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THE STATE OF US AI INNOVATION AND READINESS:
A CONVERSATION WITH OSTP DIRECTOR ARATI PRABHAKAR

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UNCORRECTED TRANSCRIPT

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MURO: Thank you so much, everyone, for joining us. It's definitely a privilege to probe the importance of innovation investments in general and in the AI domain. So there we go. We want to we want to talk this morning about the importance of innovation investments in general, but also in the AI domain with Director Prabhakar, who knows a lot about this. Has a lot of, I think, important thoughts to share. I'm Mark Muro, a senior fellow at Brookings Metro, where I work on regional technology, ecosystems and industrial strategy, especially of late. And I want to draw out this morning some of the director's wide knowledge about the importance, status and direction of US R&D spending. We can't talk about this enough. We need to revisit first principles at times and also keep up with new developments. Government R&D in general and in the AI domain specifically is absolutely critical after all. Yet it is notable how much of the discussion today is dominated by the private sector's role here. For decades, technology research has coexisted. In academia, government and industry. But the balance has been shifting, increasingly over the last, decades and recently of late, including as deep learning has become the leading technology and AI. There're reasons that these two dynamics have occurred simultaneously, but some estimates place the industry share of US research expenditures over 75% of total US spend. We'll fact check that, in a few minutes. In AI, the locus of the action resides heavily in Big Tech's major research labs located in a few superstar, cities. And as to one imperfect metric of the tangible innovation outputs industry produce 51 notable machine learning models in 2023, while academia contributed 15, according to Stanford's Institute on Human Centered AI. So that's again, just another background fact, all of which suggests the nation needs to reflect on the scope, the nature and ideal purpose of US R&D investments in general and for AI. Is it properly sized? Where is it heading? What is it doing and what should it be doing? And we should always ask those questions. But I think this is a particularly important moment to do so. So I want to turn to our guests, Dr. Prabhakar, who, as I was saying, is perfectly positioned to, touch on these questions. The past leader of two R&D, agencies, DARPA and NIST. She is now the Director of the White House Office of Science and Technology Policy and Assistant to the President for Science and Technology. In this capacity she is the president's chief advisor for science and technology and a member of the president's cabinet. So with that on record, I'm going to just ask a few questions, and then we will have some time, to to hear your questions. So to start with, let's just start with why does government R&D matter? You know so much in the first place. And why does it matter who carries it out? Right?

PRABHAKAR That's that's a great place to start. Thank you so much, Mark, for doing this. It's really a delight to be at Brookings with you. And looking forward to this conversation. Why does federal R&D matter?

Well, it is in our lives and all kinds of ways. It often isn't visible, but it's the foundation for so much that shapes the world that we are in. And, you know, think about it every time that you use GPS to figure out where you are on the map, federal R&D made that possible. I have a dear friend who is a cancer survivor, many, many happy years of life with his grandkids and friends like us. Federal R&D made that possible. I think about the solar panels that are on the roof of this building. I think about the mRNA vaccines that are protecting a lot of people in this room from Covid. Federal R&D made that possible. If you're watching this on a live stream over the internet, of course, federal R&D made that possible. So it is, foundational to the, lives that we're living to our economy, to our national security. And that is, you know, that's the fundamental reason that, support for federal R&D has been such a priority for President Biden and for Vice President Harris. The good news is that they made an enormous amount of progress in the first couple of years of this administration, in both putting R&D to work, but also boosting the R&D that we need for the next generation. Unfortunately, with the budget caps that we're living under right now, federal R&D have taken a hit. But I really want to come back to the point you made, which is the moment that we are in, because this is a moment where we have to be serious about investing in federal R&D and getting it right, both because of the competitive world that we're living in. But also when I look under the the, you know, when I look inside of R&D and federal R&D and I see the prospects accelerated by AI. We're going to need it to achieve some of our huge ambitions. And I think that's actually more and more possible with what's bubbling today.

MURO: One follow up. So when we talk about the federal role, what is, distinctive about it, as opposed to the also valuable role of the private sector, the and then that then we could talk about how we're doing on the the.

PRABHAKAR Absolutely. It all matters. And I'll just say my personal history is half public service, leading federal R&D organizations. The other half was Silicon Valley, mostly venture capital. And so I very much have this idea of of how much it takes. We do amazing things with R&D in this country, but every big thing does take all of those different components. So the federal role in particular, a couple of very key roles. One is the basic research foundation that spans all disciplines and pushes the boundaries of knowledge that if you don't have that, you can't do any of the other things that we need to do. So that's the foundation of the foundation. The second important role is R&D for public missions, not for the things that the market's going to support, but for national security, for providing the weather, for human health, all the things that are public missions. And, and you can see that in the mix. We spend almost \$200 billion a year in federal R&D. And it's a mix of this foundational research and then R&D aimed at these public missions.

MURO: How are we doing in terms of the budget numbers?

PRABHAKAR Let's say let's start with the top level picture, the US level for R&D spending in 2021, the most recent fully baked numbers, the US, is, as a country, public and private, spending \$800 billion, in that year on R&D. Let me tell you what's notable about that. For many years, everyone's been anticipating that China's growth and R&D spending, which is unparalleled. No one has ever seen R&D spend grow that fast, that they would surpass us. That actually hasn't happened. And the reason is that our private sector has really put the pedal to the metal on R&D spending. It's the intensification of the innovation economy. It's where our AI advances have come from. But many more, things, especially in the IT sector. And what that means is that as a country, we're spending 3.5% of GDP on R&D, which is terrific. And then again, I keep coming back to the one, the foundational piece of that. The federal part has continued to grow over time, but it has not kept up with the pace of the economy in the broader innovation system. So that's where we are today.

MURO: While these, I think you call them aspirations become, more and more important. The list is getting longer. Do you want to talk a little about the, I guess, convening you, you, you, you brought together recently to really brainstorm about the. Possibilities for the future.

PRABHAKAR Yeah, maybe just to shift to AI because I think that is that is, it's it's exciting and it's sexy and everyone talks about it all the time, but it actually is so broad and it affects so many different aspects, not only of our lives, but every field of research. So that I think it is one of the most important forces to understand and to grasp in R&D. So just maybe just to set the table by talking first about the work in on AI. Yeah, yeah. And then and then I'd love to get to AI aspirations, which is a recent project that we've been doing. So I started in this job in October of 2022. And in November of 2022, GPT ChatGPT came into the world. I ended up spending a lot of the last year and a half on AI. And what happened is that, first of all, of course, we all understand that I was already in our lives in so many ways behind every ad that you're served online, but also behind airline ticket pricing and behind the diagnosis you get at the air and behind whether you get a yay or nay on your mortgage application. So it was in our lives, but it was a little hidden. And then what happened with generative AI, with chat bots and image generators is it was no longer hidden, it was in your face. And so last year really became a moment, that the president and the vice president seized to say, first of all, this is the most consequential technology of our times. We know it will bring promise and peril. That's what powerful technologies do. And the the job that they set out, the task that they set out for all of us

was, was to manage its risks so that we can seize its benefits. And that work got done through voluntary commitments that the vice president, the president got from industry through a massive executive order that the president signed about nine months ago, global leadership, many other actions and continuing work with Congress. So at the end of last year, I looked at the enormous progress that this administration had made and and getting us on the right track. Lots more to do. But we got aimed and started in the right direction on managing risks. And and you have to do that. But the reason you're doing that is to build a stable platform so that you can reach for the stars. And so what does reaching for the stars look like? Well, companies are doing it right. They're going to work and they're doing things that are going to be for business productivity, consumer applications. But we've got the country's work to do as well. And that's what led to our project called AI aspirations. That's about using putting AI to work to achieve the big things that this country needs to do, from health to dealing with climate change to lifting up opportunity for every person. And, that's just that's been a lot of fun. But that's the frame is bringing up this part of the orchestra.

MURO: From the art of adoption. Oh, so how are we doing on AI R&D in that context? Right. So again, the the industrial focus in the great labs of big tech, you know, is especially significant here. What is how are we doing. And balance balancing that or offsetting it also with public sector investment.

PRABHAKAR Yeah. Yeah. And you are absolutely right that we are at a moment where this, this particular huge surge in AI capability has come from big tech companies who are plowing billions of dollars into massive compute, which has driven the generative AI era, that came on top of a foundation that was laid across literally six decades of public and private support. But but tracing all the way back to DARPA in the beginning of the term artificial intelligence. Exactly, exactly. And I'll tell you, you know, a decade ago, I was leading DARPA during the Obama administration and machine learning, this era of of machine learning driven. I was already bursting on the scene. Ironically, a decade ago, we were like, oh, it's not that good at dealing with speech and translation and text. That's that's what changed for generative AI. But even a decade ago, it was already phenomenally valuable for looking at patterns of cyber intrusions or, sorting antibodies from a survivor of Ebola to look for the antibodies. That would be good treatments. So I found we were using it in so many different ways in research even then and, and, and now to come to this moment. So public private investment in AI is huge. It's visible. It's it's, shaping a lot of the discourse. And it it is critically important because those tools to generate images, to analyze text, to generate text, to manage video, the, you know, that's all about the language we humans speak. And so it's going to have, phenomenal implications for business and for business. Productivity, but also for the government's operations. And at the

same time, the underlying technology is also extremely powerful for all these other public missions. It may not just be large language models that we're using. And that's what I aspirations really got after. What does that look like to use AI for health. So maybe just unpack. Let me unpack one of those because I think it'll bring it to life. In health one, the area that we chose to dive into. I'm sure everyone has read these these, audacious claims about how it's going to make it really easy to design new drugs. So we actually dug into that. And the AI aspiration we ended up defining was, was an aspiration to design and approve new drugs in months rather than decades, which is mind blowing. And, what's going on? Why is this even a possibility? Well, it's actually not because of large language models. It's not about AI models that read a bunch of, research papers that are written by human beings. It's more about AI models that are trained today. If you've seen AlphaFold, it's about being able to fold proteins. It's being trained on biological data. That's that. It's making huge advances on that side. If you want to build biological molecules that work in the complexity of the human body, what you really need is clinical data. And a lot of that, there's a lot of clinical data. It's, voluminous, it's messy. And most, most of all, it is locked up. It's mostly owned by pharmaceutical companies from all of they're successful, but many more failed clinical trials. And so if you really want to achieve this huge advance in designing drugs that work for solving unsolved diseases, you actually have to figure out how to train on a bunch of data that you can't get your hands on, so that. So you start to see what's what, what some of these really tough challenges are. Well, it turns out designing drugs without figuring out how to change how you approve them doesn't really move the needle that much.

MURO: To force the issue.

PRABHAKAR So so then you get to, well, what would it take for the FDA to change how they approve drugs? And when you get FDA to the table and now we're come to the government's role because pharma companies can do whatever they would like to push the technology forward for design. But ultimately, it's the government's role to say, yes, this drug is effective and safe. That's the FDA. And so the reason I think we now have a real path to these kinds of huge advances for new drugs is because ARPA-H the new ARPA at, at for health that President Biden started, ARPA-H is putting together a program that offers the prospect that, the FDA would actually use AI models as gates into an accelerated approval process, even just the early stages, like agreeing on toxicity for for a new, a new compound. And that is bringing pharmaceutical companies to the table with a willingness to to find a way to have their data trained on. So just I wanted to unpack that because it gives you, you know, this is not you just show a bunch of data or data to a model.

And magic happens. It's a lot more complex. And it gets that these public missions, and I think it's an example of the big things that are going to be.

MURO: So briefly, where are we in terms of the budget balance between private and public investment? And then I want to get into, you know, some recent, recommendations of quite large, step changes on, on, on the public side.

PRABHAKAR On, on AI specifically. So again, within the federal R&D enterprise, when, the cross-agency effort that does the accounting looks at it, they roll up about 3 or \$4 billion a year that's being spent on AI, R&D. Pretty modest. And it's been you know, it's been at that level growing modestly for quite a while. So we're not seeing yet a big surge in public spending again, partly because budgets are constrained. And then in contrast to this public the private investment that's just skyrocketing. That's where we are today.

MURO: And do we have a rough figure for private sector?

PRABHAKAR And I've seen numbers that are all over the map, and a lot of them are, you know, it's R&D expenditures. And then you have to figure out how you account for all the compute, but just as a benchmark, the most, but the leading edge models that we're seeing today, the amount of compute that's being put into them is in the billion dollar range. Right. And that that's, that's, that's literally servers that are churning away. And so add to that, people with quite, quite handsome salaries, large numbers. So it's, it's a very substantial multi-billion dollar and accelerating investment.

MURO: What do you make of the large suggested numbers have been put forth by the National Security Commission on AI, and endorsed by the Senate AI working Group, which is an interesting exercise. I mean, they call for a move, what, from roughly 3 billion to 32 billion a year? What do you think of that? How do we get there? It's not the right call. And what are your priorities?

PRABHAKAR That is exactly the direction that we need to move. And, it's a substantial additional investment. Let me put it in context. First to think about the fact that we spend nearly \$200 billion a year on R&D across the federal government. So percentage wise, that's about the right size. It needs to be a sizable percentage if we're really going to seize this moment. I also want to put it in the global context, because what we know is that, every other country is racing to use AI to build a future that reflects their values. Those are

not always our values. You can look at what China is doing to use AI to create a surveillance state. Just just what they are doing. The 13 million Uyghurs, and the way that their lives are being controlled through these technologies is astonishing and really quite horrific. It's those are not the values that we need to be that we're going to express when we use AI. But I think we've done great work to get I started on the right track for managing risks, but we have not yet, as a country, made the significant investments it's going to take in R&D to realize these huge benefits. I am very happy to see those, that kind of focus, thinking about what it will take.

MURO: Very good to just get you get your view on this. I want to open it up in a minute, but, one one more question. That sort of is two, you know, our work at Brookings Metro has explored significant gaps in the geographical and demographic inclusivity, not just of the AI sector, but the the R&D system as a whole. We think those are important for maintaining consensus in this country. So I wonder to what extent are those priorities, you know, important for your thinking as you look, look at this and advise, you know, the next you know, the the current administration. Super important.

PRABHAKAR Super important. We've been talking about federal R&D as a whole. We've talked specifically about AI. But I want to come you know, what I pay a lot of attention to is are we investing at the right level in federal R&D? And equally critically, how how are we exactly. Because both of those matter. And I'll tell you, our our old paradigm was let's invest in basic research and then good things will happen. And they did in certain parts of the country to the great, enrichment of, of a small number of people. And a lot of other things did not happen. And one of the things that did not happen is we did not pursue the great American objective of creating opportunity for absolutely every person, regardless of their social circumstances and regardless of their geography. And and we are seeing that manifest. And, and I think some of the deeper problems that we have as a country today. So part of what we are doing in this era of federal R&D is getting after that issue. And a very specific I think, very important part of that is, is the first new directorate at NSF in three decades. It's called the Technology, Innovation and Partnerships Directorate. It was created under this president. It's authorized it's had some initial appropriations, and it's off to, I think, a very strong start. A keystone program for that directorate is regional innovation engines. And it is all about, going to giving communities across the country a chance for them to figure out what what they see as their greatest economic opportunities out ahead based on what they know and their geography, the companies that they already have, the what's bubbling in their universities because we have amazing university research across the country. And and so today, with that, with the great start that NSF has made with regional innovation

engines, we have nine of these engines around the country. They have each been funded at \$15 million for the first two years to get started. The if budgets can hold. And this is why this is what happens when budgets are at risk. If budgets hold, they can each get to as much as 160 million over ten years. That is real money that's going to help companies and universities and community colleges and labor organizations come together. And if it's in North Carolina, where we have one of these, regional innovation engines, that is about high performance textiles and a circular economy for textiles, building on decades and centuries of expertise on textiles. If it's in Arizona, it's about water, which is life and death in a place like Arizona. So it's it's very localized and it's driven by these communities. But when you go visit these places and you meet people who are working in an hourly wage job, but going to a community college, getting an apprenticeship in a business that might have really promising prospects going out ahead. And you can see how it's starting to change people's lives. You start to see that connection between the investment and innovation, and then the thing, you know, the whole point of the exercises for people to lead a better life.

MURO: And I think important that it maintains the generations long consensus around new technologies in this country, which has threatened potentially. Well, let's, I think we have a couple of minutes for a few questions. Let's see, why don't we start here?

AUDIENCE QUESTION: Hi, I'm Bob Hershey. I'm a consultant. Could you tell us a bit more about these regional programs?

PRABHAKAR Absolutely. I love these regional programs. I'll tell you more about those for sure. I mentioned that we've gotten a good start with nine. I want to point out that there are also 59 different regions that have gotten smaller planning grants. And so, you know, you have to start that this is a vast country. And I think the opportunities to build these kinds of activities is going to, if we can keep nurturing it. I think this can blossom in many, many places. You know, look, some of these are going to be good little efforts that do a few good things. A few of them can really turn into major economic hubs that really have transformative effects. We've seen that in Research Triangle, we've seen in Austin, we've seen in other regions, and the federal encouragement when when people already are on the ground trying to, you know, breathe life into this. I think that can be a really valuable partnership. So it's something I'm very hopeful about.

MURO: Right. Well, back here.

AUDIENCE QUESTION: Yes. My name is Roger Cochiti. I'm an editorial contributor on technology policy for The Hill newspaper. And as background, I spent much of my career with technology driven, R&D driven companies COMSAT, IBM, Verizon, and part of that was in the front lines dealing with investor relations. So my question draws a little bit on your private sector experience, which is there seemed to me to be two dilemmas I'd ask you to comment on, and one private sector R&D, spending the first best epitomized by a comment a major investor made to me about my company spending money on broad R&D, and that is that this is foo foo dust. And if your management team can't get rid of it so we can increase the ROI, then we will find a better management team to do it. In other words, justifying it to investors, especially raters especially, you know, private equity who can say, I can make this company saying I can make it profitable? Is dilemma number one. Dilemma number two is that most of the companies that generate a lot of the, R&D spending you were quoting are what the FTC would describe as monopolies. We can only look back to Bell Labs and IBM research. You know, when you're a big, big, big company and don't have to worry about your quarterly returns, you can spend money on broad R&D. Very few, startups even obviously nobody in stage A, B, C but but once you've reached the point that you are business, telling your shareholders, well, we need to spend a lot of money on R&D because we need to plan for the next 25 years or something like that. It's very difficult for a startup company. So how do you avoid the two traps of number one? Raiders looking at this as a waste of money and telling other investors and shareholders and number two, smaller companies just simply not being able to do it and it being the domain of the, of the biggest, companies. Thanks.

PRABHAKAR I thought that was that was a beautiful exposition of some, some of the dynamics that happen in private sector R&D. I really resonate with your first point because I was briefly CTO of a publicly traded company. So I had the R&D budget, and I rapidly realized that every one of my CEOs management meetings was about how to make the numbers, not next quarter, but this quarter. And the only thing I could do to help make the numbers this quarter was to spend less. So that was not very satisfying. So there are industries where those pressures are very real. And and it and it does drive to only spending R&D on the things where, where revenues and profits are tangible, where they're, they're very, very visible. And I think your point about, bigger companies, it's really are big tech companies in the IT industries. Who are they are the ones who are driving this rapid acceleration of US R&D spend, mostly private sector spend. Our manufacturing industries and our pharma industries continue to be R&D intensive, but it's really only our IT industries where they've just zoomed ahead. And I think it really does reflect your point. I will tell you that the bigger overarching issue in my mind is that even for those companies, at the end of the day, if those R&D investments aren't turning into profits and growth, they're not going to continue. And actually, I think we're at

a moment in AI, where the excitement of last year, you know, we're in the hype cycle, right. And so, so some of the noise is going to get washed out. And what that looks like is there will be some places where people will retreat on R&D spend. So all of that is going to happen in the private sector. But to me it underscores that it's only the federal government. It's only we as a public that are going to support the research that is long term in nature. That's the deep foundational research that reaches across every part of the country, not just where people have business operations. And those are the elements that we have to make sure that we continue to nurture because of all these dynamics in the private sector.

MURO: I think we have time for one quick question. Who has the shortest question? Okay. All right. Back here. Yeah. Yeah, sure.

AUDIENCE QUESTION: Thanks. Well, I'll try to keep this short then. Basically, it's been awesome to hear all about, your excitement about the opportunities for innovation and to keep, as you said, harnessing the benefits. But to your earlier point, part of the calculus is also balancing and managing the risks. So how do you and others in the federal government feel about how to strike an appropriate balance between the benefits and the risks? And how do you feel about, say, California 1047, other efforts at the state level to, take a more aggressive regulatory approach to AI innovation, especially in the states where, that innovation is most active.

PRABHAKAR Everyone asks me if I'm for AI or against AI, and I just think it's the wrong question. I want us to be aggressive about managing the risks, and I want us to be aggressive about seizing the benefits. And I actually think they go hand in hand because right now, many people in this country don't trust AI. And our some of the polling still shows, I would say, somewhat more fear than hope in the United States. And until that trust is there, we're not going to realize its business potential, and we're not going to realize its potential for public missions as well. So I see them going very much hand-in-hand. And I think, again, I think the president and the vice president, with their leadership have put they've charted the right course. We're doing a lot through executive action, through how the government uses AI. And I think that's exactly the right start. There's so much more to be done, including legislation. But I do think that that's on the right track. I'll also tell you, ironically, when you get to the seizing of benefits, it's in building AI systems and putting AI to work that you actually figure out what the real risks are. And, and, and you find the paths to build in the mitigation. Just to go back to drug design for a minute, those biological design tools that are going to allow us to target cancer cells better, it turns out they are the exact same bio design tools that are going to make

biosecurity headaches even worse. But if you know that going in and again, if we're playing our public role as ARPA-H bills, that program, they are going to be building in the guardrails and the norms and practices for using these powerful AI bio design tools. So that's a little bit of a sense of how I see these two proceeding together. I want to come back to the role of R&D. I've talked about the role of R&D and putting AI to work for public missions. One of our public missions is the foundational research and AI, including the research that's going to help us make sure that AI systems are safe and effective and trustworthy, because right now, it's a pretty empirical business. We've thrown a lot of data and a lot of compute. We've built these blackbox models that do astonishing things. But the ability to trust them does not rest on a solid foundation. And that to me comes back to foundational research, which, again, is a public role that we need to be playing as well.

MURO: Very helpful. Well, that's been extraordinarily informative. Thank you so much for joining us. And, please join me in thanking, Doctor Prabhakar.

PRABHAKAR Thank you. Thank you so much. Thank you.

MURO: So Valerie will be joining us to moderate a panel. And we will reflect on your.

WIRTSCHAFTER: I think so much work. I'm Valerie Wirtschafter and I'm a fellow here in the AI and Emerging Tech Initiative and the Foreign Policy Program. We're very excited to be joined by this great panel. And I know you all have a lot of questions, so hopefully we can get to some of those for the panel conversation as well. We're joined here by Mark Muro who you've all met, and then Dr. Erwin Gianchandani, who is the Assistant Director in the Directorate for Technology, Innovation and Partnerships at the National Science Foundation, and Dr. Sujai Shivakumar, who's the Director and Senior Fellow in the Renewing American Innovation Project at CSIS. So, given timing, I would love to just jump right into questions. So perhaps, maybe Sujai and then Mark we would love to get your reactions to the conversation we just heard.

SHIVAKUMAR: So I think I think I talked to Prabhakar hit all the right. So yes, I think Dr. Prabhakar hit all the right notes in terms of what the promise as well as what we need to do to make sure that we achieve that promise. I think, you know, one of the key issues is that, while we do have, you know, what we what what might be broadly called a lead in AI, we need to make sure that our stewardship of that lead is one that captures the advantages of that lead, and also make sure that the, the, you know, the, the roots of that, of

that growth are continuing to continue to be nourished through long term support for research, development and the growth of our in our innovation ecosystem.

WIRTSCHAFTER: How about you, Mark?

MURO: Yeah. In short, but I, especially appreciated the, the, director's strong claim for the importance of public sector R&D investments, especially given the massive tilt that we're seeing in especially, AI R&D to to the big research labs, the big tech. That is a crucial part of where the nation needs to go. But I just don't believe that a passive approach that relies too heavily on the private sector, on this one, to drive innovation and determined research agendas, you know, will win the strategic competition we face. But also, leverage these technologies sufficiently for the national good. I just don't think our history suggests that passivity is the right stance. So we need active shaping of the technologies and sectors to help us solve national chart challenges. In addition to the challenges that the companies want to solve, develop varied use cases, maintain safety, and foster regional and social inclusion, those things won't necessarily happen on their own. And to the extent we can find a way to complement what Big Tech is undertaking on its own right, we will be much better off.

WIRTSCHAFTER: Thanks so much. And Erwin, maybe kicking over to you. So we talked a little bit about it's not necessarily a perception but a reality. That much of AI innovation is really being driven by the private sector. So curious, you know, and we talked a little bit about this as well as how stark that imbalance is. And then perhaps, and the director hit on the regional innovation engines that are part of your directorate. But talking a little bit to us about what the NSF is doing around AI, R&D, we know that there's the national artificial intelligence research resource, the pilot phase. How is that going? What are some of the things that you all are working on?

GIANCHANDANI: Yeah. So first of all, thanks for having me. And great to be here with all of you today. I only caught the tail end of the director's comments, but I think one thing that, you both have alluded to and that I heard her say, that sort of is and very much in line with the way that we think about things, that NSF is the belief that it is absolutely the case that private sector investments across emerging tech and including in AI have soared over the course of the last decades. Right. If you go back 3 or 4 decades ago, for instance, it was the academic. It was the academics, supported largely by the federal government, where, the vast majority of the investment was, was based. And today that has absolutely flipped. The pendulum has

absolutely flipped. But Director Prabhakar noted, I think at the very end of her remarks that, it is also the case that the private sector investments and I think it was an answer to the question from the gentleman in the back. Private sector investments really are grounded in, you know, what is the product at the end of the day, what is that profit that? And how do we grow that profit margin into the future. And I think that is an important to. Distinction. That is the important distinction to draw here, that our investments out of the federal government, out of the National Science Foundation, which has long been a leader in artificial intelligence R&D and in all of the emerging technology areas, for that matter, really are instead grounded in what are the foundational questions that we should be asking that can give rise to the innovations that enable that private sector R&D and that private sector growth potential? Ten, 15, 20 years from now. And as much as we through my directorate the Technology Innovation Partnerships Directorate, want to accelerate that pace of discovery and innovation. It is it is absolutely the case that that starts with the federal government and with federal investments. So to answer your question briefly, in terms of the things that we're doing, you know, when I think about the portfolio that we have in artificial intelligence, I really try to cast sort of three key thrusts around that. One is around the investment in research, the research and development activities. You know, over the course of the last, several years, a couple of very visible, prominent investments that we have, the National Artificial Intelligence Research Institutes or AI Institute's program. We started that in 2019 a little bit on a whim at the time, and today we have invested on the order of a half \$1 billion, comprising investment by NSF, the US Department of Agriculture. The private sector has actually partnered with us on this program as well, to be able to support institutes all across the country to really drive, the foundational research questions, as well as the use cases in agriculture and transportation and in meteorology and so on. Similarly with the engines program really trying to catalyze regional innovation, trying to really harness the geography of innovation that exists all across the country, the demography of innovation that I guess exists all across the country. The challenges that we face that are unique on the West Coast versus the South versus the Northeast and so forth. So seven of the ten inaugural engines that we funded back in January are, in the AI space or intersect with AI. And I'll note that that was \$150 million investment by NSF. It has already unlocked more than \$350 million in private sector, state and local government, matching commitments. So a 2 to 1 match on the American taxpayers dollar. So there's the research dimension. You talked about the NAIRR the National AI Research Resource. So that is, an effort that NSF has initiated going back to about 2020, when Congress authorized a task force to really look into this effort that NSF co-chaired with OSTP. We've initiated a pilot. It's \$30 million. It is, candidly, a drop in the bucket relative to what the task force articulated was the need here, on the order of \$2.6 billion over 5 or 6 years of support for the research resources, the, access to compute the access to data sets, the software workflows, the, the technical

prowess, the technical capability of being able to stitch all of these resources together and federate them. But the pilot is underway. We've funded, on the order of more than a couple of dozen projects. At this point, we have, more than a couple dozen companies that have partnered with us, contributing, more than that, \$30 million as a match at this point. So in, in compute cycle. So I think we're excited about at least being on the right trajectory, subject to what Congress does in '25 and '26 and so forth. And then the third piece is workforce development for us. We're known as a research agency. But you can't do research if you're not thinking about the workforce. You can't do any of this, frankly, in STEM if you're not thinking about the Stem workforce. And so at all levels, you know, not just graduate students and postdocs, though we certainly have a graduate research fellowship program that we're proud of. But technicians, practitioners, entrepreneurs, educators, K through 12 community colleges, technical schools, thinking about what are the rigorous and engaging curricula and instructional materials, how do we train the faculty and teachers, to teach to that curriculum, instructional material? How do we really meet people where they are at the end of the day and entice folks to engage in, in, in AI and, and the, the fruits that are the benefits that come from that across a whole myriad of sectors as well.

WIRTSCHAFTER: That was great, super thorough, and a lot of sounds like a lot of interesting stuff going on. So maybe to you, Sujai, I know you had a report come out recently. Or at least I recently saw it. So I'm curious, especially in terms of the US in comparison to other countries. And I think the report that you wrote was with China comparing China and Chinese R&D. And I know that the director talked about this a little bit as well, but I wonder if we can maybe dig in a little bit to what you found in terms of where the US stacks up in terms of public investment in AI and where the gaps are, where the successes kind of what does that comparison look like? Maybe a level deeper.

SHIVAKUMAR: Yeah. Thanks. You know, the when, Dr. Prabhakar was speaking. She mentioned that the US spends about \$800 billion a year, private and public, on research and development. I think the Chinese number is about 680 billion. What's different, though, is that the US spends a significant part of that, at least the public part, on basic research. The Chinese budget is very much more on the application part of the development and commercialization. Where do they get their, you know, up their feed in from? It's basically, the fact that, in the United States and around the world, the norm is that scientific research is a public good. We we we spend money on this research. If we put it out for the public? They absorb this information. They are much more focused on developing and commercializing it, both for the market as well as for their military applications. So there are two things that we need to do. One is we need to improve our absorptive

capacity of our own research. We have a innovation system that is healthy and parts and not so healthy in other parts. A primary, agent of actually eating away at the robustness of our innovation system was the fact that we basically offshored a lot of our manufacturing. Manufacturing is actually the hub. It actually connects our research infrastructure, our education infrastructure and, you know, research and development infrastructure, our workforce infrastructure and so forth. A lot of that, the impacts of that on all the other parts of our ecosystem is now being felt. And so when you see what's the chips and science actors doing, and the investments in programs like TIP, what it's doing is actually encouraging manufacturing to come back. That, in turn, was putting a lot of pressure on issues like how do we develop the workforce, how do we, update our, regulatory system? You know, to allow for rapid permits, a whole series of issues that we haven't grappled with for some decades are now being thrust forward. The other part is, how do we connect more effectively the different parts of our ecosystem? This is why the partnerships issues that has not been focused in, in Irvin's directorate is so critical because you can have a lot of all these different activities going on, but unless you connect them, it doesn't the you need to connect them in order to make sure that the some is more than just just the, you know, a quick some of the parts. So the, the sort of activity, though requires a long term effort. You can't just do this for two years, five years and then have the whole process being, you know, rethought of when NSF is celebrating its 75th anniversary next year. When NSF was established in the 50s, it wasn't set up for five years. It was set up for the decades because, part of the effort was to win the Cold War, and that was thought of as a decades long effort. Similarly, we have a new, you know, new reality in the world. We are not only competing, competing militarily, we are also competing for our economic security. And that is going to be, again, a decades long effort. The Chinese have a long view. We need to develop in our political system a long view approach towards consistency and the long term approach towards building these partnerships that connect more in a more healthy ecosystem that not only delivers in terms of, you know, technological applications, but a much more inclusive one, which is the other point that the that, Dr. Prabhakar pointed out.

WIRTSCHAFTER: Super. So cognizant of the time and the number of hands that I saw in the room before, I'm going to bundle a question for the two of you, which is about gaps in funding. So I know, Mark, you've been very vocal in a lot of your research about the lack of resources devoted to the science part of the Chips and Science Act. And of course, the NSF has been on the receiving end of certain budget cuts. So I'm wondering, you know, in terms of the impact of these types of gaps, what kind of impacts are happening? What does this do for the government's ability to foster innovation, to invest in these types of big ideas? So

maybe we can start with Erwin and then go to Mark, and then I'll open it up for questions. Let's see. Oh, we'll go with Mark and then Erwin.

MURO: Okay I'll, I'll just say a few things. I mean, first, we are directionally moving in some of the right directions. And that is gratifying. But there are in some ways, the the, commitments are not being fully delivered on even now. For instance, on the N science part of chips, you know, there's significant, appropriations shortfalls beneath the approved levels. In some cases, such as the tech hubs that hobbles the concept of the the. Idea, which actually was. It calls for sustained, very large scale funding, right, to drive particular region based, transitions forward. So I think that. There's a lot to be concerned about here, even though we also finally can see some of the right directional moves. There is a disturbing historical precedent for underfunding over sustained amounts of time in the American Competes Act from, you know, 2007 and the decade after that where there really we never made the target. So I think that's really an urgent time right now to really be, identifying the directions, which I think we now have in front of us, many of them even models. But we need to make sure that we're delivering. Yeah.

GIANCHANDANI: I didn't mean to put Mark on the spot, but I figured he'd give sort of a broad brush strokes overview, and then I could dive in a little bit on NSF. To answer your question. Yeah. So so a couple of things I would say, first of all, I think it's worth noting, and I don't say this in jest. Right. I think it's just worth noting that almost on the same day, almost to the same day that the president signed the FY 24 appropriations package for the federal government, the discretionary part of the package, the NSF budget this year went down about 5 to 8%, depending on how you count, depending on how you do the math of last year's appropriations bill. And almost at that same exact moment, the People's Republic of China was announcing an investment that was augmenting at the level of, \$10 billion over the course of this next year in AI and quantum information science. Right. So I think that that goes to show you that, yes, we have this sort of chronic underinvestment when it comes to authorization levels versus appropriation levels that we need to be mindful of. But I think also we are facing a very particular moment in time that isn't quite what we saw in 2007, maybe isn't even quite what we saw in 2017 with the ICA, the American Innovation and Competition Act. When it comes to this particular most recent authorization around chips and science. I also would argue that, it's it's worth noting that what chips and science was able to do, the and science part is what I'm going to focus on in particular is something that we don't do every day, even here in Washington. Right. We've established a whole new directorate at the National Science Foundation and codified it in law. The last time we established a new directorate was more than three decades ago. Think about where you were three

decades ago. Okay. And then in addition to that, not only did we we codify it, but we articulated a set of investments through the TIP directorate, like the engines program, like entrepreneurial fellowship, like the key technology areas that really are critical at the end of the day, to ensuring US competitiveness. It's a whole new approach to sort of industrial innovation. And to Suja's point from earlier, it talks to the point of how do we bring together the private sector and philanthropy with the federal government, with state and local governments, with tribal nations? How do we really harness that full potential? Because and we talk about it a lot in my in my field, one of my fields, I was an undergrad in computer science when I was getting my undergraduate degree more than two decades ago. It turns out that three quarters of all PhDs in computer science at the time would go off into academia. Today, three quarters of all PhDs in computer science go everywhere but academia, right? So it's imperative for us to be able to build the opportunity space for the Nexus, for the for the cross-sector synergies, as the director talked about, as Sujay talked about and Marcus talked about, to really be able to, help address the challenges that we face. So I think the the budgetary shortfalls are incredibly problematic. You know, every year at NSF, for instance, there's a couple billion dollars worth of projects that are about as competitive as the projects that we are able to fund that we just can't get to because of appropriations shortfalls. And that's just today, back today, without doing anything special. That's that's the budget shortfall. And that is lost opportunity. That is, you know, those folks are also going to think about where can they get funding elsewhere if they can't get funding from NSF, if they can't get funding from the US government? This is a national security issue in in our estimation, as we think about today and looking forward. But despite that sort of concerning posture, I think we also have to remind ourselves that this is a huge moment in time, more than a generational opportunity with chips and science that we all have to seize upon as we go forward. All right. I will open it up to questions for the remaining at a time that we have. So please raise your hand. Maybe we could take a couple at a time. We could start here and then go in the back there.

AUDIENCE QUESTION: Hi. Thanks. My name is Shiv, and I'm a researcher at Duke, an Intel fellow. And one thing we saw with the chips industry was that US did develop that expertise on the software side. On the design side. But after three decades There were a big supply chain risk more upstream may come to critical minerals, may come to production, and so on. Similarly, with AI. It seems like a lot of the R&D. Is going into the software. And as have seen with Nvidia. A lot of private investment is also Focused on hardware, because that's a very crucial part of how these models are being trained and where data centers and data farms are being built. But given that when these farm data farms are being built, the cost of energy and other regulations also come into play. How is the U.S. federal government, in terms of Polish policy shift, assure

that these we won't hit that ceiling again. Where maybe a decade down the line, we have the software expertise, but we cannot translate that to actual productive products, because either the data centers are not in the US or we face other hardware issues.

GIANCHANDANI: Can I just take a quick swing at that question? That's a great question. A couple thoughts that I would say, because I think you raised a really, really important point just in the way you frame the question. And then I'll answer your question. You know, in the same way that a few years ago we woke up and we, we realized that we had these supply chain issues and semiconductor challenges. Right. And we instituted the Chips and Science Act to try to course correct. My big worry is five years from now, ten years from now, at some point in the future, maybe it's even sooner than that. We wake up one morning and we have those same issues, not just in semiconductors and chips, but in AI and in quantum and in biotechnology and so forth. I think that's really what's on the line here. To answer your question specifically in terms of what are we doing today? So I will tell you that it is absolutely the case that we have investments across our portfolio that touch on not just the software side, which we tend to talk about a lot, and the intersectionality between AI and agriculture or AI and health care or AI and transportation, but also on the hardware side that undergirds the feasibility of being able to achieve that. For example, there's, one of the ten engines that we funded earlier this year is down in Osceola County, Florida, and it is specifically looking at, advanced packaging and advanced packaging to help with thinking through the next generation of AI systems that can leverage that, future chipsets and packaging capabilities. So, and that's, that's potentially \$160 million investment by the federal government over ten years, subject to appropriations backstopped by additional funding and matching commitments that have come to the table from the state, from the local county and from others and local industry as well. So I think that we are trying to look holistically, but your question also speaks to the importance of not just innovating in the hardware space, but making that hardware accessible to researchers across the spectrum so that folks all different parts of the country can have access to the resources. That's what the NAIRR is all about. And that's why I think the create AI legislation that's been proposed on the Hill is so important, building off of the work of the task force.

AUDIENCE QUESTION: Hi, I'm. Jeremy Swank, I'm the co-founder and CTO of a startup called VERBA AI, we focus on leveraging AI to detect misleading narratives, AI generated content, things like deepfakes. And cheap fakes. As the leader of a startup, you know, really excited about this kind of renewed public investment in artificial intelligence. I'm wondering kind of the relationship there to not just AI, but also AI and its relation to trust and safety, a verb for AI when it comes to detecting something like deepfakes we've

realized that, you know, just creating the most powerful model or using, you know, the most amount of compute, compute is not necessarily the biggest differentiator there. So I was wondering, you know, as the leader of a startup, how we can best leverage the resources out there and how those resources are kind of oriented towards the trust and safety angle.

WIRTSCHAFTER: Cognizant of time. Maybe we had one more question, and then we can we'll do it right here. And then we can answer both of those and we'll wrap up right here in the front.

AUDIENCE QUESTION: David Lockett, co-principal investigator, School of Applied Computational Sciences. I serve on the Computer Science Teacher Association policy committee. What role, if any, does computer science policy play in Artificial intelligence, and will that spearhead additional funding for future initiatives? So I know you touched on that briefly. So.

GIANCHANDANI: Okay. All right. Okay. So let me let me take the second question, and then. I'll ponder the first one and come back. We won't forget about you. So, so I absolutely think that, organizations like CSTA and others that have, I think, paved the way to. I mean, let's just let's just remind everybody that ten years ago, versus today, the change that we see in high schools across the United States in terms of the adoption of computer science as, of course, the adoption of the AP Computer Science Principles exam. I mean, it has completely changed the landscape in terms of who all is taking these courses and who all is benefiting from these courses. I think one really impressive stat that I that I love to tout, for instance, this is like my one moment to brag about NSF if I can, is a \$10 million investment by the National Science Foundation's Computer and Information Science and Engineering Directorate, circa 2008 to 2015. It was under the leadership of a program officer, Jan Cooney. That effort resulted in a new AP exam framework and coursework that was disseminated across the country. And in 2016 2017, when that course was deployed, it became the single largest launch of an AP exam in the College Board's history. More than 55,000 students took that exam. Today, more than 150,000 students take that exam every year, and the numbers of women, Blacks and Hispanic students and test takers have tripled relative to where they were beforehand. So I think that, it starts with and we recognize that AI is a multidisciplinary area by definition. But I think and we talked about some of the security and trustworthy aspects, but I think it's absolutely critical for us to think about, okay, at the high school level, I mean, you got to engage folks early on or you lose them, right? So at the high school level, what are the, rigorous and engaging curricula and instructional material that we should be thinking about? And that's grounded in research, and it's grounded in collaborations between researchers

and practitioners, including teachers. Just one other quick comment to the to the, CEO of a startup in the back. Congratulations and keep up the work that you're doing. I think, I think that what I would say to you is, you know, when we talk about some of these, resources that we're trying to make available that we're trying to unlock, we have been very intentional about keeping the startup community in mind. It's not just about the academic enterprise. It's also about thinking through, startups and small businesses and how can we support them. So the NAIRR, for instance, is meant to I was in the task force report unlock resources for colleges, universities, as well as the startup ecosystem. And I encourage you to take a look at that.

MURO: And I just add really to both questions, the importance of regional delivery as well. The people, the talent, the technologies really are latent in places. They're not the only source. Obviously, we we you can argue that we're doing just fine with just a few, you know, front, front line, innovation centers. But I think for both of these purposes, like making sure that there is at authentic leading edge activity research and training in, at the regional geography is extremely important to reach different kinds of people.

WIRTSCHAFTER: Well, excellent. We are over time. So thank you for being with us. Thank you all for joining us. I had many more questions that we did not get to, but I'll be sure to, you know, ask them at a later date. This was wonderful and I'm so grateful for your time, and I hope you have a wonderful rest of your day. Thank you for joining us.