent we have more ambitious non-pricing climate goals, like renewable portfolio standards or other types of, say, efficiency regulations that are binding at a certain cost.

That's all rolled into that measure of the carbon tax equivalent. And so I think if you-- and this is globally. So I think Americans tend to concentrate very much on what's happening at the federal level in the US, but we should recognize that emissions in the US are not unrelated to what happens everywhere else because there are these spillover effects via markets and technology spillover and things like that.

And so yeah. I would definitely be keeping an eye on that over the next 10 or so years, I guess, to see if-- to see to what extent our model projections are being borne out.

MIKE LIVERMORE: Yeah. Yeah, it's really interesting, I mean, in a way that we probably just keep our eye on emissions then is that under the more optimistic scenario--

FRANCES MOORE: Well, that's a slow-- that has a slower response. And that also-- and that also depends more on you have this question about what emissions technologies do over time. But I think you can really distinguish, are you in mostly this set of more positive-type social political system world or not, based on what happens to the carbon price in the fairly near term?

MIKE LIVERMORE: OK. Well, all the more reason for us to hope for a stringent carbon price. Not only will it actually generate the outcome, but it will predict that we'll be in a good world as well. So OK. Well, very good, Fran. Thanks so much for chatting with me today. This was a super fun and informative conversation.

FRANCES MOORE: Thank you so much for the great questions.

[MUSIC PLAYING]