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RESEARCH AND DEVELOPMENT FOR THE PUBLIC GOOD:
STRENGTHENING SOCIETAL INNOVATION

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P R O C E E D I N G S

MR. WEST: Good morning. I'm Darrell M. West, vice president of Governance Studies at Brookings. I'm pleased to welcome you to our webinar on R&D for the public good.

Investing in research and development is one of the most important things that we do. In 2020, for example, the United States spent about $708 billions on R&D that figure is from the National Science Foundation. Most of this money, $517 billion came from the private sector with about $143 billion coming from the public sector.

And this is a big change from 40 years when the public and private sectors devoted roughly the same amount of money to R&D. But over the past four decades, private investment has skyrocketed as a percentage while public sector investment has grown at a much smaller rate.

At one level, there's nothing wrong with businesses having primacy over government in R&D spending. America has a vibrant private sector that enables business leaders to scan the landscape, decide where the investment opportunities are and position their firms for a future growth. Yet at another level, there are problems with the bulk of R&D money coming from the business community.

So for example, vital national interest may get overlooked to the detriment of the overall country. Profitable consumer products likely will get advantaged over unprofitable societal innovations even if the latter are important for public health and national security. And then finally, innovations that need to get financed in order to promote longer term public goods may receive short (inaudible) over items that promise a quick payoff.

In recent years, we've seen business leaders outsource key products and components to other nations such China, India and South Korea. As an example, the semiconductor manufacturing sector largely has been outsourced to Taiwan and South Korea. The same thing has happened with medical supplies and drugs. Many of these items are manufactured in India and China. And during the pandemic many American healthcare providers found it difficult to get the personal protective equipment and the pharmaceutical medications that they needed.

This week, Brookings has put out a paper that I wrote entitled "R&D for the public good, Ways to Strengthening Societal Innovation in the United States." And it analyses the current situation and makes a number of recommendations in order to improve the status quo.

So for example, I argued we need to boost public sector investment in R&D. We need to use federal money to address geographic inequalities. That we need to deploy R&D to help with climate change. We need to elevate equity as an allocation of principle in a way that we're using federal money. We need to provide greater flexibility to state and local governments because they often are closer to what is needed in their community and have a better sense of how to use the money. And then we need to devote money to train the next generation of STEM leaders.

So if you want more details on the paper, it is available free of charge online at brookings.edu and I will refer you to that site if you need further details on that.

To help us understand these issues, we're delighted to have two distinguished experts with us today. Carol Robbins is a senior analyst in the Science, Technology, and Innovation Analysis Program of the National Center of Science and Engineering Statistics at the National Science Foundation. And that is the part in itself that actually compiles R&D data, and they provide a tremendous resource for researchers who are interested in looking at those tends.

And then also with us we have John Villasenor who is a professor of engineering at UCLA and also a nonresident senior fellow at Brookings.

Now if you have questions for our panelist, you can email them to us at events@brookings.edu, that's events@brookings.edu or Twitter at @BrookingsGov by using #USInnovation. So we're happy to take any questions that you have.

So I'd like to start with Carol. I mean you analyze R&D data from the National Science Foundation. What is covered by federal funding right now and how do you assess the long-term R&D trends? Robbins

MS. ROBBINS: So one of the issues in terms of the difference between business funding and federal funding that you've described has to do with the fact that business funding has increased at a very rapid rate. So 90 percent increase over the past 10 years. And the federal funds for R&D have increased but at a much slower rate.

So what that means is that you see that dramatic shift in the shares of total spending that goes on. One of the things that I think is most important about federal funding is that federal funding is the primary source of funding for basic research, right? It's conduct in universities and in federal labs.

But the money is coming from the federal government.

Now, it is true that business has increased their share of basic research, but not to the extent to make up for that which comes from federal funds. And so, I really do think that when we think about basic research, that fundamental engine of growth, those monies are still coming from the federal government.

MR. WEST: Carol, just a quick follow up question on that. Are there areas that you think need more investment?

MS. ROBBINS: So actually, that's a little bit outside of my portfolio. I can tell you where the federal funding is going and a lot of it is going into areas of health and biotechnology. And of course, we've seen the great benefit that has come from the human genome project.

I think that the National Science Foundation has taken a direction to expand what they call the geography of innovation and make sure that the benefits of federally funded R&D are spread more uniformly across the country. And there have been several programs that have been stood up recently to address that need.

MR. WEST: So, John, I would like to bring you into the conversation. And we know that much of our current R&D comes from the private sector and that that has generated lots of new products and services. But are there things that are not being covered by businesses that would benefit the entire society? John, you are on mute. If you can unmute yourself, please?

MR. VILLASENOR: Thank you. Businesses tend to fund research that logically enough they see as furthering their goals as businesses, which means that they're less likely to fund things that might be very important on a societal level but doesn't directly impact the business.

I'll give you an example that you and Carol both have sort of alluded to it. The infrastructure of things like the integrated circuit, the chips supply. Critical infrastructure in the United States. There's just an array of areas where there's a very strong need for advancing the technology, but it may not be directly within the portfolio of corporate R&D funding. And that's an area where I think the United States government funding can play as an absolutely vital role.

MR. WEST: So, Carol, one of the goals of R&D is to spur innovation, but sometimes we're not entirely sure what we mean by innovation. And then also how we should be measuring

innovation. So I'd be curious of your thoughts on what we mean by innovation and how we can measure.

MS. ROBBINS: So, Darrell, I think that's a really interesting question especially given the topic of this discussion. When we're thinking about innovation, the data that we have in the federal statistical system comes from very high-quality business surveys.

And firm businesses are asked, have you introduced a substantially new product or process in the last three years? And we have really good information about that. And what we can say at the industry level is pharmaceuticals, chemicals, computer industry, very high rates of introducing these new products and processes.

What we don't know as well is about the innovation that is taking place in universities, governments and in households. And so, when we think about those benefits, we just don't have the knowledge or the tools at the current moment to see the innovation that's going on in the government. And yet, we know that it's there and we know that investment takes place perhaps 20, 30 years ago and leads to great advances now. For example, all the work that was done, as you mentioned, in your report on the vaccines and the human genome project.

Clearly, that's an example of very strong government innovation and we don't have measures for it. So we just don't know.

MR. WEST: John, I would like to get your thoughts on that as well. What would be meant by innovation and how can we measure it?

MR. VILLASENOR: I do a personal line of it. I teach several times a week right now in the very same building at UCLA where the very first internet message was sent in 1969.

And, you know, had you tried to measure -- and of course, as everyone I think knows that was funded by the government, by the Department of Defense. And had you tried to measure the result of that funding in say, 1974, five years later or 1979 maybe people would have said, well, you know, has it really had that much impact? But of course, while the internet has had a lot of impact, it just took a few decades, right? It took until sort of the mid- '90s before it really took off on a global level.

And so, the reason I mention that is because by definition some of this basic research can take decades sometimes to play out. And if you look at, you know, the extraordinary work that was done in relation to the COVID vaccines. There was a lot of amazing work done just in the last several

years. But the foundation for that work was decades of funding much of it from the government in, you know, this sort of fundamental basic research that made these vaccines possible.

So I think it's a long way of saying one way to measure innovation is to look at sort of direct short-term outputs. You know, companies and job creation and new products and things like that. But there is a segment, a vitally important segment, of the results of these investments that will not become clear until decades later.

And I think that's a good thing because government is the best place to actually fund the kind of research that can be world changing on those time scales.

MR. WEST: So, Carol, you mentioned that the federal government has introduced several new programs in an effort to diversify funding and also spread it out a little more equitably on a geographic basis.

Could you talk a little bit about some of those programs and how they operate and what they're trying to accomplish?

MS. ROBBINS: Well, I think one of the most significant ones is a new directorate in the National Science Foundation called Technology Innovation and Partnerships. And the overall goals for this are really some of the things that we're talking about. Boosting innovation capacity, create sustainable innovation ecosystems and demonstrate inclusive growth.

And so, I really do think that this is an example of the kind of translation work that we are talking about. And so, what this program will do is set up regional innovation engines to begin the process of finding translational work. So use inspired research and development. The translation of innovation with results to society and quite importantly workforce development to grow and sustain regional innovation because we know very well that the full demographic breadth of the United States is not engaged in our science and engineering or our innovation programs.

And then I think more broadly than the National Science Foundation, a very critical project that the federal government has been engaged in is citizen science. And so, citizen science is a way that people can become involved in creating and collecting data that's critical to their own lives. Whether it's in terms of environmental quality or in terms of health issues. And some of it is really the exciting stuff that might be a little bit more pie in the sky like looking at the stars.

But those kinds of things enable people to be part of the scientific process. And also, to address their needs especially when we're talking about helping the environment. And so, I think those are areas where people become engaged with researchers and innovators and can get drawn into the process. And there's growth in this activity at the federal level.

MR. WEST: And, John, I'd also like to get your thoughts on this effort on the part of the federal government to diversify funding and spread the money out a little more equitably across the country.

MR. VILLASENOR: I think it's absolutely a terrific idea. There is extraordinary human capital all over the country. And a lot of those incredibly talented people are at these emerging -- what are sometimes called emerging research institutions. Institutions that have not traditionally gotten nearly the funding support that they deserve.

And I think it's a win/win situation. I think we're going to get better innovation because we're funding more people. And of course, it's good for those institutions to grow their portfolios and to attract students. And so, it's a win/win all around. I think it's great and I'm glad that the United States government is focusing on that.

MR. WEST: And, Carol, I'm curious about any comparisons between what the United States is doing versus other nations just in terms of the amount of money being devoted to R&D. Is the United States keeping up? Or are we falling behind in certain areas? I mean what's your sense of kind of the global landscape?

MS. ROBBINS: So I think that the most uniformed way to think about the effort that an economy is making on R&D is R&D expenditures as a share of gross domestic product. And we look at that quite a bit.

I know in your report you look at federal funding as a shared GDP. And I think that an integrated perspective is a useful one as well. And the reason that I say that is that federal funding, government funding and private funding have been shown in many studies to be complements, right? They fuel each other and interrelate, not substitutes, right? Not one is better than the other. And so, when one has a robust system of both private and federal R&D that can generate strong growth.

And so, the U.S. has ranged in between two and a half to just under three percent of

GDP for the past many years. But recently, it has cranked up to three percent. So we see a bit of an increase. Now, there are economies and nations that spend more in terms of their overall federal -- their GDP. So South Korea would be one where they have a measure about three percent. And actually, China is just about where we are at three percent.

MR. WEST: John, how do you see what is happening in the United States compared to other countries? Are there other countries that you think are doing R&D differently or better?

MR. VILLASENOR: Well, better but certainly, for example, China I think has a very strategic approach to how it ingrates its public and private sector R&D. Obviously, China is very different country and the ties between the government and the private sector are very different than they are here in the United States.

But I do think that sometimes in the United States, we would benefit from a more sort of holistic kind of strategic approach to some of the R&D funding. Particularly in light of some of this sort of longer term geopolitical, you know, challenges of maintaining American economic competitiveness in a very competitive environment. In terms of, you know, ensuring that we've got good supply chain control or at least so we're not vulnerable.

The kinds of supply chain disruptions that we saw during the pandemic. Really in hindsight, that shouldn't have happened, right? We shouldn't have been in a position where, you know, first line healthcare workers didn't have, you know, personal protective equipment. That's just, you know, it doesn't make sense.

And so, this sort of strategic investments that can avoid that kind of dislocation in the future is something that we can probably do a better job of doing.

MR. WEST: So, Carol, one of the other aspects of innovation concerns human talent. And I know NSF as well as other federal agencies are devoting a lot of efforts to try and develop new talent, support STEM education and so on.

Could you describe some of the activities that are taking place there? And how that may position the United States for success down the road?

MS. ROBBINS: So I don't have a full picture of all of the activities that are going on at NSF, but clearly it's an area of great interest.

What we have started to do is really collect better data. And so, one thing that we have been working on is greater demographic richness, right? Many times, we can tell you how many R&D researchers there are and whether they're men and women. But we don't always have enough granularity in the data to tell us about different demographic groups.

We also know that people with disabilities are less likely to be engaged in science and engineering and innovation. And so, when we're able to highlight these things in the data, it gives an opportunity for policy to address this.

The other thing that we have done is we've recently put together a set of statistics on skilled workers who have less than a bachelor's degree because this breadth of science and engineering activity in innovation needs more people than just people with an advanced graduate degree.

And so, what we see is that while the skilled workforce with less than a bachelor's degree is more broadly spread in the United States than that with advanced degrees. Nevertheless, what you find is that perhaps in the middle parts of the country, you've got more of these skilled workers, less people with advanced degrees. But it tells you that there's an opportunity for growth there and for an expansion of the kinds of activities that are taking place.

So what I can tell you is about what we measure in terms of our workforce and what we want to measure better. We want to measure demographics better. And also, the geographic distribution so that we have benchmarks that policy can measure against.

MR. WEST: So, John, how would you assess the job the United States is doing in developing the next generation of talent? And are there other things we should be doing better in that area?

MR. VILLASENOR: You know, I think in general we have a really robust system of R&D and higher education. And in that sense, you know, in a kind of broad sense I think we're doing really well. Could we do better? Yeah, I think we could.

I think the focus on emergent research institutions is one example of how we can do better. I still think they're going to be people who fall through the cracks. Institutions that fall through the cracks that don't get the research support that they deserve and could do amazing things if they receive.

And I also another -- I guess the thing I would say is even if you look within the sort of

more traditional research institutions, you know, what are sometimes called the R1 research institutions. We can do a better job of engaging people in those institutions, right? I am quite sure, you know, I have had the privilege of working with amazing students at UCLA.

But I'm sure there are some students at UCLA who would be amazing and be interested in doing research but for whatever reason don't get the opportunity to or don't get connected to the research activities that are going on even at these places. So I think we can do a better job at being kind of more inclusive to -- even within these sort of traditionally institutions where you have a lot of traditionally high research activities. So there's a lot of room for improvement.

MS. ROBBINS: So, Darrell, I would like to add another point on this issue of the science and engineering workforce. And that is for many years, and this is something that we measure in our NCSCS data.

Foreign born scientists and engineers have played an oversized role relative to their numbers in some of our -- in most innovative industries. And many of these people have advanced degrees and are engineers. And so, one of the challenges is while we need to welcome these people and we need them in our workforce because they are critical. We need to also find a way to be growing our own.

And so, what we see when we look at the issues that may be related there. Is we see performance on K through 12 education in science where the U.S. is underperforming some of its advanced economy peers and challenges on engaging people to enter STEM careers and also to stay there.

MR. VILLASENOR: And if I could just add, you know, a point that's almost so obvious that I feel it doesn't need to be made, but I'll make it anyway. You know, we still suffer in STEM from a very significant gender disparity. You know, I look around my classes in engineering and, you know, it's not anywhere near 50 percent, you know, in terms of the male/female split.

And so, what that means in necessity is that we're missing out on an extraordinary amount of female talent. And I know there are very complex reasons for that but that's something that I think we should be continuing to endeavor to create more opportunities there.

MR. WEST: Yeah. We definitely need to do better on the gender front. And as Carol

pointed out on the immigrant front. I always like to remind people of these studies that have shown half of the Silicon Valley companies had an immigrant founder or cofounder. And so, the story of American technology innovation is very much intertwined with the story of immigration.

And of course now, we're in a time period where immigration is more contentious, more controversial. There are people who want to cut back on that. And I think they don't necessarily realize if we're cutting back on immigration, we actually may end up on cutting back on technology innovation just because there aren't a sufficient number of native-born American students who are going into these STEM fields.

MR. VILLASENOR: Yeah. I see this, you know, every day. And, yeah, that's just incredibly important. Not only do these people found companies but they create enormous numbers of jobs when they find these companies.

And a lot of these people who found these companies, they are some of the world's most incredibly innovative brilliant people. They can go anywhere. And if the United States doesn't welcome them then they will create their companies somewhere else. And create those jobs somewhere else. And they will. And so, that's just incredibly important.

MR. WEST: Now, we're starting to get some questions from our audience. And I do want to remind people if you'd like to ask questions you can email them to us at events@brookings.edu, that's events@brookings.edu or Tweet at @BrookingsGov by using #USInnovation.

So we have a question from Renu Fuquani (phonetic) of Discovery Partners Institute. And this individual wants to know how industry and university partners can work together in order to advance R&D? Carol, you want to talk about that?

MS. ROBBINS: Yeah, I can say one of the things that we do measure is when there is a technology transfer office in a university then not only are the data visible, right? The licenses that come, the patents, the startup companies that are based on the university's technology and we can see growth there and we can measure it.

However, technology transfer offices are not ambiguous. They are not in every university. And so, one thing that does come to mind -- and my understanding is they're not cheap things to set up. So where those offices are not in place that at least provides an opportunity to set something

up that can focus on that activity.

MR. WEST: So, John, what is your sense of how industry and universities can work together in order to advance R&D?

MR. VILLASENOR: So, yeah. That's a really important question. I would say in addition to the more sort of formal mechanisms that Carol was alluding to. There are also what you might call sort of informal mechanisms in the sense that I think a lot of industry funding is spurred by earlier government funding.

So even if there might not be an explicit collaboration, you know, once government funding has sort of provided some momentum to a particular area of research that will make it more attractive for industry people to then come in and continue that funding even though there might not be a formal collaboration.

So there's a sort of a seeding effect that happens with a lot of this industry, with a lot of the government funding, which then spurs a bunch of industry funding. And that's a form of what you might call informal collaboration that I really think is very important.

MR. WEST: So we have a question from Timothy Wojohn (phonetic) of the National Science Foundation. And Tim wants to know if John or Carol either of you have any ideas for increasing funding for what he calls Hard Problem R&D that are often difficult or impossible to raise money for from the private sector?

MS. ROBBINS: I'll let John do that one.

MR. VILLASENOR: Yeah, it's a hard question to answer. It's a hard problem question. It's a hard question to answer.

You know, I think what I would say is that whenever I've talked to program managers at places like DARPA. I've just been really impressed by the sort of very kind of almost entrepreneurial approach they had. And they know that their funding some high-risk things. And I think there is an appreciation among people at funding agencies that have the hard problems. And quantum computing being a really good example of a really hard problem. But that is getting quite a bit of research funding, right?

And so, I think if the people who are working on the hard problems can articulate the vital

importance of those problems. And again, I'll use quantum computing as an example where the importance is indisputably vital then I think the funding will flow. I think when you have a hard problem where it's harder to articulate this sort of payoff that it will solve that's when it gets harder to get funding.

MR. WEST: And, Carol, if I could extend that question just a little bit. Kind of beyond the NSF to just in my paper, for example, I suggest we need to devote more R&D to issues such as climate change, income inequality, racial injustice, government challenges. Like all the big challenges that we are facing as a society right now.

How is, you know, the federal government or the private sector addressing these societal types of questions? Kind of beyond the issue of consumer products that they might be interested in developing?

MS. ROBBINS: Yeah. So that's a really interesting question. And so, then the issue is, well, how do we measure those things, right? And what data do we look at?

And on the area of climate change, there is an area that we can look, which isn't perfect, of course. But that's patents. And of course, we know that most patents come from the business sector. Or there are many reasons why a federal government would not patent its output, right? It might want to make it openly available. In fact, often that's the purpose of federal government research for it to be widely used.

However, coming out of the Kyoto Accords, looking at the issue of climate mitigation. There was an international effort to say, how can we identify the technologies that are directly related to reducing the amount of CO2 gas in the atmosphere? Improving water quality? Mitigating different kinds of environmental damage? And so, what was done there was a patent classification system was developed that links directly into our existing system so that we can actually track over time growth in at least patented technologies.

And sometimes, you will hear some of these referred to as Net Zero patents but is actually a wonderful framework that at least gives us some ability to measure. And so, that really -- the challenge -- I find an important issue when we think about these challenges. How do we know what's happening? And if we can't measure it, it's going to be hard to have policy milestones that get met. So I think that that's one area that we can think about.

MR. WEST: Now, Troy Estelline (phonetic) has a question about universities basically converting basic research into actual products.

So his specific question is, how can we address the R&D that happens in universities and the challenges in transforming discoveries and insights into what he calls accessible socially valuable products, services and systems? So basically, how can we move from the basic research to the actual application?

MR. VILLASENOR: Well, I'll take a stab at that. It's a hard -- it's a broad question. You could have a whole separate session on that.

But I would say I think there's, at least in engineering I've seen over the years, a pretty well-trodden path of people, you know, university professors who do research on a topic and then go on to recognize the commercial opportunities that are resulting from that research and go on to spin off companies. And many times, those companies do extremely well.

So I think that's a -- and I think universities, it is important for universities to provide a climate that is subject to obviously, you know, making sure that, you know, proper dollars are spent in a proper way and all that kind of thing to encourage that type of thing. Because, you know, who better to know how to apply a technology than the people who have actually developed it themselves?

So I think that's something that has happened and will continue to happen. And there's plenty of companies that are household names now that arose from, you know, people doing work in the universities.

MS. ROBBINS: So one thing that I would add is that the funding agency can be explicit if that is, in fact, the intended goal, right? Of the funding to translate innovation results into society, right? As I described this TIP program.

However, again, we don't want to -- well, we have traditionally relied upon universities to produce basic science. And so, being clear about what is wanted from the research, I think is going to be most helpful. And segmented projects that say the intention of this is to find something that can be translated into a public use is one way to do it.

But I wouldn't want us to turn all of our attention to that and turn away from basic research because as John mentioned earlier. The benefits of this may not be apparent now. We won't

know them for 10 or 20 years.

MR. WEST: We have an interesting question from Spencer Douglas of the Defense Intelligence Agencies. So he wants to know what we can do to increase risk taking in a culture that he says is very risk adverse?

MS. ROBBINS: I'll let John do that one.

MR. VILLASENOR: You know, I guess I would say that it is certainly the case that there are aspects of university research culture. There are risks of respite, but there are also quite a few people and there's also an aspect of taking risks.

And I guess I would say also that it's very seldom that university research complete fails. What you rather it generally either really succeeds or it does decently and sort of adds, you know, kind of marginally to the knowledge of something without necessarily hitting it out of the park.

But you don't see a whole lot of object failures in university research. And I think encouraging risk taking is, you know, partly a function of the culture of the university. But it's also partly a function of the funding agencies, right? In the sense of being willing to fund, you know, they have to be, you know, if they want to take risks, they have to be willing to fail.

Like that's the definition of risk, right? Is that it may not work. And so, I think there has to be a culture in the funding agencies as well of understanding. And I think there is to some extent this culture that not everything they may find is going to live up to the aspirations of the people who originally proposed the funding.

So we can do better in that respect, but I think there is, you know, a fair amount of kind of work that's done where the payoff isn't certain. And sometimes, the payoff is far better than anyone imagined like the internet. And sometimes, the payoff isn't necessarily quite as good. But it still contributed to training students and advancing knowledge.

MS. ROBBINS: Yeah. The one thing that I would add is that when a research program is focused on a particular outcome, it looks like a failure if that outcome wasn't reached in the intended time period.

And so, perhaps being open to alternative uses from the outcomes of research can be useful because then that will perhaps allow us not to drop a project but find a way to continue it or send it

off in another direction. And then again, as John suggests, you get what you ask for. And so, if you only reward short-term results then you are going to get cautious researchers.

MR. VILLASENOR: Another thing I would add is sometimes it's only in hindsight that it's really easy to appreciate how much risk there was. I'll give an example again in the '90s, DARPA funded quite a lot of work in technology called CMOS, it's all capitals, C-M-O-S. It's a particular kind of semiconductor category.

And at that time, it was unclear whether that semiconductor technology could be used to build very low power, high speed, you know, processors of the kind that are all over the place in firms and things like that these days. It was a risk endeavor and it worked. It paid off. But we don't tend to remember.

You know, when we sort of walk around with all these amazing devices that we have today. We don't tend to remember that was the product that was at that point, a very high-risk research, but that's what it was. And it succeeded from that place. So I'm just mentioning, it's not always obvious even in the moment that it is high risk.

MR. WEST: So Shawn Fishman (phonetic) has a question about accountability in the R&D space. And he specifically asks, what are the guardrails for transparency and accountability in order to increase public trust in what we're doing in the R&D space? And how we're spending federal money?

MS. ROBBINS: So I would like to take a stab at that. And I think that that is an approach which is -- it's a challenge in the academic community. And it's obviously a challenge in the federal government. But what we are seeing is increasingly an emphasis on transparency. On providing the datasets so data can be replicated.

I think that that is really one of the most critical things. I think results that use data that no one can look at are things that we have to be less confident in than when one can rerun the data and see that we get the same results. Those things are very important. And I also think that open access and increased open access overall to the results of research will help here as well.

MR. VILLASENOR: I'll just second that. Sometimes, I'm looking for a research article and I find it online and it says, you know, I'm asked if I want to pay $30 to read the article? And, you know, I'm not going to do that. And if that was funded through federal dollars, it seems reasonable that

we should have the access to it without paying.

MS. ROBBINS: Research from the National Institutes of Health, of course, have been public for many years. And they have a wonderful database. And the National Science Foundation also has the principle that the results of research shall be open and made available to the public.

MR. WEST: So Anna Quinton (phonetic) of Northern Illinois University has a question about the CHIPS Act. She cites -- says there's a newly created emerging research institution's designation within the CHIPS Act. And she wants to know how that can help us reach the goal of expanding the footprint for research institutions and also engaging a more diverse school of both students and faculty?

MR. VILLASENOR: I think I can take a stab at that. I may be mistaken, but I think the emerging research institution designation has been around for quite a while. I think the national academies did a report, I think it was over 10 years ago on these.

Now, I don't know whether the CHIPS Act definition is the same as what was used earlier, but the questioner is absolutely correct that there is this focus in the CHIPS Act. And I think it might -- again, I may be misspeaking, but I think it defines emerging research institutions as the colleges and the universities that have less than a $50 million in federal resource expenditures. And there's, I think a certain percentage the awards have to better those institutions.

So I think that will indeed -- I think it will achieve its goals, right? By definition, by some programmatic structure it is going to ensure that some of these dollars, a significant amount of these dollars, are going to these institutes. And as I mentioned before, I think there's an extraordinary depth of talent in this country. Much of which is not at what you might traditionally call a R1 research institution. So I think it is all upside and I think that's going to have the obvious benefits which is put research dollars in the hands of people who might not otherwise have received them.

But I think it's going to have a bunch of downstream benefits that are good benefits, really important benefits that are hard to even fully appreciate now.

MS. ROBBINS: And so, I would add that there are two parts of this that I think are of benefit. And I agree with John that that is the intention there. And we do see some of these programs being set up.

So in addition to training the workforce in areas which perhaps is outside of Silicon Valley, the Research Triangle in Boston. The presence of these newly trained, highly skilled workers also allows for economic development, right, in higher technology industries.

And that provides and additional benefit because of course what we've seen in the past is that graduates from very fine universities in the center of the country end up going to the coast, right? To look for their jobs and not staying there where they were trained to build businesses.

MR. VILLASENOR: And if I could just have one more thought on this. You know, we focused a lot on federal funding when we talk about public funding. But state legislatures play a role in this also.

And I think this is an area that's complementary to the question in the sense that state legislatures can and should be investing in their university systems including in supporting developing a strong R&D ecosystem. And so, I think that's a really important part of the puzzle as well. It's not just federal funding here that can shape these sorts of issues.

MR. WEST: That's a great point. And we actually do have a question about state and local government and the resources that they are putting in. This is from Kim Bubla (phonetic) who wants to know, what can we hope for at the state and local level in terms of R&D spending?

Are they tending to invest in similar sorts of things? Is the federal government? Are they doing things differently? How should we assess their role in the whole ecosystem?

MS. ROBBINS: The first thing that I would say is that state level funds are very limited for R&D. State budgets are under enormous pressure. And so, expecting that there will be great growth coming from state governments into the local institutions is probably not the best place where we're going to get help.

More in terms of perhaps supporting the kind of consortiums and technology transfer and helping set up robust institutions, right? Where perhaps the state and local government, the universities and industries are working together.

MR. VILLASENOR: Yeah. I would just agree with that. I mean you're never going to have state funding research at the level of, you know, DARPA or the National Science Foundation or the National Institutes of Health. It's just the budgets don't exist.

But I also do think that states can, and in many cases are, be more than simply passive bystanders to the research ecosystems in the university systems in their states. And I think states can do a better or worse job on fostering the climate which makes faculty want to set up shop at the universities in their state, you know, for providing funding for this sort of kind of capital funding for research labs and things like that.

Because you know, the National Science Foundation isn't going to fund a university to build a big new science building, right? That's not the kind of thing as far as gets NSF funds. And that kind of funding is going to need to come from other sources. So states can still play a really important role in providing the infrastructure that can then make it easier for universities in that state to attract external, private and federal government funding for research. And that can help create the ecosystem.

MS. ROBBINS: I think an example of what John is mentioning is certainly what was done in New York state around semiconductor and nano technology research. They have built a very large research program. And certainly, there's federal funds, but in terms of setting the equipment and the infrastructure, the state had to have played a very major role.

MR. WEST: So we have a question from Jenny Majear (phonetic). And she wants to know has there been any major reforms or institutional changes in federal R&D funding over the last few years? And then she wants to know in addition are there any new policy initiatives and major programs at the federal level? Are there any interesting examples of public, private partnerships that can be mentioned?

MS. ROBBINS: Well, certainly the one that comes to mind is the CHIPS Act, right? That is a major piece of legislation with a lot of money behind it. And so, I think that that is one thing that we can point to.

In terms of changing policy, I think if we look at some of the orders that have come out of the executive branch there is a shift towards more inclusivity. So that perhaps is another policy direction as well.

MR. WEST: John, any thoughts from you on that?

MR. VILLASENOR: Nothing else.

MR. WEST: New initiatives or -- okay. We have a question from Tamara Borrero

(phonetic) who is a senior advisor from Strategy and Policy. And she wants to know if there are any insights regarding the role of R&D from both the public and private sectors in solving major national social problems such a poverty, hunger, education and I would add healthcare initiative.

MS. ROBBINS: Yeah. Absolutely. So when we think about hunger, right? We think about our food supply, and we think about the production and science and innovations have been significantly behind this. Disease resistant crops. Another example is vitamin enriched rice, right? Which is grown in other parts of the world.

So those are pretty important things with regard to hunger. Certainly, we know that there have been many advances that directly affect health. And in terms of poverty, obviously, now we are thinking of the role of social science. And that's a bit more complex. I think that increasing access to education is certainly an important part of this challenge.

MR. WEST: Sarah Renton (phonetic) of ETQ International makes a comment and says, the metrics used to measure technology transfer by universities are very limited.

And so, this person wants to know are there better ways to do this? Can we get better data, so we actually are in a better position to track the technology and transfers that do take place? And in general, how do we overcome some of the problems in terms of transferring the knowledge from the universities into the rest of the country?

MS. ROBBINS: So I would agree that the data that we have on technology transfer is somewhat limited. As I mentioned, not all or not all universities have a technology transfer office. And so, the data which I use in my report, science and engineering indicators, can only comes from universities that have technology transfer offices.

And so, expanding that set of information, I think would be useful. But I think that the questioner has something in mind, knowledge exchange, right? Which perhaps is a broader set of variables than the limited ones which are on startups and licensing and patents.

And so, there one has to begin to define what do you mean? Okay. Another way you can do it is collaborations. One can look at collaborations between universities. And one does that in a couple of different ways, but one way is to look at who is coauthoring on a piece of research?

And what one often finds is that the collaborations take place between the people in the

R1 universities or perhaps the R1 universities and some of the best universities in other parts of the world and not as often between perhaps a flagship university in a state and then some of the other associated public universities that aren't quite as research intensive.

So perhaps developing more specific metrics there is something that is quite possible. I'm trying to kind of think of what's in the realm of possible without standing up new surveys because that's a long and complicated process.

MR. VILLASENOR: I would add that, you know, again since I'm at UCLA, I see it there. The technology transfer office at UCLA, I think they do a good job. But they only see I think a fraction of, you know, what might be called the transfer of innovation culture, right?

If you have a graduate student who earns a Ph.D. in engineering and then, you know, goes and starts a company after graduating or joins a small company or joins a big company. There is, I think a transfer of innovation capacity that goes along with that person that is never going to be measured by just looking at, say, a licensing -- a count of licenses or assessment of the dollars from licensing.

I actually think that if you could quantify it, more of the innovation transfer would be, you know, happening organically in that fashion than through contracts and licensing that you could actually sort of hold in your hand and can count.

The question or the challenge and perhaps the question is getting at is how do you sort of measure that other than just say it's important. Which is not necessarily particularly satisfying if you're trying to sort of assess it. And I don't have a good answer to that, but I know just organically kind of looking at it that's a huge, huge aspect of the ecosystems. You know, all these people getting these engineering degrees and going out and entering the workforce, starting companies. And there's just a huge, huge benefit there.

MS. ROBBINS: On a university-by-university basis what I have seen are very nice reports looking at the job trajectories of alumni. And that enables one to take a deep dive into the kind of issues that John is mentioning, right?

Did you go down the road and start a company somewhere else? Or how many people did you hire? And so, I would I suppose suggest that the questioner could look there to begin with, so we begin to get some idea of what are the most salient questions that are on those alumni surveys and find

some way to translate that.

MR. WEST: So Minerva Tantaco (phonetic) of NYU has a question. How can AI and other emerging technologies be used to increase equity instead of reducing it? Of course, there's a lot of criticism today that technology is making inequality worse.

Is there some way to use federal R&D monies to place a greater emphasis on equity or think about how technology can be part of the solution as supposed to part of the problem?

MR. VILLASENOR: Yeah, I mean I'll take a stab at that. Well, first of all, I think I mean there is certainly a concern with AI inequity, but I would also sort of argue that there's also a huge concern with equity when AI isn't involved. In other words, you know, even when there's no AI, there's a lot of equity concerns.

And so, it's, you know, AI can often through data analysis actually help expose and make clear inequalities that would have been perhaps harder to identify absent the AI. So AI can be part of the solution as well as part of the problem.

And in terms of the funding link, I would expect that any funding agency that is funding AI work or at least AI work where there's an equity issue. You know, if you're funding AI to develop better protein folding then maybe that particular, you know, AI system is not -- equity is not much of a question. But if you're funding AI in a way that impacts or could impact equity, I would imagine, I would assume that there's a very high degree of awareness about the importance of equity.

And similarly, among people who are requesting, who are seeking funding for AI work. I can't imagine seeking funding to do work on AI where I didn't sort of put front and center, if it was appropriate given the context, some of the equity issues. So, you know, one of the benefits for the very high degree of awareness in the public conversation about AI and equity is that it really is a top-of-mind topic. And I'm cautiously optimistic that we're really moving in the right direction.

MS. ROBBINS: So the only thing that I would add is that, and this is a bit of technological argument, to the extent that artificial intelligence allows us to do things that were skill intensive much more quickly than I think it makes much technology more accessible.

And the example that I would give is using AI as a means to diagnosis illnesses in a way that was more expensive to do perhaps with a radiologist or with highly skilled professionals. And so,

then the issue is we have created something new which can be provided at a lower cost. How do we make sure that that is available to all of the population? That is only a partial solution to the challenge that the question addresses.

MR. WEST: And the thing that I would add to the answer that each of you gave is just the importance of investing in lifelong learning, right? Now, our education model and our investments in human capital and talent basically go up through about age 25 or 30 and then after that people are on their own.

And I think in an era where there's going to be a dramatic acceleration of technology and innovation, we're going to have to invest in people upscaling and reskilling at ages 30, 40, 50 and 60. Basically, throughout people's lifetimes. And so, as a society, we have to figure out how to do that. And also, who is going to pay for that? I think those are social contract types of questions that are part of this inequality question.

Fallen Egneg (phonetic) who is the director of economic strategy asks about the link between workforce as a key to our indeed development and how we should think about high skilled immigration and the domestic workforce development. How we can have policies, workforce of policies that are more optimal in order to boost domestic R&D?

MS. ROBBINS: So I guess what I would say about this is it's not an either/or. It really is of both, right? We have industries that are relying now on foreign born talent. And taking that away would likely be quite damaging to those industries.

But again, I think that there's a complementary between these really highly skilled workers and the development of a STEM workforce that has perhaps less than an advanced degree. And that those things really can go hand in hand.

But critical to this, I think we would find as improving our K through 12 science and engineering education system because we need to get to the point where our young people are able to tackle physics and calculus when they get to community college so that they can go into the more technically oriented programs.

MR. VILLASENOR: I'll just second that. You know, I couldn't agree more that we, frankly, should do a better job at our K through 12 education particularly in terms of encouraging people

to consider and perhaps go into STEM careers.

And the other thing I'll say is, you know, high skilled immigration and, frankly, immigration of all skill levels has been the absolutely foundational part of American economic growth and prosperity in net/net, I think creates, you know, creates jobs.

And so, I really hope that we can over the long term adopt and maintain a policy where we welcome the world's best and brightest to come here and bring their talent and skills here with all the job creation and short- and long-term benefits that that involves.

MR. WEST: Yeah, I think we have time for one more question. Noel Capps (phonetic) of Ender and Publisher (phonetic) asks whether there are ways to create a more deliberate and programmatic collaboration between public and private sectors particularly involving what he calls R1 and R2 research universities? And would that represent another kind of model in order to spur innovation in that sense?

MS. ROBBINS: So I would say, yes. And I would say that this technology innovation partnerships program out of the National Science Foundation newly stood up has exactly that kind of promise because indeed if an idea is coming out of research, well, it's going to end up having to make this transition, right? From the research into something which is useful and viable and then provided somehow to consumers.

And so, it's natural I think that when we focus on this use inspired research and translation of results that that will by necessity involve that kind of partnership between the public and the private sector.

MR. WEST: John, your thoughts on public/private partnerships?

MR. VILLASENOR: Yeah. I think it can be really effective. I think it's very context specific. You know, what works in one particular time, in one particular area may not be the right thing in another area.

But I think it absolutely needs to be on the table because there's a subset of context and problems where that is going to be by far the best way to sort of get impact over a moderately reasonable short time scale. So I think it's absolutely a -- it should definitely be in the portfolio that people have under public sector funding.

MR. WEST: Well, I want to thank both John and Carol for sharing your perspectives on R&D and how we can do a better job in this area. We write regularly about these questions as well as other aspects of technology innovation at @Brookings.edu.

You can check out our tech tank block where we undertake research and present a commentary on leading issues effecting the digital economy. We also have a tech tank podcast where we host interviews of experts who are devoted to discussing these issues. So for our audience, I thank you very much for tuning in. And John and Carol, thank you very much for your insights.

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