BUILDING REGIONAL INNOVATION ECONOMIES

HEARING

BEFORE THE

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OF THE

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BUILDING REGIONAL INNOVATION ECONOMIES

WEDNESDAY, JUNE 9, 2021

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to notice, at 10:01 a.m., via Zoom, Hon. Haley Stevens [Chairwoman of the Subcommittee] presiding.

U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Building Regional Innovation Economies

Wednesday, June 9, 2021
10:00 a.m. EDT – 12:00 p.m. EDT
Zoom

PURPOSE

The purpose of this hearing is to explore the role of the Department of Commerce, and particularly the Economic Development Agency (EDA), in supporting the development of regional innovation economies, and the opportunities for and challenges to expanding this role, including in partnership with Federal science agencies.

WITNESSES

- **Mr. Dan Berglund**, President and CEO, SSTI
- **Professor Erica R.H. Fuchs**, Department of Engineering and Public Policy, Carnegie Mellon University
- **Ms. Paula Nas**, Director, Office of Economic Development, University of Michigan-Flint
- **Hon. Elizabeth Hutt Pollard**, Secretary of Science and Innovation, State of Oklahoma

OVERARCHING QUESTIONS

- What are the critical elements and who are the necessary partners in developing a successful strategy for local and regional innovation economies?
- What is the role of the Federal government, and in particular the Economic Development Agency (EDA), in supporting the development of local and regional innovation economies?
- How can research universities strengthen their role in helping to anchor local and regional innovation economies?
- How can efforts to build regional innovation economies include equity and shared prosperity as a priority?

OVERVIEW

For decades, Silicon Valley, Boston's Route 128, and a short list of other regions have garnered international attention for seeding dynamic high-tech companies that bring jobs and wealth to the region. Policymakers across the United States have tried to replicate this success by supporting the development of local, state, and regional innovation economies through the funding of growth centers, innovation clusters, and technology hubs. These efforts generally involve investments in infrastructure—such as science parks or manufacturing facilities—and/or programs that support commercialization, workforce development, entrepreneurship, and industry maturation.

Typically, local governments focus on certain industries, such as automobiles, batteries, and robotics, in which they have some underlying strengths or infrastructure. New Mexico, New York, and Ohio have all created public private partnerships to develop R&D centers, awarded cash to build manufacturing facilities, and gathered funds to provide early-stage capital for start-ups. Since 2006, the Michigan Economic Development Corporation has worked with the Federal Government to build up an advanced battery cluster in the state.

The Federal Government has long played a supportive role in regional innovation, both directly and indirectly, through funding research at universities, location of Federal R&D facilities, co-funding construction of research parks, and its purchase power (i.e. military procurement). Many Federal agencies have programs that contribute to regional economic development, including the Department of Energy (DOE), the Department of Labor, the Small Business Administration, the Department of Commerce, the Department of Health and Human Services, and the Department of Defense. For example, DOE's Energy Program for Innovation Clusters, known as EPIC, is devoted to developing technologies and systems for energy-efficient buildings.[1] However, to date, the funding for these programs has been relatively small.

Responding to the National Academy of Sciences report, *Rising Above the Gathering Storm*,[2] that argued the United States was ceding leadership in advanced technologies, Congress created new authorities and programs in the *America COMPETES Act* in 2007 and the *America COMPETES Reauthorization of 2010* to boost regional and local innovation economies across the United States. Most notably, in the 2010 Act (P.L. 111-358) the Committee on Science, Space, and Technology led the authorization for a new Regional Innovation Program (Sec. 603), now known as Build to Scale, and a new Office of Innovation and Entrepreneurship (Sec. 601) at the Economic Development Administration.

THE ECONOMIC DEVELOPMENT ADMINISTRATION

The Economic Development Administration (EDA) was created with the passage of the *Public Works and Economic Development Act (PWEDA) of 1965*. The mission of the agency is to lead the Federal economic development agenda by promoting innovation and competitiveness and

[1] https://www.energy.gov/technologytransitions/initiatives/energy-program-innovation-clusters
[2] https://www.nap.edu/catalog/11463/rising-above-the-gathering-storm-energizing-and-employing-america-for

preparing American regions for growth and success in the worldwide economy. At its peak in 1979, funding for EDA was 0.25% of total GDP.[3] In comparison, today's EDA budget is less than 1 percent of that level. EDA runs several regional innovation programs through its Office of Innovation and Entrepreneurship.

Build to Scale

The goal of the Regional Innovation Program created in the *America COMPETES Reauthorization of 2010* is to encourage and support the development of regional innovation strategies, including regional innovation clusters and science and research parks.[4] EDA established the program, recently renamed Build to Scale, with an initial appropriation of $10 million. For years, the program was funded at $15 million. The most recent appropriation was $38 million.

The Build to Scale program is comprised of three competitions to further technology-based economic development. All competitions have a cost share requirement of 50 percent. The Venture Challenge supports entrepreneurship and accelerates company growth in communities, regions, or combinations of regions. The Venture Challenge awards grants to intermediary organizations like accelerators, universities, community colleges, and non-profits supporting new business ventures that are scalable by nature, challenging the status quo of markets, commercializing technologies, and furthering job creation.

In many regions across the United States, start-up companies can struggle to get access to capital to advance and grow their businesses. The second challenge, the Capital Challenge, seeks to increase access to capital in communities where risk capital is in short supply by providing operational support for the formation, launch, or scale of investment funds that would invest their capital in scalable startups as well as organizations that expand capital deployment within a community, region, or regional industry.

Finally, in 2020 the EDA partnered with the Department of Energy to fund a pilot challenge called the Industry Challenge.[5] This competition supported entrepreneurship related to the use of ocean resources, including support for commercialization of "blue" technologies, related startups, and job creation. EDA announced it would not host the Industry Challenge for the FY 2021 cycle.

There are several notable limitations to the Build to Scale program. The foremost challenge for the program is its funding. The program is limited in the number and size of the awards it can make. While the EDA does prioritize geographic diversity in its awards, many rural communities struggle to compete for funding. Moreover, the matching requirements in this program can exclude rural communities that lack the resources to participate.

University Center Program

Institutions of higher education are critical players in the development of vibrant economic ecosystems. To bolster this resource, EDA established the University Center program to focus on

[3] https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-1979-19033
[4] https://www.govinfo.gov/content/pkg/PLAW-111publ358/html/PLAW-111publ358.htm
[5] https://eda.gov/oie/buildtoscale/capital/

leveraging university assets to build regional economic ecosystems that support innovation and high-growth entrepreneurship, resiliency, and inclusiveness. University Centers (UCs) respond to the needs of their specific regions. For example, some UCs have responded to the needs of small- and medium-sized manufacturers and processors by offering technology transfer and commercialization assistance. EDA has allocated approximately $7.4 million to this program in FY 2021, funding approximately 22 grants.

STEM Talent Challenge

EDA also operates the STEM Talent Challenge, which seeks to develop or expand regional workforce capacity to support entrepreneurial ventures, industries of the future, and other businesses that have a high likelihood of accelerating economic competitiveness and job creation within a region.[6] The STEM Talent Challenge is designed to help communities with two activities – planning and development, and program implementation.[7] For FY 2021, EDA allocated $2 million to this program.

Accelerate Response and Recovery (R2) Network Challenge

In 2020, EDA collaborated with the National Institute of Standards and Technology (NIST) and the First Responder Network Authority (FirstNet) to create the Accelerate R2 Network Challenge.[8] This competition sought to create a nationwide network or networks of organizations working to address the nation's most pressing disaster response and resiliency challenges with innovative technologies. In July 2020, the agencies selected a public-private partnership to establish and operate the R2 Network.[9]

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

NIST is a non-regulatory agency within the Department of Commerce with a mission to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology. NIST has two extramural programs focused on building manufacturing capabilities in regions across the United States: Manufacturing USA and the Hollings Manufacturing Extension Partnership (MEP).

Manufacturing USA

Manufacturing USA is a network of manufacturing innovation institutes coordinated through NIST. These institutes serve as partnerships between companies, academia, and entrepreneurs to develop and deploy manufacturing technologies. There are currently 16 Manufacturing USA institutes focused on a wide range of technologies. NIST currently operates one manufacturing USA institute on behalf of the Department of Commerce. Most of these institutes are funded by the Department of Energy and the Department of Defense. In FY 2021, the Manufacturing USA program at NIST was funded at $16.5 million. The FY 2022 President's Budget Request includes

[6] This program is authorized under the Stevenson-Wydler Technology Innovation Act (15 U.S.C. § 3723).
[7] https://eda.gov/files/oie/stem/Section-28-STEM-Talent-Challenge-NOFO.pdf
[8] https://eda.gov/oie/accelerate-r2/
[9] https://eda.gov/news/press-releases/2020/07/01/r2-network-challenge.htm

$166.65 million for the Manufacturing USA program to support the establishment of two additional institutes.[10]

Manufacturing Extension Partnership

The MEP program is a Federal-State-industry partnership made up of Centers in all 50 states and Puerto Rico. These Centers work with local manufacturing communities to strengthen the U.S. domestic manufacturing base. MEP Centers also provide small- and medium-sized businesses with technical assistance and guidance on cybersecurity. MEP has proven to be a successful model for Federal-State partnerships with significant payoff in economic growth and job creation in the U.S. As of 2019, for every dollar of Federal investment, the MEP National Network generates roughly $29 in new sales growth for manufacturers and $31 in new client investment.[11] While Congress funded MEP at $150 million in FY 2021, the President's Budget Request calls for a large increase to $275 million in FY 2022.[12] President Biden has stated he wants to quadruple the program within a few years.

Advanced Technology Program

The Advanced Technology Program (ATP) (later renamed the Technology Innovation Program (TIP)), was a NIST program established by Congress in the late 1980s and last funded a decade ago. ATP was designed to stimulate early-stage advanced technology development in industry that would otherwise not be funded. Rather than focus on basic science to advance the knowledge base or development of consumer products, ATP focused on high-risk, generic, pre-competitive, enabling technologies with the potential for high social returns. NIST offered funding through the program to single companies and industry-led consortia of universities, businesses, and/or government laboratories. Only large companies participating in the program were required to have a 60 percent cost share. At its height, this program received $340 million in 1995. In 2007, the *America COMPETES Act* replaced ATP with TIP, restricting the program to SMEs and requiring a blanket 50 percent cost share. Ultimately, despite moderate success, the program failed to attract a strong constituency and fell victim to political battles over the role of government in supporting industry-led research.

EXPANDING THE FEDERAL ROLE IN REGIONAL INNOVATION

In recent years, many stakeholders and policymakers have called for Congress to supercharge Federal regional innovation programs to bolster resources for local and regional innovation economies.

In 2011 and 2012, the National Academies Board on Science, Technology, and Economic Policy held two symposiums to study the role of innovation clusters in promoting economic growth, efforts to develop an integrated regional innovation initiative, and the role of research parks in promoting innovation and regional and national economic development.[13]

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[10] https://www.whitehouse.gov/wp-content/uploads/2021/05/appendix_fy22.pdf

[11] https://www.nist.gov/news-events/news/2019/03/new-mep-center-will-serve-needs-alaskas-small-and-medium-sized-0.

[12] https://www.whitehouse.gov/wp-content/uploads/2021/05/appendix_fy22.pdf.

[13] https://www.nap.edu/read/13249/chapter/3

In 2019, in response to the concentration of economic growth in the United States, especially on the coasts, MIT Professors Jonathan Gruber and Simon Johnson published the book *Jump Starting America*, which proposed increased public and private investment broadly spread across the country in metropolitan areas that are on the cusp of becoming vibrant tech hubs.[14] They proposed investments on a large scale – several hundred million to $1 billion per hub, with hubs selected through a competitive process.

Later that same year, the Brookings Institution and the Information Technology and Innovation Foundation jointly published a report called *The Case for Growth Centers*.[15] This report highlighted the problem of "regional divergence" where an upper tier of certain metro areas began to grow at a faster rate than the median ones. Their report also calls for the nation to use a competition to designate 8 to 10 new regional "growth centers" across the heartland and use Federal support to scale up the innovation industries in those cities.

These ideas have caught the attention of policymakers. In *the American Jobs Plan (AJP)*, President Biden called for Congress to invest $20 billion into a Community Revitalization Fund, with the aim of growing "at least ten regional innovation hubs".[16] The goal of each tech hub is to "spark new economic activity, provide services and amenities, build community wealth, and close the current gaps in access to the innovation economy for communities of color and rural communities that have suffered from years of disinvestment."[17] Additionally, the AJP included $14 billion for NIST to bring together industry, academia, and government to advance technologies and capabilities critical to future competitiveness as well as to quadruple support for the Manufacturing Extensions Partnership (MEP). In the Senate, lawmakers are currently considering the *United States Innovation and Competition Act* (USICA) of 2021, formerly known as the *Endless Frontier Act*, which would fund regional technology hubs and boost funding for Manufacturing USA and MEP. In recent drafts, the bill would authorize $10 billion over 5 years to establish at least 3 tech hubs in each of the EDA's 6 regions.

CHALLENGES REMAIN

Any such large-scale investment must build on the lessons learned from the long history of local, state, and Federal investments in developing tech hubs and innovation economies, including the successes, the failures, and the unintended consequences.

Budding innovation economies often face a "chicken-or-egg" problem where innovation industries will not go to a region without a technical workforce, but a technical workforce will not go to a region without innovative businesses at which to work. It is unclear if increased funding for R&D or infrastructure alone will be enough to attract the workforce required for an innovation economy to flourish over the long term. As such, these investments may also have to focus on STEM education at all levels, as well as workforce development.

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[14] Jonathan Gruber and Simon Johnson, *Jump Starting America* (New York: Hachette Book Group, 2019).
[15] http://www2.itif.org/2019-growth-centers.pdf
[16] https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/
[17] Ibid.

Another challenge is the evaluation criteria that are used for selecting regions to fund. The proposals from MIT, and Brookings and ITIF all call for various evaluation criteria—such as a regional airport, top-tier research universities, and existing technical workforce. Most avoid the quality of the K-12 education systems, which is a significant factor for many who might consider picking up and moving to new hubs. It remains unclear what direction Congress can or should apply to this funding to build lasting innovation economies.

Many regions may not have easy access to venture capital or angel funding, which is concentrated in existing successful innovation economies. In credit-scarce environments, small companies are finding it difficult to survive the so-called "Valley of Death," the 5 to 12 years it often takes to turn an invention into a commercial product. It is not clear how Federal funding alone will support access to credit for new firms.

Yet another key concern is how to ensure more equitable distribution of the benefits of regional innovation economies. Places like Silicon Valley are stark examples of the income inequality and economic divides in our country. The cost of real estate has driven many Silicon Valley workers far inland, resulting in 2-hour commutes each day. The shift to more remote work as a result of the pandemic will mitigate this for some, but most technical jobs cannot be done remotely. Shared prosperity must be a goal of any new competition from the outset, including by bringing diverse community voices into planning discussions.

Finally, it is unclear which Federal agency, or combination thereof, should implement this type of program. While the EDA certainly has the expertise in regional development, it lacks the technology expertise of NIST. Moreover, it is unclear how or if the other Federal regional innovation programs from DOE, Department of Labor, the Small Business Administration, the Department of Health and Human Services, and the Department of Defense should coordinate to help facilitate regional innovation economies as envisioned by these proposals.

Chairwoman STEVENS. Well, this hearing will come to order. Without objection, the Chair is authorized to declare recess at any time. Pursuant to *House Resolution 8*, today the Committee is meeting virtually. Just a couple of reminders that we've gone over before about the conduct of this remote hearing. Members should absolutely keep their video feed on for as long as they are present in the hearing. Members are responsible for their own microphones. Please also keep your microphones muted, unless you are speaking. Finally, if Members have documents to submit for the record, please e-mail them to the Committee Clerk, whose e-mail address was circulated prior to the hearing. And, with that, allow me to say good morning, and welcome to today's hearing on *Building Regional Innovation Economies*. Thank you to our distinguished witnesses for joining us.

In recent decades economic growth has become increasingly concentrated in a relatively small number of cities and regions. This is then tracked across analysis from leading experts. Between 1980 and 2016, for instance, the top 10 metro areas saw their earnings grow 57 percent more than elsewhere in the country. The top 10 metro areas saw their earnings grow 57 percent, almost 60 percent, more than anywhere else in the country. According to a recent report from the Brookings Institution, more than a third of American jobs in high growth innovation industries within the technology sectors, computer manufacturing, biotech, telecommunications, are located in just 16 counties. We certainly want to recognize and celebrate the success of American innovation hubs spanning this country, and continue to support their role in advancing U.S. competitiveness while we drill down and identify opportunities to create economies of scale across the country, particularly in areas that have experienced decline or transformations of the resources based on trade challenges, and different dynamics that have led to decline.

The United States needs to remain globally competitive, and, as such, we must continue to address issues that are hindering geographic diversity and economic growth, and we must have intentionality in addressing some of the root causes of the increasing social and economic disparities in our country. The Federal Government has long been a partner in building regional innovation economies through many agencies across the Federal Government with different missions. Today we will be focusing particularly on the role of the Economic Development Administration (EDA) at the Department of Commerce. And, in full disclosure, I have worked at the Economic Development Administration from 2011 to 2012. Your Chair has worked there.

I was pleased to see that President Biden shares a vision to support EDA's core mission. In the *American Jobs Plan*, the President calls for supercharging Federal support for regional innovation by investing $20 billion in EDA grants to develop 10 regional innovation hubs. Such a plan, if developed and implemented carefully, could spark economic activity, economic growth, build community wealth, and help close the gap in access to the innovation economy for communities of color and rural communities in particular. We also ask the question, if the President is making these investments,

if we should stop at 10, and continue to expand and grow from there.

We have an opportunity to be intentional about how we continue to grow and achieve shared purpose in the country in an age of rapid transformation. EDA has demonstrated historic success by allowing regions to self-select what their innovation ecosystem looks like. Now we have the opportunity to build on this work, allowing the—for the growth and the development of clusters in industry-specific innovation, to build economic development in regions that may have—otherwise been left behind. That is certainly an example that we have seen across the board in a place that I call home here in Michigan. Not only did we put the world on wheels at the beginning of the 20th century with automobiles, but we built an entire innovation ecosystem that sprung up around new machines.

In 1912 the Nation's first Highway Materials Testing Lab opened in Ann Arbor, Michigan. In 1918 a police officer from Detroit invented and installed our Nation's first four-way red, yellow, green electric traffic light at the corner of Woodward and Michigan Avenues in Detroit. In 1960 Michigan became the first State to complete a border-to-border interstate. Now our auto companies, at the turn of another century, are leading the world in electric vehicle technology, autonomous and connected vehicle technology, connected infrastructure, and other innovations that are the very back bone of our Midwestern regional economy.

Building regional innovation economies is certainly no simple task. It requires many committed partners, it requires intentionality, and it requires a lot of complicated things to fall into place. Federal investments are needed now more than ever to help build new and vibrant innovation economies, transforming us and propelling us into the 21st century—the mid–21st century, where we are heading. We will learn from past successes, failures, and unintended consequences if we are to get this right. The Science, Space, and Technology Committee led the authorization for the Regional Innovation Program at EDA, in 2010, and we will continue to evaluate these new proposals for the agency. We want to thank our witnesses for being here today, and we certainly look forward to the discussion.

[The prepared statement of Chairwoman Stevens follows:]

Good morning and welcome to today's hearing on building regional innovation economies. Thank you to our distinguished witnesses for joining us.

In recent decades, economic growth has become increasingly concentrated in a relatively small number of cities and regions. Between 1980 and 2016, the top 10 metro areas saw their earnings grow 57 percent more than elsewhere in the country. According to a recent report from the Brookings Institution, more than a third of American jobs in high-growth innovation industries such as technology, computer manufacturing, biotech, telecommunications, are located in just 16 counties.

We should celebrate the successes of innovation hubs such as Silicon Valley and Boston and continue to support their role in advancing U.S. competitiveness. However, for the United States to remain globally competitive we must address issues that are hindering geographic diversity in economic growth and we must have intentionality in addressing some of the root causes of the increasing social and economic disparities in our country.

The Federal government has long been a partner in building regional innovation economies through many agencies with different missions. Today we will be focusing particularly on the role of the Economic Development Administration at the Department of Commerce.

I was pleased to see President Biden shares my support for the EDA's core mission. In the *American Jobs Plan*, the President calls for supercharging Federal sup-

port for regional innovation by investing $20 billion in EDA grants to develop 10 regional innovation hubs. Such a plan, if developed and implemented carefully, could spark economic activity, build community wealth, and help close the gap in access to the innovation economy for communities of color and rural communities.

We have an opportunity to be intentional about how we continue to grow and achieve shared purpose in the country in an age of rapid transformation.

EDA has demonstrated historic success by allowing regions to self-select what their innovation ecosystem looks like. Now we have the opportunity to build on this work, allowing the growth and clusters of industry-specific innovation to build economic development in regions that may have otherwise been left behind.

That's what we've done in Michigan. Not only did we put the world on wheels at the beginning of the 20th century with automobiles, but an entire innovation ecosystem sprung up around these new machines. In 1912, the nation's first highway materials testing lab was opened in Ann Arbor, Michigan. In 1918, a police officer from Detroit invented and installed our nation's first four-way red, yellow, green electric traffic light at the corner of Woodward and Michigan avenues in Detroit. In 1960, Michigan became the first state to complete a border-to-border interstate.

Now, our auto companies are leading the world in electric vehicle technology, autonomous and connected vehicle technology, connected infrastructure, and other innovations that are the very backbone of our Midwestern regional economy.

Building regional innovation economies is no simple task, requiring many committed partners, and many different pieces to fall into place. Federal investments are needed now more than ever to help build new and vibrant innovation economies in regions across the country.

We must learn from past successes, failures, and unintended consequences if we are to get this right. The Science, Space, and Technology Committee led the authorization for the regional innovation programs at EDA in 2010, and we will continue to evaluate these new proposals for the agency.

I want to again thank the witnesses for being here today and I look forward to the discussion.

Chairwoman STEVENS. And with that, slightly over time, asking for your obliging, I now am going to recognize Mr. Waltz for an opening statement.

Mr. WALTZ. OK. Thank you. Good morning. Thanks, Chairwoman Stevens. Thanks for holding today's Subcommittee hearing on regional innovation, and also thank you to our expert witnesses for being with us. I think the question before us is how do we spur regional innovation to ensure all Americans have the opportunity to participate in the innovation economy? And that's, you know, whether they live in Daytona Beach, in my district, or all the way up in Boston, Massachusetts, or over in Michigan. You know, this is a challenge that policymakers have long struggled with, as the Chairwoman noted, and one that has received renewed interest over the last few months, as we seek to advance our economy through technological innovation, and compete with our adversaries, and our competitors, like China.

There are multiple proposals from the administration, by our colleagues in Congress, calling for significant investments in the development of regional innovation economies, and I'm glad that the Science Committee has taken the time to carefully review and investigate these proposals. You know, and—we have to be candid, and, unfortunately, the history of regional innovation is littered with successes and failures. In the 1980's the United States invested heavily in science and technology industrial parks. Many of these parks, unfortunately, were unable to attract the high-tech companies needed to drive economic growth, and ultimately ended up failing. The buildings were impressive, but they were empty. And we need to make sure we don't repeat those mistakes. We need to make sure we don't just throw money at what we all, I think, agree is an issue, and a cause worth supporting. I hope we

can use this hearing, amongst others, as an opportunity to hear different perspectives and new ideas on how Congress can successfully support regional innovation, and avoid the past failures.

Me—my home State of Florida is a great case study, I think, in the successes and challenges of regional innovation. Our Florida space coast is a key part of Central Florida's economy. It's created jobs for Floridians in the private space industry, high-tech manufacturing, academia. From NASA's (National Aeronautics and Space Administration's) first launch, putting man on the Moon, the Florida Space Coast has pioneered technological innovations, has given the U.S. the resources and edge necessary to enhance national security, defend against her adversaries in the 21st century space race.

But at the same time, Florida has struggled in other areas of innovation. For example, Florida ranks comparatively low in access to early [inaudible] despite its size partly because many of Florida's accredited investors typically focus on real estate, or other low-tech investments because they're unfamiliar with the opportunities in innovative technology companies and equity-based investment mechanisms. Florida's technology sector also faces a skill shortage, struggling to find qualified workers to fill STEM (science, technology, engineering, and mathematics) jobs, which is a significant barrier to growth.

So one of my goals is to ensure that these critical innovation jobs continue to grow, remain an integral part of our economy, and we take a long-term, decades-long approach. To that end, I think we need to understand how to successfully bring together local, State, and Federal Government with industry, with investors, with educational institutions at all levels within our community, and I look forward to hearing ideas from our witnesses of how we can do that.

I believe that strategic investments in science, in technology, in research, in STEM education are key to enhancing our national security and economic competitiveness, so I think we have a lot of agreement there. Our Committee has already worked together, which I'm proud to say on a bipartisan basis, to develop two bills that would double down our investments in science and tech, the *NSF (National Science Foundation) for the Future Act* and the *DOE (Department of Energy) Science for the Future Act*—the *Department of Energy Science for the Future Act*. I will also soon be introducing bipartisan legislation to create a national science and technology strategy and quadrennial review process. This will allow us to direct more strategic, whole of government planning process, and put that process in place to establish some priorities, and better coordinate between agencies with a large focus on also then securing that research from theft, particularly from China.

This strategy will help the U.S. remain competitive on a global scale, and stay a leader in cross-cutting innovation. The U.S. must not fall behind in developing the technology of the futures. I believe that together our Committees and the bills will help the U.S. remain a global leader. Thank you again, Madam Chairwoman, thank you again to our witnesses, and I yield back.

[The prepared statement of Mr. Waltz follows:]

Good morning and thank you Chairwoman Stevens for holding today's subcommittee hearing on regional innovation. And thank you to our expert witnesses for being with us.

How do we spur regional innovation ensure that all Americans have the opportunity participate in the innovation economy, whether they live in Daytona Beach, Florida or Boston, Massachusetts? This is a challenge that policymakers have long struggled with, and one that has received renewed interest over the last few months as we seek to advance our economy through technological innovation and compete globally with countries like China.

There are multiple proposals from the Administration and by Members of Congress calling for sizable investments for the development of regional innovation economies, and I am glad that the Science Committee is taking the time to carefully review and investigate these proposals. Unfortunately, the history of regional innovation is littered with policy failures. In the 1980's, the United States invested heavily in science and technology industrial parks. Many of these parks were unable to attract the high-tech companies needed to drive economic growth and ultimately ended up failing. The buildings were impressive, but empty. We need to make sure we don't repeat those mistakes. I hope we can use this hearing as an opportunity to hear different perspectives and new ideas on how Congress can successfully support regional innovation and avoid the failures of the past.

My home state of Florida is a great case study of the successes and challenges of regional innovation. Florida's Space Coast is a key part of Central Florida's economy, and has created jobs for Floridians in private space industry, high-tech manufacturing, and academia. From NASA's first launch to putting a man on the moon, Florida's Space Coast has pioneered technological innovations and has given the United States the resources and technological edge necessary to enhance national security and defend against our adversaries in the 21st century space race.

At the same time, Florida has struggled in other areas of innovation. For example, Florida ranks comparatively low in access to early-stage capital despite its size, partly because many of Florida's accredited investors often focus on real estate or other low- tech investments because they are unfamiliar with opportunities in innovative technology companies and equity-based investment mechanisms. Florida's technology sector also faces a skills shortage, struggling to find qualified workers to fill STEM jobs, which is a barrier to growth.

My goal is to ensure that these critical innovation jobs continue to grow and remain an integral part of Florida's economy for decades to come. To do that, we need to understand how to successfully bring together the local, state, and federal government with industry, investors, and educational institutions at all levels within a community. I look forward to hearing ideas from our witnesses how we can do that in Central Florida, and all regions of the country.

I believe strategic investments in science and technology research and STEM education are key to enhancing our national security and economic competitiveness.

Our Committee has already worked together on a bipartisan basis to develop two bills that would double down on our investment in science and technology: The *NSF for the Future Act*, and the *DOE Science for the Future Act*. I will also soon be introducing bipartisan legislation to create a national science and technology strategy and quadrennial review process. This will allow us to direct a more strategic whole-of- government planning process to establish national priorities with better coordination between agencies with a large focus on securing research from China. This strategy will help the United States remain competitive on a global scale, and stay a leader in cross- cutting innovation.

I hope today's hearing will start an important dialogue on what strategic investments are needed to encourage and support innovation economies in the United States and will yield potential legislative ideas for the Committee to consider. The U.S. must not fall behind China in developing the technologies of the future, and I believe that together our Committees bills will help the U.S. remain the global leader.

Thank you again to our witnesses for your participation today. I yield back.

Chairwoman STEVENS. Perfectly on time. The Chair now recognizes the Ranking Member of the Committee, Mr. Lucas, for an opening statement.

Mr. LUCAS. Thank you, Chairwoman Stevens, for holding today's Subcommittee hearing, and thank you to our witnesses for your participation today. I look forward to hearing your expert testimonies on how we can support the development of regional innova-

tion economies, as innovation is a propelling force for economic growth and prosperity. I would especially like to thank Secretary Pollard for taking time to speak with us today about Oklahoma's science and innovation strategy plan. This commitment to investing in innovation will grow our State's economy, provide Oklahomans with high-paying jobs, and advance our competitiveness. Oklahoma has significant existing infrastructure in three key technology areas, aerospace and autonomous systems, biotechnology and life sciences, and energy diversification. Further investments in these key areas would advance Oklahoma's innovation and potential to become a top 10 State for science and technology. The Oklahoma City Innovation District, the Tulsa Innovation Labs, the OSU (Oklahoma State University) Discovery Building, and the Oklahoma Pandemic Center for Innovation and Excellence are also examples of Oklahoma's commitment to lead in innovation.

Despite these investments, there are a few challenges affecting Oklahoma's ability to develop an innovation economy. Oklahoma ranks last for State investment in human capital, and 36th place in total R&D (research and development) expenditures. It's important to recognize these challenges to better understand how Oklahoma can leverage State, local, and Federal Government resources, along with academic and industry, to overcome these challenges. While these challenges are specific to Oklahoma, the fact is every community has their own unique set of goals and challenges for developing their research industry infrastructure.

As my colleague noted earlier, there are multiple proposals from the administration and Members of Congress on developing regional innovation economies, and I'm happy to see that this Committee is using this hearing as an opportunity to explore these proposals, along with new ideas to foster regional innovation. As we consider these proposals, I want to make sure we keep in mind the flexibility required to ensure they work across urban and rural areas, coastal and Midwestern States, big and small communities, and everything in between. For instance, while current proposals consider regional diversity when issuing awards, more often than not many rural communities, like those in my district, struggle to compete for funding, since the matching requirements are beyond the resources available within these communities. I hope today we can learn how all communities can have the opportunity to become leaders in regional innovation, and help solve some of the 21st century's most challenging problems.

With that, I thank you, Madam Chair, and I yield back the balance of my time.

[The prepared statement of Mr. Lucas follows:]

Thank you, Chairwoman Stevens for holding today's subcommittee hearing. And thank you to our witnesses for your participation today. I look forward to hearing your expert testimonies on how we can support the development of regional innovation economies, as innovation is a propelling force for economic growth and prosperity.

I would especially like to thank Secretary Pollard for taking the time to speak with us today about Oklahoma's Science and Innovation Strategic Plan. This commitment to investing in innovation will grow our state's economy, provide Oklahomans with high- paying jobs, and advance our competitiveness.

Oklahoma has significant existing infrastructure in three key technology areas: aerospace and autonomous systems; biotechnology and life sciences; and energy diversification. Further investments in these key areas would advance Oklahoma's in-

novation and potential to become a Top 10 State for science and technology. The Oklahoma City Innovation District, Tulsa Innovation Labs, OSU Discovery Building, and the Oklahoma Pandemic Center for Innovation and Excellence are also examples of Oklahoma's commitment to lead in innovation.

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Thank you, and I yield back.

Chairwoman STEVENS. Well, thank you, Ranking Member Lucas. And if there are any other Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Chairwoman Johnson follows:]

I want to thank Chairwoman Stevens and Ranking Member Waltz for holding this hearing. And thank you to our esteemed panel of witnesses for joining us to share your expertise.

The U.S. innovation ecosystem is the envy of the world for its capacity to create new technologies, jobs, and wealth. A number of U.S. cities and regions have led the way in building vibrant technology hubs. In an increasingly technology-driven world, these hubs are where new high-skilled, high-paying jobs are being created. While they benefit the country as a whole, the prosperity created by technology hubs is not shared equally across the country. It is not even shared within the regions in which the hubs are situated. If unaddressed, the concentration of economic growth will hamper our science and technology leadership and continue to exacerbate other societal challenges.

There have been a number of proposals for building upon longstanding Federal investments in building geographically diverse innovation economies. President Biden has called on Congress to invest $20 billion to fund at least 10 regional innovation hubs and to help increase access to the innovation economy for communities of color and rural communities. He has also called for significant investments in research, technology development, and manufacturing innovation through our nation's premier science agencies. These are bold and timely proposals. The Science, Space, and Technology Committee is leading the way in thoughtful and transparent discussion and vetting of these proposals, including through this hearing.

In making any new investments of the scale called for in the *American Jobs Plan* and elsewhere, we must focus on ensuring a more equitable distribution of the benefits of new innovation economies. In addition to prioritizing geographic diversity, we must take steps to avoid replicating the income inequality and housing issues troubling our existing technology hubs. This starts by bringing a more diverse set of experts and voices to the planning table. Every city and every region is unique. The Federal government should not dictate local plans for building regional innovation economies. However, the Federal government, as a partner and co-investor, can require that every plan have certain elements and include certain kinds of partners.

Addressing these challenges at the Federal level will also require a renewed commitment to collaboration between Federal agencies. While today's hearing is focused on the Economic Development Agency, or EDA, it isn't the only agency with an important role to play. Moreover, the EDA cannot accomplish these goals on its own.

Congress must be clear about the role of each agency in contributing to regional innovation. And we must leverage the strengths of each agency for maximum benefit.

I look forward to hearing our witnesses' insights on how we can address these challenges. And I look forward to continuing the bipartisan work of this committee to advance bold and smart science and technology policies for our future.

[The prepared statement of Ms. Ross follows:]

Thank you for holding this hearing, Chairwoman Stevens, and thank you to all the panelists for joining ustoday. I represent a district that includes much of the Research Triangle Park, the largest research parkin the United States and a premier global innovation center. The Triangle is an ecosystem of hundreds ofcompanies, government agencies, academic institutions, startups, and nonprofits that in effect work inconcert to attract talent; bolster the local economy; and provide critical research, technology, and cleanenergy leadership to the region and nation. Last week I led a roundtable in my district on regionalinnovation. We determined that three key ingredients that have contributed to the Triangle's successare local business community buy-in, connections to universities, and an environment conducive tostart-ups. We also discussed challenges facing the region, including the need for more early educationSTEM opportunities to strengthen the talent pipeline and the growing affordable housing crisis.

Chairwoman STEVENS. Also at this time I want to take a moment to introduce our just phenomenal witnesses, who have graced us with their presence today. Our first witness is a sincere privilege for me to introduce, Mr. Dan Berglund. Mr. Berglund is the President and CEO (chief executive officer) of SSTI (State Science & Technology Institute), a non-profit organization that leads, supports, and strengthens efforts to improve State and regional economies through science, technology, and innovation. Mr. Berglund has held this position since SSTI was founded in 1996, and under his leadership, SSTI has developed a range of services focused on communication, education, information, data analysis, and research. Prior to his position at SSTI, Mr. Berglund served as the Director of Ohio's Thomas Edison Program, and the Ohio Technology Transfer Organization, and as the Assistant Deputy Director of the Ohio Department of Development's Division of Technological Innovation. But all of that's to say, if you are in the technology-based economic development world, you are connected to SSTI, and leveraging their resources, or you are very likely doing it wrong.

Our next witness is Dr. Erica Fuchs. Dr. Fuchs is a professor in the Department of Engineering and Public Policy at Carnegie Mellon University (CMU), and a Research Associate with the National Bureau of Economic Research. Her research focuses on the development, commercialization, and global manufacturing of emerging technologies and national policy in that context. Professor Fuchs is leading Carnegie Mellon's College of Engineering moon shot on national technology strategy in critical technologies supply chain and infrastructure. She also was the founding faculty director of CMU's Manufacturing Futures Initiative, an initiative across six schools aimed to revolutionize the commercialization and local production of advanced manufacturing projects.

And now, for our next witness, Ms. Paula Nas, I would like to yield to my friend, and the dean of the Michigan delegation, Mr. Kildee, to introduce Ms. Paula Nas of the Economic Development Office at the University of Michigan at Flint.

Mr. KILDEE. Well, first of all, thank you, Chairwoman Stevens, and Ranking Member Waltz for holding this hearing, and I'm sure

I'm joined by our Chair, Chair Stevens, and my friend, Representative Peter Meijer, in welcoming a fellow Michigander to testify before us. It's my pleasure to welcome Paula Nas to testify as a witness today. Paula is the Director of the Office of Economic Development at the University of Michigan—Flint, where I once, many decades ago, was a student. She's been a lecturer in Economics at U of M-Flint for the past 25 years. She oversees several impressive programs that I've been observing for some time, including the Economic Development Administration's University Center for Community and Economic Development, the GIS (Geographic Information Systems) Center, the Innovation Incubator, and the Cybersecurity Training Center at U of M-Flint. Her primary academic interests are law and economics and microeconomic theory. She's a graduate of the Honors Program at U of M-Flint, and holds a Master's in Economics from Michigan State University, a fact which I will not hold against her, and a J.D. from Wayne State University Law School. She's also an active member of our community, serving on a number of community boards and councils, including as a member of the Grand Blanc City Council, a large suburb of my hometown of Flint. She serves on the Board of Educational Association of University Centers as well. So, Paula, thank you for your commitment to the community, to economic development in our region, and for joining us to share your expertise today. With that, Madam Chair, I yield back.

Chairwoman STEVENS. And, with that, let it be known that three of the 14 Members of Congress from Michigan are on the Science, Space, and Technology Committee.

Our final witness is the Honorable Elizabeth Hutt Pollard, Secretary of Science and Innovation for the State of Oklahoma. Secretary Pollard was appointed to her position in June of 2020. In this role she places a strategic emphasis on enabling science and innovation to impact health, commerce, and STEM education for Oklahoma. Prior to her appointment as secretary, she served as Deputy Secretary of Science and Innovation. In addition to her cabinet role, Secretary Pollard is Executive Chair of Applied Silver, a materials science health tech company located in Silicon Valley, addressing infection control and antibiotic stewardship.

As our witnesses should know, you will each have 5 minutes for your spoken testimony. Your written testimony will be included for the record for the hearing. When you have completed your spoken testimony, we will begin questions. Each Member will have 5 minutes to address the panel, and we will start with Mr. Berglund.

TESTIMONY OF MR. DAN BERGLUND, PRESIDENT AND CEO, SSTI

Mr. BERGLUND. Good morning, Chairwoman Stevens, Ranking Member Waltz, and Ranking Member Lucas, and distinguished Members of the Subcommittee. My name's Dan Berglund, President and CEO of the State Science & Technology Institute. I'm honored to appear before you today to discuss a topic that I've dedicated 36 years of my professional life to. My testimony is grounded in my personal experience of 7 years in creating, administering, and evaluating innovation programs in Ohio, and over the last 29 years working with all 50 States to build innovation economies.

For several decades, many States, as well as municipalities, philanthropic, and industry partners have been investing in their regional innovation economies to create tectonic opportunities. As I outlined in my written testimony, Georgia, St. Louis, and Pennsylvania, among others, are those that have been remarkably successful. We need to build on their examples and other successful efforts. Those efforts that are working share characteristics that can guide a responsible Federal program. They, first, bring all actors together. The private sector, institutions of higher education, economic development organizations, nonprofits, foundations, to work collaboratively. Second, they develop an approach that's customized to the local strengths, needs, and cultures of the region. And third, they make long term, sustained commitments that are of a scale to make a difference, and flexible enough to adapt to emerging opportunities.

Data show we face significant economic problems. In 1970 the middle class made up 62 percent of U.S. aggregate income, according to the Pew Research Center. By 2018 that had declined to just 43 percent. The percentage of population in the middle class shrunk in every State but Nebraska from 2000 to 2017. In 2018 the Pew Research Center calculates that Black median household income stood at 61 percent that of White households. An Iowa State University economist, David Swenson, has estimated that between 2008 and 2017 98–1/2 percent of non-farm job growth occurred in metropolitan counties. Meanwhile, the Chinese are making major investments in science and technology. While we lead in basic research, that is not enough. As valuable as basic research is, many people have a mistaken belief that if we just fill the pipeline with basic research, it'll somehow magically make it into the marketplace throughout the U.S. It takes more than magic. It takes hard work and resources that, right now, are coming primarily from States and universities to identify the research with commercial potential, fund proof of concept, and actually get the technology to the private sector.

We know this work can be done successfully because we're seeing it done at the local level. So what do we need to do? There's 40 years of experience at the State and local level on approaches to build innovation economies. We need a national strategy, and the funding to take those lessons and implement them in a sustained effort to bring this work to scale, and in all areas of the country. We need bold, robust support from the Federal Government that offers flexible funding to States and organizations to build regional innovation economies, and transform our national economy. Funding from the Federal Government that addresses the whole innovation system, rather than individual elements of a system, would be critical to building a regional innovation economy, and different than any other Federal program.

The regional technology hubs proposal of the *Endless Frontier Act* deserves serious consideration by this Committee. The legislation accomplishes much of what I've described above, with specific focus on entrepreneurship through business development, technology maturation, and workforce. The legislation as it passed through the Senate Commerce Committee could support dozens of hubs that are focused and large enough to have a meaningful im-

pact on their regions. The results would be more areas and people benefiting from a technology economy, and a stronger country. As I outlined in my written testimony, there are specific items in *Endless Frontier* that should be addressed, including the makeup of eligible recipients metrics, evaluation of the program, and where the program is located.

In summary, we can no longer afford to follow an approach where regions are cobbling together support from States, private entities, and single-purpose Federal programs. Congress, which clearly recognizes the critical threats facing the American economy, should guide a strategic substantial investment in regional innovation economies. Thank you for the opportunity to provide this testimony. My apologies for going over.

[The prepared statement of Mr. Berglund follows:]

Testimony of Dan Berglund
President and CEO of the State Science and Technology Institute (SSTI)
to the U.S. House Representative Committee on Science, Space & Technology's
Subcommittee on Research and Technology
June 9, 2021, hearing
Building Regional Innovation Economies

Thank you for the opportunity to testify on a topic that I have dedicated 36 years of my professional life working on—seven working for Ohio's Division of Technological Innovation; four as an independent consultant assisting states and regions to develop, implement and evaluate their innovation strategies; and, the last 25 years leading SSTI. My testimony is grounded in my personal experience in creating, administering and evaluating initiatives in Ohio; serving as the lead author of a book that described and categorized all states' technology programs; and, over the last 29 years, working with all 50 states to provide them with data, best practices and the experience gleaned from practitioners, consultants and academic researchers on what works.

SSTI is a national nonprofit organization that offers information and services needed to succeed in today's innovation economy. We strive to maximize the nation's capacity to deliver successful outcomes within the context of the complex innovation communities in which each of us participate every day. Focused originally on states, our membership has broadened to any organization that is focused on creating a better future through science, technology, innovation and entrepreneurship—this includes state economic development organizations, institutions of higher education, federal laboratories, venture development organizations, incubators, research parks, manufacturing extension centers, local governments, and others.

Since its inception in 1996, SSTI has worked to share lessons learned from a nationwide network of practitioners and policymakers dedicated to creating a better future through science, technology, innovation and entrepreneurship. SSTI conducts research on common performance standards, identifies best practices, analyzes trends in and policies affecting the innovation economy, and fosters greater connection and cooperation among and between all public, private and nonprofit organizations encouraging prosperity.

A board member of one of our member organizations once said that they were working to get their community more pie and that there are two ways to get more pie—you can either steal pie from someone else or work together to make a larger pie. His organization, like that of the other 150 SSTI members, is focused on how we can work together to make more pie.

The American economy faces serious threats. Some, like the shrinking middle class and income inequality, have persisted over decades. Others, like China's threat to our economic leadership, have been steadily increasing. Across the country, there has been broad and bipartisan recognition that reinvesting in American science and innovation presents a—if not *the*—path forward.

For several decades, many states, as well as municipalities, philanthropic and industry partners, have been investing in their regional innovation economies as a means of creating economic opportunities in the face of new technologies and global threats. Georgia, St. Louis and Pennsylvania are among those that have been remarkably successful. We should not hesitate to build on their example and use federal investment to strengthen our regional innovation economies.

The successful efforts share characteristics that can guide a responsible federal program. Successful initiatives do the following:

- Bring all actors together (private sector, institutions of higher education, economic development organizations, nonprofits, foundations) to work collaboratively. Importantly, who takes the lead depends on what issue is being addressed and who is best suited to address that issue, not who has the biggest budget.
- Develop an approach that is customized to the local strengths, capabilities, needs and culture of the region. While there are some who talk about building the "next Silicon Valley," successful regions and states recognize there is only one Silicon Valley—and one Research Triangle—and one Route 128—and the job of each region is to work on building the regional innovation economy that makes sense for their area.
- Make long-term, sustained commitments that are of a scale to make a difference—and flexible enough to adapt to emerging opportunities and seeking broader impacts.

In short, a federal initiative that empowers an inclusive group of stakeholders to enact a strategy tailored to the strengths and opportunities in their specific region through a substantial and sustained investment is the best approach for strengthening our regional innovation economies—and, therefore, the American economy as a whole.

Innovation economy investments

In considering what we need to do today to build regional innovation economies, we should consider first what has been attempted and what we can learn from that work.

Dr. AnnaLee Saxenian in her brilliant book, *Regional Advantage*, described the origins, growth and differentiators of Silicon Valley and Route 128. Silicon Valley and Route 128 were not planned as technology hubs, but they did not happen by accident either. One of the points she illustrated is the absolutely critical role that the direction of federal R&D funding to these two areas made in their creation; there is a myth that has sprung up over the years that these areas grew up spontaneously and solely because of the private sector, but, in fact, their status as tech behemoths was as a result of defense R&D building an intellectual infrastructure that served as a foundation for all else to come. This is not to say that they became the centers of technology solely because of federal R&D—as many communities with impressive research capacity but lacking spin-off economic activity can attest. Securing federal R&D funding hardly guarantees success for a thriving regional innovation economy—but it was a critical element.

Research Triangle Park (RTP) in North Carolina, however, was specifically conceived in the 1950s as a planned area to build a technology concentration that would benefit from the strengths of the region's universities. The success of RTP was slow in coming with visible results being seen about 15 years after conception. Again, the federal government was a critical element in catalyzing development when it announced the National Environmental Health Sciences Center would be located in RTP.

While state efforts to increase competitiveness can be traced back to the creation of the North Carolina Industrial Extension Service in 1955 and Georgia's Industrial Extension Service in 1961, today's innovation activities are more closely tied to the 1983 launch of the Ben Franklin Technology Partnership program in Pennsylvania under the leadership of Republican Governor Dick Thornburgh, and Ohio's Thomas Edison Program under the leadership of Democratic Governor Richard Celeste. Programs in

Michigan, New York and Illinois quickly followed Pennsylvania and Ohio. It is worth noting that the commitment to improving competitiveness through innovation has been a nonpartisan issue throughout the decades.

The motivations for creating these programs will sound familiar. These Great Lakes states were facing significant, structural economic problems with a severe national recession that included the decline of their traditional economic base and the rise of an Asian economic superpower—back then, the concern was Japan. As a result, public and private leaders in these states were driven to modernize and diversify their economies to make them more globally competitive, and to spur the creation of high-quality jobs that would result in a higher standard of living for all. Additionally, they wanted to find new ways to grow the assets they had, particularly the research universities they were already funding, and learn from the experiences of Silicon Valley, Route 128 and RTP. Critically, states' business leadership urged elected officials to act and partnered with policymakers to design and implement the programs.

State and regional commitments toward innovation and technology-based economic development have exploded across the country since then. Over the last 40 years, we've seen myriad approaches at the state and local level with successes and failures alike. Economic transformations in metro Atlanta, Pittsburgh, Albany, and parts of Cleveland and Milwaukee can be traced back in part to the investments that states, communities, foundations and the private sector made.

Georgia: Georgia Research Alliance

These early 1980s organizations were joined in 1990 by the Georgia Research Alliance (GRA). GRA was formed, in part, as a result of the state losing out to Austin, Texas, in a competition to serve as the home for the headquarters of the Microelectronics and Computer Technology Corp. (MCC). Georgia's business community saw an opportunity for improvement by investing in the state's research enterprise and encouraging the state's universities to work more collaboratively. Where the programs from the early 1980s operated out of state economic development agencies, GRA was set up as an independent, non-profit corporation with the business community providing funding to support GRA's operating expenses, the state providing funding to recruit eminent scholars to the state's research universities and build out laboratories for the scholars, and universities raising matching funds for the eminent scholars.

Over the past 30 years, the state of Georgia has provided more than $660 million in state dollars to GRA, which has strategically invested those funds at Georgia's leading research universities, with every dollar going to build intellectual capital and physical research infrastructure and launch new companies around discoveries made at those universities. Many of the changes in metro Atlanta's economy over the last 30 years can be traced back to the investments GRA made in the state's research enterprise and facilitating the creation of start-up companies based on university-developed technologies.

GRA's 30-year return on investment is $7.8 billion in direct investment, including:

- $5 billion in competitive research grants and contracts awarded to the 75 world-class scientists (GRA Eminent Scholars) recruited to Georgia by GRA; and,
- $1.6 billion in private investment in 195 GRA portfolio companies—all built around technologies and discoveries made at Georgia's universities and launched with the support of the GRA Ventures Program; these companies generate more than $1 billion in revenue and employ more than 1,500 people.

Just one of the companies GRA has assisted is Diasyst, which makes it easier for doctors and their staff to track and manage patients with diabetes. Patients use an app to record their blood sugar levels; the data is automatically sent to their healthcare team. The Diasyst platform synthesizes many individual measurements into a single actionable data point, which in turn reduces the number of trips to the doctor and allows doctors to adjust medications more precisely. Half of the adult population in Georgia has diabetes or pre-diabetes, and it is a condition that disproportionately impacts Blacks and those who live in rural communities with inadequate healthcare. Studies of the platform indicate participants who use Diasyst showed, on average, lower A1C (blood sugar) levels. The company is a start-up out of Emory University that grew out of a project an undergraduate student from Georgia Tech conducted with an Emory professor. The company now employs 20 people. GRA provided financing at critical stages of the company and technology development.

Missouri: BioSTL

Like many parts of the heartland, the St. Louis region experienced a clear shift out of manufacturing firms and into services firms. Significant downsizing in core industries, including the defense industry in the 1990s; significant re-structuring and closures in the automotive industry; and the loss of local corporate headquarters through global mergers and acquisitions marked this transition. To counter the region's economic decline, in 2001, corporate, philanthropic, academic, and civic leaders—led by the late-Senator Jack Danforth's brother, Dr. William Danforth—launched BioSTL, as the lead entity of St. Louis' bioscience cluster, to capitalize on St. Louis' scientific strengths and to position the region as a leader in the high-growth sector of biosciences.

Execution of a shared, regional vision by BioSTL and its partners has resulted in: more than $2 billion in locally-managed venture capital (up from $0 in 2000); more than 1000 jobs in the Cortex innovation district; growth of the Donald Danforth Plant Science Center into the world's largest, independent plant science institution; the launch of more than 300 new bioscience startups through BioSTL's startup arm, BioGenerator; and a growing STEM talent pipeline through the STEMSTL ecosystem to ensure inclusion and equity in new career opportunities.

Together, with over 20 years' of work, these coordinated initiatives to grow St. Louis' innovation economy have served to stabilize declines in the region's economy and position St. Louis to be globally competitive in the 21st Century. While significant challenges still exist across the region, St. Louis' bioscience innovation economy is helping rebuild a culture of innovation and entrepreneurship, which waned in the 20th Century. While biosciences account for just more than 2.5 percent of regional employment, a new breed of bioscience entrepreneurs has garnered nearly 80 percent of all venture capital to the region and increased the number of establishments in the cluster from less than 800 to more than 1500, creating thousands of high-paying jobs (from associates degree-level technicians to Ph.D.-level biologists)—that average 55 percent higher wages than the regional median. This growth, through a long-term, regional commitment to building the innovation economy, has helped diversify the region's economy and provide economic resilience to job losses (even within the bioscience cluster) caused by global corporate consolidation, economic recessions, and the pandemic.

Pennsylvania: Ben Franklin Technology Partners

Since its inception in 1983, Pennsylvania's Ben Franklin Technology Partners has invested in more than 4,500 technology-based companies and boosted Pennsylvania's economy by more than $25 billion, helping to generate 148,000 jobs through investments in client firms and spinoff companies. The in-

demand, family-sustaining jobs created by Ben Franklin's clients pay an average of $79,364 annually—52 percent higher than the average non-farm wage in Pennsylvania. Not only are these jobs that pay well, they are jobs that can help attract and keep talent and drive Pennsylvania's economy.

Even during the pandemic year of 2020, the Pennsylvania Department of Community and Economic Development reports that its programs administered through the Ben Franklin Technology Development Authority had an impactful year. The $42 million in public funds resulted in 100 new company formations, 2,071 jobs created, 14,721 jobs retained, $2.2 billion revenue earned, and 295 new products commercialized.

One of the start-up companies that Ben Franklin Technology Partners of Northeast Pennsylvania (BFTP/NEP) has assisted is Scranton-based Signallamp Health (SLH), an IT-enabled Chronic Care Management provider that works as an extension of primary care practices. It allows physicians to provide better care to patients who have multiple chronic conditions. Utilizing a proprietary electronic medical record interface, experienced registered nurses deliver telephonic care to patients, focusing on prevention. SLH has more than 1,000 doctors under contract, representing 78,000 eligible patients. Signallamp extends the reach and clinical capacity of healthcare providers to manage vulnerable patients, including those affected by COVID-19, outside of the traditional clinical setting. SLH serves more than 25,000 patients across seven health systems, dozens of group practices, and 10 states. In 2019, the company expanded its product offering to provide telehealth services to individuals with Opioid Use Disorder. With more than 100 employees, the company was recognized on the Inc. 500 list of the fastest-growing private companies in the U.S., ranking No. 240 overall, No. 18 in the health industry, and No. 1 in Pennsylvania, with a three-year growth rate of 1,844 percent. SLH received just over $300,000 from BFTP/NEP in three separate rounds from 2015 to 2020.

Ohio: JumpStart

One of the venture development organizations Ohio helps support reports significant results in 2020 as well. JumpStart, which is based in Cleveland and services northeast Ohio, works with dozens of other non-profit economic development organizations, universities, and institutions in Ohio to support tech startups through technical assistance and venture capital investment, helping early-stage companies start and scale. In 2020, technology companies receiving assistance from JumpStart and its partners directly and indirectly supported an estimated $882 million of economic output, including $490 million in payroll from 7,186 jobs which helped support more than 4,400 households.

New York: LaunchNY

Launch NY was established to serve the 27 westernmost counties of New York State, including Buffalo, Rochester, Syracuse, and Southern Tier regions, including urban, suburban, and rural communities, which have been among the most economically distressed in the country with poverty rates exceeding 30 percent in the most affected areas. With a dying traditional-industry base among companies ranging from Bethlehem Steel to Eastman Kodak, creating new-economy businesses has been a critical focus. Against this backdrop, Launch NY was created as a nonprofit venture development organization in 2012 to provide pro bono mentoring and seed capital for high-growth potential startup businesses. It became one of only 15 U.S. Treasury Designated Community Development Financial Institutions (CDFIs) nationwide, and the only one in New York State, providing venture capital directly to businesses in low income communities. Shortly after starting its first fund in 2016, Launch NY became the most active seed fund in New York State and one of the most active in the country. Serving a region that in 2010 saw

only 3 percent of the venture capital invested in New York State annually and was not even considered among the top 100 regions in the U.S. for entrepreneurship, Launch NY has helped drive the incredible progress reflected in Western New York being rated among the top 100 emerging ecosystems globally based on The Global Startup Ecosystem Report from Startup Genome in 2020.

Since 2012, Launch NY has served 1,210 companies, has more than two dozen experienced local entrepreneurs-in-residence, and developed its National Mentor Network of 2,000 industry, business and investment experts. Launch NY mentored companies, including 27 percent women-led and 26 percent minority-led startups, that have created 4,300 jobs, attracted nearly $1.3 billion in co-investment and follow-on capital, and generated over $146 million in annual revenues. Those funded by Launch NY starting in 2016, including 73 portfolio companies comprised of 33 percent women-led and 27 percent minority-led, have created nearly 350 jobs, attracted over $69 million, and generated over $16 million in annual revenues. Launch NY also leads the premier Emerging Cleantech Opportunity (ECO) Incubator, one of six designated clean-energy incubators sponsored by the New York State Energy Research and Development Authority (NYSERDA), as well as the Founders Go Big program, an innovative diversity and inclusion initiative introduced in 2020. Over 70 percent of Launch NY's portfolio companies are in low-income census tracts and nearly 45 percent are led by persons of color and/or women.

Oklahoma: i2E

States with smaller populations or dispersed population centers often use single organizations to build a critical mass of activity across the state. Oklahoma's partnership with i2E provides a good example. i2E is now in its twenty-third year of operations and client services. Since inception, i2Ee has received $49 million in state funding from the Oklahoma Center for the Advancement of Science & Technology (OCAST). i2E has leveraged that state funding into $938 million in private capital while serving more than 740 Oklahoma companies. The $938 million represents a 19X return measuring *only* private capital attracted by i2E client companies. In addition to the private capital, i2E clients report annual wages that are consistently 50-90 percent above the average annual wage in Oklahoma. Clients also consistently report that 80 percent of their revenues originate from outside Oklahoma through national and international sales. Including other gains to Oklahoma, such as jobs created, $85.1 million in grants received, and number of patents issued, the quantitative impact is astounding.

Approaches to strengthening regional innovation capacity can be sector based (such as BioSTL), focused on one or more key assets within the regional economy (such as tying equity financing to entrepreneurial development for companies like Jumpstart, I2E and Launch NY do) or nodal, meaning they concentrate small public investments on single places over a long period of time. Incubators, research parks and innovation districts are examples of nodal approaches to supporting regional innovation capacity.

Pennsylvania: University City Science Center

The University City Science Center (Science Center) in Philadelphia presents an example of a long-term sustained investment in a specific facility to serve as a node for encouraging the growth of innovation-based companies in the heart of the city. Established in 1963, the Science Center is a nonprofit innovation intermediary that helps commercialize promising technology, convenes people to inspire action, and cultivates talent for a 21st century STEM workforce. The Science Center supports multi-state and regional economic development through a suite of commercialization and finance programs supporting an eclectic portfolio of entrepreneurs from proof-of-concept through all phases of growth.

Over the last 10 years the Science Center has supported over 600 startups and invested $14 million, with over $1 billion raised in follow-on funds. The Science Center's 2020 impact included: 45 percent minority founders supported; $43.3 million in follow-on funds for companies in Science Center programs and 44 percent non-white, 51 percent women attendees at Venture Café.

Wisconsin: The Water Council

In 2009, forward-thinking Milwaukee business, education and government leaders came together to establish The Water Council, which has coalesced one of the most concentrated and mature water technology clusters in the world. Recognizing the need for smarter and more efficient use of water worldwide, The Water Council is increasingly focused on water stewardship as a natural complement to water innovation in the effort to preserve freshwater resources in the Midwest and around the world. Today, The Water Council has established itself as a global leader in the water industry.

In 2013, The Global Water Center (GWC) opened in the Walker's Point neighborhood of Milwaukee as The Water Council's headquarters and a collaborative space for water technology corporations, start-ups and local universities. The GWC serves as the physical manifestation of Milwaukee's water hub and has spurred significant development in Walker's Point, including new headquarters for major corporations such as Rexnord, Komatsu, Michels and Rite-Hite.

The examples that I've provided here just begin to scratch the surface of what is being done across the country. While the results are impressive, there is so much work that needs to be done.

Threats to the American economy

Data show we face significant economic problems—and these problems transcend presidential administrations. In 1970, the middle class made up 62 percent of U.S. aggregate income, according to the Pew Research Center; by 2018, that had declined to just 43 percent.[i] The percentage of population in the middle class shrunk in every state but Nebraska from 2000 to 2017, according to an analysis by *Stateline*.[ii] The gap between Black and whites median household incomes continues to be far too wide. In 1970, the Pew Research Center calculates that Black median household income was 56 percent that of white households; by 2018, we had barely made any progress in closing that gap with Black median household income at 61 percent that of white households.[iii] And, we need to work to ensure all regions of the country benefit from a growing economy. Iowa State University economist David Swenson has estimated that between 2008 and 2017, 98.5 percent of non-farm job growth occurred in metropolitan counties.[iv]

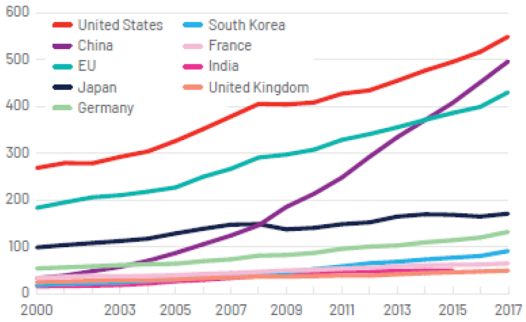
SSTI has pointed out, alongside other organizations, the geographic concentration of venture capital and the movement of venture capitalists toward larger and later-stage deals.[v] We have also reported on a similar, although not as severe, concentration—primarily because the venture capital concentration is so lopsided—of federal R&D.[vi]

Meanwhile, the Chinese are making major investments in science and technology, and this is not just political rhetoric. In the 35+ years that I have been in the field, I have seen few charts that are more chilling than the one reproduced here from the National Science Board's *The State of U.S. Science and Engineering 2020.* While the press focus was on the likelihood that China would surpass the U.S. in R&D expenditures, the real story in my view was the pace at which the Chinese investment was accelerating. From less than 50 billion in purchasing power parity dollars in 2000, Chinese R&D spending increased to

roughly 500 billion in purchasing power parity dollars in 2017. While U.S. spending increased over the same time period, it was not nearly at the same rate of increase as China's.

Figure 11. Gross domestic expenditures on R&D, by selected region, country, or economy: 2000–17

Billions of PPP dollars



NOTES: PPP is purchasing power parity. Data are for the top eight R&D-performing countries and the EU. Data are not available for all countries for all years. The EU includes France, Germany, and the United Kingdom. See p. 22.

SOURCES: NCSES, National Patterns of R&D Resources; OECD, MSTI 2019/1; UNESCO, UIS R&D.

Indicators 2020: R&D

[vii]

The report points out that countries vary in their focus on basic research, applied research, and experimental development. It states, "According to the most recent estimates, the United States spends 17 percent and China spends 6 percent of its annual R&D funds on basic research. ... China spends 84 percent of its R&D funds on experimental development, compared to 63 percent in the United States."[viii] An NSF press release at the time quoted one member of the National Science Board as saying, "Basic research is the 'seed corn' of our US S&E enterprise, a global competitive advantage, and the starting point for much of our GDP growth since World War II."[ix]

The implication here is that as long as we lead in basic research, we will be fine. There is no question that basic research is of fundamental importance—see again the origins of Silicon Valley and Route 128—and I commend the House Committee on Science, Space and Technology for its recent action to increase funding for the National Science Foundation.

At the same time, part of the economic advances China, South Korea and Japan have made in recent decades have been because of their expertise in investing in experimental development. Assuming that the U.S. will be fine because we continue to invest in basic research is representative of the typical D.C.-centric approach on science and technology: fill the pipeline with basic research and somehow magically that research will make it into the marketplace. It will take more than that.

Catalyzing regional innovation economies

The practitioners involved in tech-based economic development know that the private sector is not getting everything to the market and that it takes hard work to make it happen. Among the steps are identifying research that has commercial potential, determining a strategy to get it to the marketplace, and finding funds for proof-of-concept.

We know this work can be done successfully because we're seeing it done at the local level.

U.S. supremacy in basic research will be meaningless from an economic perspective unless the federal government begins investing in and encouraging investment in a strategic fashion to move our research "seed corn" to planting and ultimately, harvest.

So, what do we need to do?

States have been referred to as "laboratories of democracy" so frequently that it's almost become a cliché, but as the cliché goes, there's a reason a phrase becomes a cliché. We have 40 years of experience at the state, local and university level on approaches to build innovation economies. What we don't have is a national strategy and the funding to take those lessons and implement them in a sustained effort to bring this work to scale.

The federal government has played a relatively minor part when it comes to an intentional role in building regional innovation economies. The Economic Development Administration (EDA) and the Appalachian Regional Commission (ARC) were created in the 1960s to focus on the general economic development of specific distressed areas, and these are important agencies. But what we need now is an approach rooted in 21st Century challenges, recognizing that these challenges are occurring in every community.

We need bold, robust support from the federal government that offers flexible funding to states and organizations to build regional innovation economies and locally-designed efforts that address broad national goals, but allow for differences in delivery and emphasis based on local conditions. Emphasis from the federal government has been on funding for physical assets rather than the operation of the organizations going in those buildings. As a result, we have, for example, a proliferation of building construction for incubators with communities scrambling to determine how they will fund the actual service delivery.

The examples of Research Triangle Park, the Georgia Research Alliance, BioSTL and the Ben Franklin Technology Partners, show that it takes a sustained, long-term commitment for this work to succeed. The federal government should provide long-term support designed to encourage transformational results, and this investment should occur in dozens of regions across the country.

A particular challenge in building regional innovation economies is the specific constraints placed on funding that is received. Those constraints are understandable from a funder's perspective, but they discourage cooperation among the elements required for an innovation system. For example, developing a workforce is key to a regional innovation economy, but workforce development funding from the federal government is rarely tied to broader efforts to develop an innovation economy. Funding from the federal government that addresses the whole innovation system rather than individual elements of a system would be a critical additional tool to building a regional innovation economy. It would help break down the silos that have occurred between the K-12 systems, higher education,

workforce development, economic development and tech-based economic development communities, all of which have important roles to play but are not incentivized to work with each other.

Regional Technology Hubs

As I prepare this testimony, the U.S. Senate is considering a regional technology hubs program as part of the *Endless Frontier Act*, and as the program has come out of the Senate Committee on Commerce, Science and Transportation, it deserves serious consideration by this committee.

The legislation accomplishes much of what I have described above with specific focus on entrepreneurship and business development, technology maturation and workforce. The legislation as it passed through committee would accommodate dozens of hubs that are focused and large enough to have a meaningful impact on their regions. The result would be more areas and people benefiting from a technology economy and a stronger country.

The need is significant across the country. Based on past state initiatives, I would consider a range of $20-50 million annually per hub as a sufficiently-strong investment to allow for transformational programmatic activities over the five-year authorization of the program; I am assuming that this amount would be used for program operations and delivery, not building construction. Like other federally-funded organizations, the hubs should be able to apply for continued funding. The scale of investment in each hub should vary based on the need and stage of the region's development. The range should be assessed as part of the program evaluation.

As this committee considers its priorities for investments in regional innovation economies, the Senate bill offers a framework. Additional considerations include the following:

a. *Consortium requirements*. Recipients of a substantial, federal regional innovation economy grant should include *all* of the relevant stakeholders. This appears to be the intent of the regional technology hubs program, for example, but the Senate committee version is not entirely clear whether a consortium may or must include each of an institution of higher education, local or tribal government, state government, economic development organizations, industry, and labor organization. The consortia should be required to have all of those organizations as members. Again, a lesson learned from our experience is that those efforts that have been successful are the ones that bring *all* relevant actors together.

b. *Selection criteria.* Congress should articulate selection criteria for significant investments in regional innovation economies to provide clear guidance to the implementing agency.
    - Regions requesting $20-50 million over five years should be proposing to expand the availability of well-paying jobs through science, technology and innovation, and have a reasonable proposal for how this can be achieved.
    - More specifically, applicants should be expected to articulate their vision for inclusion and shared prosperity among all and the likelihood that they will be able to achieve it. The technology industry from virtually every conceivable measure—workforce, founders, venture capital received—has a woeful record of building a sector that includes all people. Large IT companies are talking about the problem, and there are attempts being made at the local and state level to address this, but they are still nascent and need to be encouraged.

c. *Metrics*. The primary metrics used to evaluate the success of each investment in a regional innovation economy will depend on what the region is attempting to accomplish. Historically, for state programs, the metrics of success shift over time as the development of the regional innovation economy changes; for example, in some communities building research capacity is critical, so measuring the increase in research funding, particularly from industry, is a reasonable measure. As research capacity improves, shifting focus to start-up company success in raising follow-on funding, sales and employment is a reasonable approach. All regions should be measuring R&D, commercialization, company formation, employment and sales but the hub's performance should be evaluated based on the ones relevant to its goals.

d. *Evaluation*. In comparison to Canada and the European Union, the U.S. spends little on evaluation of its economic development programs and analyzing the broader results of the work undertaken. For decades, the Economic Development Administration's research and national technical assistance program has been below $3 million per year. An investment in regional innovation economies should follow the lead of the Manufacturing Extension Partnership and some of the NSF-funded centers that do annual evaluations. Spending $70 million—less than one percent of the total authorization level of the Senate's proposal—is reasonable.

e. *Administration*. The best federal agency to operate a program of this nature would be a new one that could be completely dedicated to understanding and improving regional innovation economies. The Department of Commerce has a track record of operating the Build to Scale program through the Office of Innovation and Entrepreneurship and the many innovation-related activities at the National Institute of Standards and Technology (NIST). The Senate's approach of placing the regional technology hubs within EDA in consultation with NIST is, therefore, understandable. However, I would encourage the committee to consider the creation of a new agency within the U.S. Department of Commerce—such as by evolving the Office of Innovation and Entrepreneurship into an agency in its own right and allowing EDA to continue its focus on distressed communities. This new agency would focus exclusively on innovation and competitiveness and could be responsible for not only the regional technology hubs program, but also the regional innovation strategies program, the Hollings Manufacturing Extension Partnership and the Manufacturing USA Institutes.

Summary: Creating a better American economy

Many areas of the country have a strong base of R&D activity that can be better-nurtured into new products, companies, and well-paying jobs. However, we can no longer afford to follow an approach that forces regions to piecemeal support from states, private entities, and single-purpose federal programs. Instead, Congress, which clearly recognizes the critical threats facing the American economy, should guide a strategic, substantial investment in regional innovation economies.

Regions as diverse as Georgia, Western New York, Oklahoma, Milwaukee and St. Louis have provided examples of how initiatives can help foster new technology hubs in areas that are not known historically for startups or venture capital. These types of efforts succeed through the efforts of broad partnerships, strategies tailored to the regions, and sustained investments. As well as these efforts have fared, only the federal government is positioned to transform this approach from a series of one-off successes into a national strategy capable of bolstering American global competitiveness.

Regionally-driven, federally-funded investments can advance emerging tech hubs to the international stage while catalyzing a new crop of emerging regions. Such an effort will result in new technologies—including life-saving treatments, energy-saving devices, and productivity-boosting processes—higher-paying jobs for Americans of all backgrounds, and a renewed footing atop the global economy.

Thank you for the opportunity to provide this testimony.

[i] "The Gaps in Income between Upper-Income and Middle- and Lower-Income Households Are Rising, and the Share Held by Middle-Income Households Is Falling." *Pew Research Center*, Pew Research Center, 7 Feb. 2020, www.pewresearch.org/fact-tank/2020/02/07/6-facts-about-economic-inequality-in-the-u-s/ft_2020-02-07_inequality_06/. (accessed June 6, 2021).

[ii] Henderson, Tim. "Economists Remain Worried About Slow-Growing Middle Class." *The Pew Charitable Trusts*, www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2019/05/20/economists-remain-worried-about-slow-growing-middle-class. (accessed June 6, 2021)

[iii] "In the U.S., Black-White Income Gap Has Held Steady since 1970." *Pew Research Center*, Pew Research Center, 7 Feb. 2020, www.pewresearch.org/fact-tank/2020/02/07/6-facts-about-economic-inequality-in-the-u-s/ft_20-02-04_economicinequality_3/. (accessed June 6, 2021)

[iv] Swenson, David. "Most of America's Rural Areas Are Doomed to Decline." *The Conversation*, 4 Jan. 2021, theconversation.com/most-of-americas-rural-areas-are-doomed-to-decline-115343. (accessed June 6, 2021)

[v] Rittenberg, Jason. "Useful Stats: Later-Stage VC Has a Banner Year, Uncertainty about Early Stages." *SSTI*, ssti.org/blog/useful-stats-later-stage-vc-has-banner-year-uncertainty-about-early-stages. (accessed June 6, 2021)

[vi] Edwards, Colin. "Useful Stats: Federal R&D Obligations by State and Agency, 2019." *SSTI*, ssti.org/blog/useful-stats-federal-rd-obligations-state-and-agency-2019. (accessed June 6, 2021)

[vii] National Science Board, National Science Foundation. 2020. *Science and Engineering Indicators 2020: The State of U.S. Science and Engineering.* NSB-2020-1. Alexandria, VA. Available at https://ncses.nsf.gov/pubs/nsb20201/, p.8

[viii] Ibid., p. 9

[ix] "America's Share Decreasing as Global Science and Engineering Grows." *National Science Board*, nsf.gov/nsb/news/news_summ.jsp?cntn_id=299790. (accessed June 6, 2021)

Dan Berglund
President and CEO, SSTI

Dan Berglund is the president and CEO of SSTI, a non-profit organization that leads, supports, and strengthens efforts to improve state and regional economies through science, technology, and innovation. SSTI is the most comprehensive resource available for those involved in technology-based economic development. Leading SSTI since its inception in 1996, Mr. Berglund has helped SSTI develop a nationwide network of practitioners and policymakers dedicated to improving the economy through science and technology. SSTI works with this network to assist states and communities as they build tech-based economies, conduct research on best practices and trends in tech-based economic development, and encourage cooperation among and between state and federal programs.

Under Mr. Berglund's leadership, SSTI has developed a range of services focused on communication, education, information, and research. The *SSTI Weekly Digest* provides its readership of several thousand with information on the key stories affecting the tech-based economic development community. The SSTI Annual Conference routinely attracts hundreds of tech-based economic development practitioners and policymakers to further their professional development and learn how to apply best practices to their situation. Mr. Berglund also oversees SSTI's research projects, which have included an examination of state R&D tax incentives, science and technology strategic planning, and funding for tech-based economic development.

In addition to being a frequent speaker at national and international conferences, Mr. Berglund has provided assistance to dozens of states and localities as they create, administer, and evaluate their tech-based economic development programs and strategies. He currently serves or has served on a number of boards or advisory committees including: the Committee of Experts for the Council of Competitiveness' Center for Regional Innovation; the Hawaii Innovation Council; the Georgia Tech School of Public Policy Advisory Board; Advisory Group for the Connecticut Governor's Advisory Board for Technology Transfer and Commercialization; and, an Advisor for the Impact Assessment of Texas' Advanced Technology and Technology Development Programs.

Mr. Berglund is the co-author of *Partnerships: A Compendium of State and Federal Cooperative Technology Programs*, the first comprehensive description of technology-based economic development programs. The publication provides an in-depth review of the state and federal government's programs, including their goals, administration, and their results.

Prior to joining SSTI, Mr. Berglund worked as a private consultant. This work included: the development of an economic impact assessment report for a state technology program; preparation of a regional technology strategy for a multi-county region; and, a feasibility study for a university-industry marine science and technology center.

Mr. Berglund served as the Director of Ohio's Thomas Edison Program and the Ohio Technology Transfer Organization (OTTO), Ohio's largest public/private economic development programs. The Edison Program is widely recognized as a national leader in business/university cooperation in the development and implementation of new technology. OTTO was one of the nation's oldest industrial extension agent programs.

Prior to his appointment as Director, Mr. Berglund served as the Assistant Deputy Director of the Ohio Department of Development's Division of Technological Innovation. In this role, Mr. Berglund participated in the development of Ohio's science and technology strategic plan, the creation and implementation of Ohio's Small Business Innovation Research (SBIR) Program, and the evaluation and funding for the Edison Technology Centers, Edison Incubators, and Edison Seed Development Fund.

Mr. Berglund holds a B.A. in Political Science and Economics and a B.A. in History from Ohio University.

Chairwoman STEVENS. With that, Dr. Fuchs.

TESTIMONY OF PROFESSOR ERICA R.H. FUCHS, DEPARTMENT OF ENGINEERING AND PUBLIC POLICY, CARNEGIE MELLON UNIVERSITY

Dr. FUCHS. Fuchs. Thank you, Chairwoman Stevens, Ranking Member Lucas, Ranking Member Waltz, and Members of the Subcommittee. Trained as an engineer, I bring perspectives from my research laboratory, which is the factory floor of manufacturing firms across the United States and around the world. Over the last half a century, the global geopolitical balance of scientific, economic, and production capabilities has shifted away from U.S. dominance. Today China is the largest producer, and second largest consumer market. The U.S. is no longer in a singular position of scientific and technological leadership across domains. Meanwhile, we face equal or greater challenges on our home front. Economic inequality has increased, and social mobility declined. Central to these trends are trade and technology change. While increased and more evenly distributed science and technology funding is essential for national security, economic prosperity, and social welfare, realizing policymakers' multiple objectives for these Federal investments will require institutional innovations to ensure our technology investments realize the economic and social benefits we seek.

First, strategic investments in science and technology can change the playing field and rules of the game. To regain and maintain global economic competitiveness, our priority should be making products that can only be made here, and that everyone in the world wants. In advanced semiconductors for communications, our research finds that while firms can save costs in the short term by producing older generation products offshore, the innovative next-generation products hold potential to address national security firm—concerns, and enable firms to access new, larger markets. Those innovative next-generation products can only be produced in the U.S. and Europe, and involve more skilled and innovative jobs for high school educated operators. Similarly, as the world scales up electric vehicle production, the country that leads in innovations in battery recycling and cobalt-free batteries has the potential to change global market prices, change the global location of production, and free itself from single country supply risks. Our research again suggests that battery production may involve more skilled and empowered jobs for high school educated shop floor workers. We need to invest to ensure we make these and other critical technologies here.

Second, to help regions reap locally the longer-term economic benefits of research and technology investments, we need to strategically invest in infrastructure now. Nationwide investments in the infrastructure of the future hold promise not only to improve security, productivity, and equity, but also to revitalize the U.S. worker skills and manufacturing ecosystems necessary to manufacture the products of the future. The mason, floorman, engineer, and computer science skills relevant to intelligent transportation and urban infrastructure systems have corollaries in resilient grid infrastructure, privacy preserving health infrastructure, and intelligent man-

ufacturing. Our investments and trainings should be strategic to leverage these overlaps, and the career transitions between them.

Third, the U.S. must invest in the intellectual foundations, data infrastructure, and analytic capabilities necessary to inform technology investments. Research by ourselves and many other shows that inadequate data and analytic capability is weakening government decisionmaking regarding critical technologies, supply chains, and infrastructure. Our research demonstrated the possibility of using text processing of public information to substantially improve the government's real-time situational awareness of critical medical supply chains during COVID. In other work we are leveraging new tools to quantify the skills required for emerging technologies before large-scale investments are made, and to better understand skill crosswalks that enable firm pivots and skill transitions. The executive branch, legislative branch, and all agencies need access to, and to be informed by the data and analytics today's technology and public/private collaborations could make possible.

Finally, the U.S. should create a nimble entity with national technology strategy as its mission. U.S. agencies are single-mission driven, and yet technology investments, by their very nature, simultaneously affect security, economic competitiveness, and social welfare, including health, environment, and equity. Regional investments in research and development, in infrastructure of the future, and local economic development have the potential to have their investments multiplied, if thoughtfully linked. A new directorate focused on national technology strategy will need to be empowered, to influence, and have incentives to collaborate with the excellent mission-oriented agencies in our government. Getting these investments right is non-trivial, but as we've shown in our research, win-win solutions exist. This directorate must be backed by the star-studded interdisciplinary data and analytic team necessary to make tradeoffs transparent and help policymakers ensure the security and welfare of all citizens in our Nation.

[The prepared statement of Dr. Fuchs follows:]

Carnegie Mellon University

TESTIMONY
BY
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HEARING ON BUILDING REGIONAL INNOVATION ECONOMIES
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
JUNE 9, 2021

Thank you Chairwoman Stevens, Ranking Member Waltz, and Members of the Subcommittee for convening this important hearing. I am a Professor in the Department of Engineering and Public Policy in the College of Engineering at Carnegie Mellon University, and a Research Associate with the National Bureau of Economic Research. My research focuses on the development, commercialization and global manufacturing of emerging technologies, and national policy in that context. My "research laboratory" is often the factory floor of manufacturing firms in regions across the U.S. and around the world.

Over the last half a century, the world and the U.S.'s position in that world has changed dramatically. The global geopolitical balance of scientific, economic, and production capabilities has shifted away from U.S. dominance. China is now the largest and most rapidly growing consumer and producer, and the U.S. is no longer in a singular position of scientific and technological leadership across domains (Branstetter, Glennon, and Jensen 2018; Segal 2019). At the same time, the U.S. faces equal or greater challenges on its home front. Domestic economic inequality has increased (Autor, Katz, and Kearney 2008; Autor 2014; Leonhardt 2017, Autor 2019), social mobility declined (Chetty et al 2017, Chetty et al 2020), and political polarization is on the rise (Autor, Dorn, Hanson, and Majlesi 2020). Center stage to both of these trends are trade and technology: research has documented negative impacts of import competition on employment and earnings in trade-exposed local labor markets (Autor, Dorn and Hanson, 2013; Acemoglu et al. 2016) and a rise in political extremism in locations hardest hit by trade (Autor, Dorn, Hanson and Majlesi, 2020).

Unfortunately, in this moment of dual internal and external crises, we lack the intellectual and institutional foundations to guide our nation on how to act. While earlier research highlighted the benefits of global trade (Ricardo 1817) and technology change

(Solow 1957), empirical evidence has increasingly pointed to how these benefits can be uneven: Globalization can decrease some wages (Samuelson 2004, Autor et al 2016) and innovation (Fuchs and Kirchain 2010, Fuchs 2014, Autor et al 2020) domestically; certain forms of technology change, such as automation, can reduce jobs without increasing productivity (Acemoglu et al 2020) and exacerbate inequality (Autor et al 2003). In light of these more recent findings, some intellectual leaders have suggested slowing the progress and adoption of technology (Piore 2018, Acemoglu et al 2020), and gradualism as a principle for trade policy (Autor et al 2016). Others are raising concerns about the U.S. losing global technology competitiveness, particularly to China (Augustine and Lane 2020). These experts are arguing for dramatically increasing funding of science and technology (Segal 2019, Johnson and Gruber 2019, Augustine and Lane 2020), and using regional distribution of funding of science and technology to reduce inequality and jobs (Johnson and Gruber 2019).

It is these very debates -- central to the sovereignty of our nation and well-being of our citizens -- that bring us together today. Unfortunately, these debates as they currently stand have two fundamental flaws: they confuse the complex relationship between innovation and jobs, and they overlook the heterogenous nature of technologies and thus the different effects of different technologies on a wide variety of outcomes. It is only by first rectifying these misunderstandings, that it begins to become clear that missing from these debates is that there may be win-win technology choices -- strategic technology investments that could meet multiple national objectives, such as improving national security and economic competitiveness, winning in global trade, and increasing the number of good jobs. I unpack these issues with four points:

First, science and technology can change the playing field and rules of the game. To efficiently and effectively realize the nation's multiple objectives -- national security, economic prosperity, and social welfare -- some portion of our science and technology investments should be approached as strategy on a chess board. In order to regain and maintain global economic dominance, our priority should not be reshoring existing commodity products. Rather, we should focus on making products that can only be made here, and that everyone in the world wants. In my research on advanced semiconductors for communications, we find that while offshoring reduces production costs in the short-term, it reduces incentives for and the possibility of firms undertaking innovations that may have significant implications for national security and in the longer term hold potential to enable those firms to access larger markets (Fuchs and Kirchain 2010). In addition, while the short-term incentive is for firms to produce older generation technologies offshore, the next generation products can only be produced in the United States and Europe (Fuchs and Kirchain 2010), and involve more skilled and innovative jobs for high school operators (Combemale, Ales, Whitefoot, Fuchs 2020; Combemale and Fuchs 2020). Our early research suggests a similar story is likely true in vehicle

electrification and battery storage. Lithium-Ion batteries are currently the largest end use of cobalt (accounting for 50% of global cobalt demand.) Currently, more than 60% of all mined cobalt production comes from the Democratic Republic of the Congo (DRC), and cobalt mining in the DRC is expected to continue to be 62-70% of global production through 2030 (Fu et al 2020). With Lithium ion battery demand, particularly for electric vehicles, projected to increase by over 300% throughout the next decade, cobalt-dependent technologies face the risk of significant impact from supply concentration and mining limitations in the short term (Fu et al 2020). The country that leads in innovations in battery recycling and cobalt-free batteries has the potential to change the rules of the game, and have a better chance at winning given those rules. In addition, there is reason to believe aspects of electric vehicle production may be associated with better jobs (Combemale, Ales, Whitefoot, Fuchs 2020; Combemale and Fuchs 2020; Cotterman, Whitefoot, Small, Fuchs research in progress.)

To be clear, growing science and technology funding is important, and not all of it (perhaps even not most of it) should be focused on strategic aims. Government-funded research increasingly and disproportionately fuels innovation (Fleming, Greene, Li, Marx, and Yao 2019), U.S. science and technology funding as a percent of GDP is close to its lowest levels since WWII (Johnson and Gruber 2019, Segal 2019) and has fallen below other developed nations (Augustine and Lane 2020). However, increases in science and technology funding alone will be insufficient to ensure U.S. technology competitiveness without a strategy for how to ensure that those investments realize legislators' national objectives. Here lists can be helpful, but alone are insufficient.

Take, for example, the context of semiconductors. Orders of magnitude greater science and technology funding is sorely needed to address domain specific-challenges such as the end of Moore's Law in advanced semiconductors (c.f. Khan, Hounshell, and Fuchs 2018), with economic prosperity, national security, and social welfare at stake.[1] However, it would be easy to misallocate funding in an attempt to address this problem, and indeed to misunderstand the challenge itself. The microprocessors being produced today are commodity devices, or recombinations of commodity devices. While today's microprocessors are ubiquitous and essential to national security, there are multiple methods to improve the security of these devices even if in part or in full produced at a foreign fab (c.f. Sweeney et al 2019; Vaidyanathan et al 2014; Imeson et al 2013; Jarvis et al 2004.) However, the country that discovers the next computational device holds the opportunity to lead not only in economic prosperity but also in military competency and

[1] During the 1990s 50% of growth in GDP in the U.S. and worldwide have been traced back to Moore's Law, and more specifically, biannual advances in microprocessors and the complementary product and process innovations that made and used those microprocessors up and down the supply chain (Jorsensen). Through Moore's Law, chips have become so cheap, small, fast, powerful and abundant in such numerous applications, that their social benefits increase quality of life in ways that transcend economic quantification (Khan, Hounshell, and Fuchs 2018).

AI. Scientific limits have in recent years brought the four-decade long cadence of Moore's Law to a halt. While advances in software and reconfiguration of existing hardware technology is allowing us to continue to make computational advances, a new Beyond-CMOS computational device will be required within the next decade to continue not only advances in computational hardware but also planned advances in AI (Khan Hounshell, and Fuchs 2018). For the vast majority of applications, that decade-out solution for advances in computing will not be quantum. Inventing this next device will require advances in basic science -- including physics. Commercializing this next device will require a national foundry to experiment across the computing stack (e.g. with the device design and production process itself, as well as with the chip architecture and software to program that device) and discover the best-suited device or devices to various applications. Here, I am not promoting choosing technology winners. I am emphasizing the importance of spending our limited national dollars on the *right problem*. In my original work on DARPA (Fuchs 2010), I emphasize that DARPA program managers neither leave everything up to the market nor choose technology winners. Rather, they connect disconnected actors across our innovation ecosystem to build technical solutions (sometimes two teams working on the same technical solution and a third team working on a competing solution) to national problems. On the executive side, DARPA Program Managers are able to fulfill this role due to being technologists deeply embedded in the fields and communities they fund who come to government service from industry and academia for three to five year stints, often as strategic steps in climbing their career ladder (Fuchs 2010).

We also need more even nationwide distribution of science and technology education, funding, and commercialization (c.f. Johnson and Gruber 2019, Atkinson, Muro, and Whiton 2019). More even distribution of science and technology funding holds promise to accelerate innovation: For example, Bell et al find that there are many "lost Einsteins" – individuals who would have had highly impactful inventions had they been exposed to highly impactful innovating individuals (and in the case of girls, innovating women) in their communities in childhood – especially women, minorities, and children from low-income families. More even distribution of science and technology funding holds the potential for societal benefits in terms of increasing scientific knowledge in the general population as well as for increasing broad-based political support for science (for related thoughts see Holdren in Powell 2020, Schrank 2021). Strategic training for new jobs and placement of new industries in areas most hard-hit by those transitions may also hold promise to grow political support for technology transitions, such as vehicle electrification (see discussions by Rodrik and Sabel 2019; Hart 2019; Hart 2020; Walter et al 2020; Karplus, V. 2021).

Finally, IF production can be kept locally, more even distribution of science and technology can also improve economic prosperity in that local region. While five of the top 10 metropolitan statistical area earnings were in Michigan in 1980, by 2016 nine of

the top ten were on the east or west coast (Johnson and Gruber 2019). Without intervention, these trends are likely to continue. This challenge brings me to my second point:

Second, investment in regional technology, innovation, and education will not necessarily succeed at accelerating regional job growth and economic prosperity unless we in parallel invest in transition pathways that ensure those regions have the local physical and human capital necessary to keep the economic benefits of those investments locally.

While the social and economic gains from novel scientific findings and technology inventions can be tremendous, they are a long-run game: it can take 10 to 30 years to go from a novel idea to commercialization, particularly in advanced manufactured products (in contrast to software). Even as new technologies move into development and the early phases of commercialization, for those novel inventions to be manufactured or commercialized locally where they were invented one or more forces would be necessary to keep them local: incentives to remain close to the inventor (for example, challenges separating research from manufacturing such as described in Fuchs and Kirchain 2010 or Combemale and Fuchs 2020), a strong local workforce in relevant domains (engineers, trainers and technicians, shop-floor operators), and there being economic geographic advantages to produce locally (from the perspective of factor input costs, economies of scale and transportation costs for that particular product and its supplies and end market c.f. Krugman 1995.) (Fuchs 2014.) I will tell a story to illustrate each.

Several years ago I traveled to a university in the Midwest as part of conducting research on the Semiconductor Research Corporation (SRC). SRC is a semiconductor-industry-led public private partnership which leverages a combination of government and industry investments to fund academics and universities to conduct research on three to seven year out challenges facing industry to continue advancing computational hardware capabilities. The particular program I was studying (which was funding multiple centers across the country) brought NIST, DARPA, NSF, and state-level funding together with industry to find a next computing device given the end of Moore's Law. It was an important, if dramatically underfunded (see Khan, Hounshell, Fuchs 2018) effort, funding centers with competing technology solutions. Brilliantly, the centers brought together physicists advancing basic research, semiconductor device experts, and industry representatives who might commercialize that technology in an attempt to discover and accelerate commercialization of the next technology revolution (Khan, Hounshell, Fuchs 2015). While too small, the program is an important step toward ensuring ongoing national leadership in computation and therethrough AI, and thus national security and economic prosperity, in winning at "technology strategy." A government official happened to be visiting at the same time, and as part of my trip, I

was invited to join him on their tour of the university's corresponding new local economic development technology incubator facility. While there were some exciting companies in the largely empty incubator facility, there were no new computational devices being manufactured or commercialized from the SRC program. With fundamental physics advances needed, they would be lucky to have something that could even be manufactured, no less would be commercialized, within 10 years. In addition there were many centers with competing device alternatives, and not all devices would "make it." Indeed, NSF's part of the program was called "Let a Thousand Flowers Bloom" to represent the importance of keeping the search for the next device broad in these early stages. (Khan, Hounshell, Fuchs 2015.)

Even once one or more of those devices was ready to be piloted or even commercialized, the midwestern city where the research was funded -- even with its world-class university - may not have been the place to do it. With a thousand new ideas underway, ideally, a single national foundry would be built to further pilot those devices and advance not only the necessary understanding of the ideal design and production of the device but also allow device architects and software engineers begin to experiment with innovations necessary for their own roles in these new computational inventions. From there, a likely final outcome might be for that technology to be produced either in the location of the new foundry, or other places where there was existing physical and human capital (including knowledgeable operators and technicians) -- such as at an Intel facility in Santa Clara, CA, Texas, Arizona, or at an IBM facility in upstate New York.

This story should not lead us to despair about the value of science and technology investments -- rather to emphasize that while we need funding of science and technology to win at the long-term game of national security, economic competitiveness, and jobs for hardworking Americans, alone those investments will not lead to a diverse and equitable distribution in jobs. Unfortunately, my research experiences suggest that the U.S. manufacturing ecosystem is sufficiently dilapidated, that keeping innovations domestically can be a challenge, even when inventors want to do so. To make sure the best science and technology advancements and the high-end operator and technician jobs that go with them happen domestically (since co-location with manufacturing is in certain contexts, particularly materials and process innovations at the technical frontier, necessary for innovation -- c.f. Fuchs and Kirchain 2010), in parallel to investing in science we need to rebuild our domestic physical and human capital across a broader swath of our country.

Let me provide an example of how, unless we in parallel revitalize our manufacturing ecosystem, funding research and development alone will be insufficient to keep manufacturing domestically. My former Ph.D. student, Hassan Khan, after receiving his undergraduate degree in Chemical Engineering from Berkeley, moved to Mississippi to help launch the manufacturing facility of a Silicon Valley headquartered

solar photovoltaic startup. Although the photovoltaic cell was invented at Bell Labs, by 2010 US capabilities in the manufacturing ecosystem had atrophied. My student found himself flying multiple times with wafers to Canada, because they didn't have locally the fabrication capabilities they needed. The firm struggled to find operators they needed in Mississippi, despite receiving thousands of applications and hired Chinese-trained operators instead. The start-up was also reliant entirely on foreign suppliers of process tools, including from Italy, Germany, and Japan. Eventually the start-up failed, unable to compete against Chinese manufacturers that captured the majority of the market. The firm's IP was sold, investors and the state of Mississippi took a loss and Hassan came to Carnegie Mellon to start his Ph.D., doing research on the SRC program. (Fuchs 2020 Testimony)

The dilapidation of our domestic manufacturing ecosystem and the loss of human capital needed for that ecosystem was highlighted by the COVID-19 pandemic. In the context of mask production, small and medium sized companies struggled with lack of easily accessible information on how to make medical-grade masks, access to machines which were predominantly manufactured in China, shipping delays related to the machines and the components required for their repair, high qualification and certification costs, and challenges breaking into mainstream hospital distributor markets. (Kalathil, Fuchs, Morgan, Karplus research in progress.) In one case, lack of elastic supply not on a spool or an automated despooler, and the inability to build or adjust the equipment, led one company for a period of time to have a worker hand unspooling the elastic, with the expected productivity slow-down (Fuchs 2020).

That said, while U.S. companies, particularly small and medium sized ones struggled to pivot into and ramp-up domestic production of masks, in our research (ongoing with Kalathil, Morgan, and Karplus) on companies that pivoted, I have been struck by how much what was left of our domestic manufacturing ecosystem was central to us being able to pivot in the cases where we successfully did so. One large American manufacturer was able to leverage its intellectual property and aerospace sourcing and production expertise to establish and ramp-up domestic manufacturing of masks within just a few weeks. General Motors was similarly able to leverage its automotive sourcing and production expertise to rapidly ramp-up domestic manufacturing of masks and ventilators. In Indiana, America Meltblown and Filtration was able, with support from the Indiana government, to leverage its expertise in filtration materials and oil absorbent products to pivot first into making meltblown polymer for masks and later to create a subsidiary for also making the N95 masks themselves Another company leveraged technical macgyvers to pivot from experience in waste management and construction to mask manufacturing. These observations during COVID have strengthened my belief in the importance of domestic core competencies in critical technologies and a strong domestic manufacturing ecosystem to responding and pivoting during crises. Some pivoting companies' previous experience in waste

management, construction, and water or oil infrastructure products has also strengthened my belief that the greatest promise for rebuilding our manufacturing ecosystems may be equitable country-wide investments in building the infrastructure of the future. (Kalathil, Fuchs, Morgan, Karplus research in progress.)

As I discussed in my 2020 testimony before the Ways and Means Subcommittee on trade, I have come to believe *strategic infrastructure investments hold the greatest promise to revitalizing U.S. worker skills and firm necessary for vibrant U.S. manufacturing ecosystems.*[2,3] By infrastructure I mean not just roads, bridges, transit networks, water systems, and dams; but also energy, communications, manufacturing, and data infrastructure necessary for all of those. In the same way that we need to build domestically the products that global markets want and only we can make, our infrastructure investments need to be for *the infrastructure of the future*. The U.S. generally lags behind other peer industrialized nations in infrastructure. The American Society of Civil Engineers (ASCE)'s 2017 report finds that the nation's infrastructure conditions are "mostly below standard," exhibiting "significant deterioration," with a "strong risk of failure." Much of our infrastructure was constructed for the climate of the 20th century, rather than for the climate of the 21st century (Chester et al. 2020), leading to additional issues of safety and reliability (Olsen et al., 2015). Transportation, transit, and urban infrastructure should be designed to enable the safe and equitable introduction of driverless vehicles and smart city systems, and the matching large-scale interconnected data infrastructure for security, privacy, resilience and machine learning on that data (Anderson et al. 2016; Berges and Samaras 2019.) Electric grids should be restructured to ensure a clean and resilient power system that can accommodate a wide range of new designs and services (NASEM 2010, Lueken 2012, NASEM 2017).[4] Foundries should be built to lead the world in the invention and commercialization of next generation semiconductors and synthetic biology. (Fuchs 2020 testimony)

Traditionally in economics, the government has an important role in investing in infrastructure because it generates positive externalities including health benefits, enhancement externalities, nation-building (historically increases land value, firms benefiting from cheaper inputs, and contributing to a sense of unity by increasing economic interdependence between regions), and counter-recessionary spending

[2] My focus on strategic infrastructure investments is due to the potential novelty of that approach. Manufacturing Extension Program and Manufacturing USA innovation institutes already play and will need to play an important role in reviving our manufacturing ecosystem. On the Manufacturing Extension Program's effectiveness in upgrading and the acquisition of competitive capabilities (c.f. Various pieces by Whitford, J.; Shapiro; McEvily, B.). On the Manufacturing USA innovation institutes, their original goals, and evaluation thereof (c.f. Recent studies by GAO, NASEM).

[3] The U.S. generally lags behind other peer industrialized nations in infrastructure: The American Society of Civil Engineers (ASCE)'s 2017 report finds that the nation's infrastructure averages a "D," meaning that conditions are "mostly below standard," exhibiting "significant deterioration," with a "strong risk of failure." This lag which can largely be traced back to funding: On average, European countries spend the equivalent of 5 percent of GDP on building and maintaining their infrastructure, while the United States spends 2.4 percent. The United States also differs from most other industrialized countries in the extent to which it relies on local and state spending to meet its infrastructure needs -- only 25 percent of U.S. public infrastructure funding comes from the federal government.

[4] Among other issues, much of our infrastructure was constructed for the climate of the 20th century, rather than for the climate of the 21st century (Chester et al. 2020). Rebuilding and reinvesting in our infrastructure to be resilient to extreme weather is essential for the safety of our communities and the resilience of our economy (Olsen et al., 2015).

(Glaeser and Poterba 2019). While entities like the U.S. Council of Economic advisors continue to link infrastructure investments to jobs, more recently, economists have begun to question the short-term benefits of infrastructure expenditures (Ramey 2019, Garin 2019). Missing from these debates has been thinking about infrastructure investments as strategic investments in technology and knowledge capabilities, equity, national security, as well as platforms not just that could enhance productivity but also innovation. Infrastructure has the interesting property not only of creating demand, but also of solving a problem and creating the physical and human capital platform upon which to build future technology investments and innovations.

Investments such as those described above address national needs for resilience, energy and internet access, and technology leadership within and beyond manufacturing. Infrastructure investments also build national capabilities for building things -- not just in the form of firms responding to the demand, but also in the form of operators and engineers. These workers will learn by doing. Indeed, as we think about these investments strategically, it is critical to recognize the interconnectedness of the knowledge and skills across these infrastructure domains. The physical and human capital relevant to deploying and managing sensors for sustainable and smart infrastructure -- from the concrete layer to forman to the engineer to the data infrastructure developer to the machine learning software -- have corollaries in resilient grid infrastructure, privacy-preserving health infrastructure, and intelligent manufacturing. We should be strategic about those complementarities, in where and how we invest, in creating demand in the complementary areas, as well as about facilitating those transitions across sectors through targeted training.[5,6] (Fuchs 2020 testimony)

Third, with parallel investments to rebuild U.S. manufacturing ecosystems, technology advance does not need to lead to fewer good jobs for hard-working high school graduates. While prominent economists have been focused on the relationship between innovation and inequality -- specifically, wage and skill polarization -- this research has focused on capital expenditures, robotics, and digitization, and lacked measures to distinguish how different technologies may lead to different labor outcomes.

[5] More work on skill transition mapping is needed. A recent OECD report has looked at current worker skills, how demand for those skills is expected to change with automation, and the training required to support "reasonable" transitions (OECD 2019). In our own research, we have been mapping skill requirements to jobs at a individual operator task level (Combemale, Ales, Whitefoot, Fuchs 2020a), and we are extending that task-level skill mapping now beyond the shop floor to technicians, engineers, and managers (Combemale, Whitefoot, Fuchs 2020). Whether at the OECD level or our own more granular one (or another method yet to emerge), we need to be mapping and broadcasting to training entities that may not have the necessary knowledge the skill transitions required from current construction and manufacturing for any of the above to the construction and manufacturing for the transportation, energy, health and manufacturing infrastructure of the future, as well as the skill transitions necessary in each skill domain to apply skills from one to the other across sectors.

[6] In facilitating these transitions, we should not underestimate the power of on-the-job learning and learning by doing (building). This is not to suggest that training isn't necessary, rather that that training may not happen "out of work", per se. Here, where large firms exist, industry in each sector should lead the training that is needed, where relevant in partnership with unions, with government facilitating assessment and dissemination of best practices and the mapping of the cross-sector transitions. Where small companies are involved, the government will play an essential role, in conjunction with larger companies, in mapping and funding necessary workforce transition training.

Our research demonstrates that some of our more important emerging technologies -- particularly those in advanced materials and processes - may be win-wins in terms of national security, the economy, *and jobs, including for hardworking high-school graduates.* As an initial example, we focused on parts consolidation -- a technically challenging objective well-known to the public for example in Intel's ability to fabricate more and more components on a single chip (Moore's Law), and General Electric's ability to additively manufacture what was formerly a 455 piece engine in just 12 parts. It's also a capability being pursued in at least 4 of our ManufacturingUSA institutes.[7] Our research shows that whereas automation leads to more low-end and more high-end skills being required of high-school educated manufacturing shop floor operators with some of the high-skill tasks moving outside the jurisdiction of the operator, parts consolidation leads to more middle skills being required of high-school educated shop floor operators (Combemale, Ales, Whitefoot, Fuchs 2020).[8] In addition, in their early days the consolidated design production processes require more "sorcery" from the operators and more back-and-forth between operators and engineers, the latter who are skill working to stabilize and understand the relationship between material, process, and geometry design decisions and production outcomes (Combemale and Fuchs 2020).[9] (Fuchs 2020 testimony)

Fourth, currently, the U.S. lacks the intellectual foundations, data infrastructure, and analytic tools to ensure that the nation's investments realize legislator's multiple objectives for them.

Technology decisions sit at the center of issues as broad-ranging as national security, economic prosperity -- including good jobs for all Americans, and social welfare -- including health, environment, and equity. While U.S. agencies are mission driven, technology investment and associated policy decisions affect multiple national objectives. Technology and investment decisions -- let's take the example of the electric grid -- can simultaneously influence national security (what if a foreign adversary brought down a large proportion of the grid?), economic prosperity (an entire month of semiconductor chips had to be thrown out due to the recent power outages in Texas), health (if more power is shifted to the grid people located near electric generation sites -

[7] The U.S. government has funded 15 manufacturing innovation institutes. One of those 15 is focused on robotics (ARM) and another one on digitization (MxD). A third has a digitization component (CESMII). At least four (AIM, America Makes, IACMI, and NextFlex) of the 15 manufacturing institutes involve advanced material and process innovations that lead to design and parts consolidation, and another three (biofabusa, lift, and poweramerica) likely involve parts consolidation or part integration through innovations in materials and processes as part of their broader projects and mission.

[8] We expect the convergence of skills we see with consolidation to generalize across contexts - from advanced materials and processes to software (Combemale, Ales, Whitefoot, Fuchs 2020b).

[9] Research suggests the complex relationship between design and production (and thus engineers and operators working together to bring new science to reality on the production floor) generalizes to immature materials and process technologies at the technical frontier. Due to technologists still being in the process of figuring out the underlying science, it is common for advanced materials and process technologies in their early stages to have non standardized production processes where the operator and engineer's joint role is more of an art and also thus difficulty separating design from manufacturing (Fuchs 2010, Fuchs 2014.) Historical examples include the early days of electronic semiconductors; and emerging technologies in chemical processes such as electronic and photonic semiconductors, pharmaceuticals, batteries, additive manufacturing, and many others yet today (Bohn 1995, Pisano 1997, Holbrook 2000, Bassett 2002, Bohn 2005, Lecuyer 2005, Bonnin-Roca et al 2017).

who are also more likely to be below poverty - will experience more pollution), environment (what mix of fossil fuels versus renewables is generating energy for the grid, how does that mix change the geographic location of jobs, and how might policy influence those outcomes), and equity (who has regular affordable energy access and who does not). As a consequence, even if each agency (the department of energy, the department of defense, the department of transportation, the department of labor, the department of the interior, and others) perfectly achieved its mission, we might achieve suboptimal outcomes when considering our multiple national objectives as a whole.

There is reason to believe that the U.S. government's experience with and capacity (institutional as well as data and analytic) to make large-scale decisions related to technology not only is limited but also has atrophied over the past 50 years. Today, on average, the U.S. spends half of European countries on infrastructure (as a percent of GDP), and only 25 percent of U.S. public infrastructure funding comes from the federal government. The last large-scale infrastructure investment by the federal government was in the 1930s. Over the last 50 years, R&D spending shifted from being dominated by government to being dominated by industry (the crossover was in 1980, Congressional Research Service 2020) and government R&D spending as a proportion of GDP has declined (Perils of Complacency). At the same time firms increasingly reduced or disbanded famous R&D laboratories like Bell Labs and shifted their focus away from more basic research (Arora, Belenzon, and Patacconi 2015.) Further, in a variety of defense-critical industries such as computing, consumers increasingly became the largest source of demand for frontier technologies, rather than government.

Between 1972 and 1995 Congress relied on the Office of Technology Assessment to provide in-depth analytics on technology decisions (Princeton OTA Legacy). From 1989 to 1999, the federal government identified critical technologies through a biennial National Critical Technologies Report (NCTR) to Congress, with feeds from multiple agencies. Various departments and agencies of the Federal government also published their own critical technology assessments between 1989 and 1999, including the Department of Defense (Militarily Critical Technologies List, US DOD, 1989, 1990, 1991), the Department of Commerce (US DOC, 1990), the Department of Energy (US DOE, 1995), and the National Aeronautics and Space Administration. Between 1991 and 2003 the Critical Technology Institute (renamed in 1998 the Science and Technology Policy Institute) provided research and analytic insights to address science and technology embedded issues related to national security out of RAND. Unfortunately, even when these critical technology analytic efforts existed they lacked i) a systematic approach for assessing relative competitiveness as well as strategic opportunities and weaknesses in critical technologies, and ii) a link between identification of critical technologies and policy actions, such as by federal research agencies, CIFIUS, the International Trade Commission, and the Intelligence Communities was weak and uncoordinated at best. (See also Mogee, Mary Ellen 1991

National Academies Press; Knezo, Genevieve J. 1993, Congressional Research Service, Bimber RAND 1994, Popper and Wagner 2003.) While the Department of Defense (and in particular the Defense Logistics Agency) used to pay for defense-critical domestic industries to be tracked in greater detail by the U.S. Census, in the last decade those funds and activities have also been discontinued.

In recent years, the need for the intellectual foundations, data infrastructure, and analytics to support technology decision-making if anything has grown. The opportunities to leverage technology combined with new institutional innovations to address those challenges has also grown. So far, however, the government stands ill-prepared to leverage those new technologies: research by ourselves and others show that inadequate data and analytic capability is weakening government decision-making regarding critical technologies, supply chains, and infrastructure. U.S. Defense agencies and policymakers lack mechanisms to assess their strategic weaknesses and opportunities versus other nations in technologies critical to national security (NASEM 2019).[10] The U.S. government lacks data on the long chain of intermediate suppliers supporting the production of final goods, and thus the resilience of our supply chains and reliance on other nations for products. Meanwhile, intra- and inter- governmental actions and knowledge pertaining to critical supply chains are siloed and uncoordinated (Nissen et al 2018). The challenges this creates have been underscored by COVID-19: While existing surveys such as the Annual Survey of Manufactures and the Economic Census provide snapshots of U.S. capabilities, these data do not capture the rapidly evolving supply status during a crisis such as the COVID-19 pandemic (the last data collected on all domestic manufacturers was 2017). Such real-time information is essential to guide decisions to coordinate and mobilize additional capacity whether during a global pandemic, other natural disasters, or war.

Novel combination of existing public and government data, natural language processing, and active machine learning hold promise to map the evolution of innovative capabilities in critical technologies and manufacturing ecosystems across countries, time, firms, technological domains, and human capital including shop floor workers and teams of leading inventors. At CMU, my colleagues Branstetter and Hovy have begun pioneering work in this direction which combines natural language processing of patents with US census data to assess capabilities in AI (Branstetter and Hovy 2020). My own work with colleagues Kalathil, Karplus, and Morgan has demonstrated the possibility of using text processing of public information to substantially improve the government's real-time situational awareness of critical supply chains (Fuchs, Karplus, Kalathil, Morgan, 2020). In other work with colleagues we are leveraging new tools to quantify the skills required for emerging technologies before large-scale investments are made (Combemale, Whitefoot, Ales, and Fuchs; Cotterman,

[10] In the inaugural session of the National Academies' study on U.S. Science and Innovation Leadership for the 21st Century, DARPA and the DOD Strategic Technology Protection Office's representatives both articulated a lack of mechanisms to assess their strategic weaknesses and opportunities versus other nations in technologies critical to national security. (NASEM 2019)

Whitefoot, Small, and Fuchs ongoing research), and to better understand skill cross-walks that enable firm pivots (Kalthil, Fuchs, Morgan, Karplus ongoing research) and skill transitions (Cotterman, Whitefoot, Small, and Fuchs ongoing research).

During the pandemic, our rapidly spun-up research using language processing to scrape and categorize text from Thomasnet, one of the largest business-to-business websites for North American Manufacturers, quickly found existing and potential domestic manufacturers. Our results suggest substantial overlooked capacity in current White House estimates, and that small and medium sized enterprises were playing an important and poorly-documented role. The US Census Bureau and International Trade Commission need access to these types of capabilities, as, likely, do other organizations, like FEMA, the Department of Homeland Security, and others. (Fuchs, Karplus, Kalathil, Morgan 2020)

More work on skill transition mapping is needed. A recent OECD report looked at current worker skills, how demand for those skills is expected to change with automation, and the training required to support "reasonable" transitions (OECD 2019). Much, however, remains to be learned about regional revitalization, manufacturing ecosystem reinvigoration, and skill transitions. Our work interviewing firms that pivoted during the COVID-19 pandemic, there are amazing anecdotes about firms originally in waste management and construction that leveraged skills therefrom to pivot into manufacturing masks. In our research on technology transitions in advanced semiconductors for communications and powertrains for vehicle electrification, we have been developing novel data collection and analytic tools for mapping technology transitions to skill requirements and jobs at the individual operator task level prior to large-scale investment (Combemale, Ales, Whitefoot, Fuchs 2020a), and we are extending that task-level skill mapping now beyond the shop floor to technicians, engineers, and managers (Combemale, Whitefoot, Fuchs 2020). Relatedly, colleagues Brynolfsen and Mitchell have been using novel methods to identify what tasks are likely to be automated in the future, and the implications for future skills (Brynolfsen and Mitchell). These types of leading data and analytic tools need to be supporting decisions by legislators, the agencies that fund technology transitions, and regions facing major technology transitions supporting that funding so as to ensure that economic development efforts match the transitions facing those regions. Such tools also hold promise to inform how strategic investments in the transportation, energy, and communications infrastructure of the future could prepare a region's workforce to have the physical and human capital and manufacturing ecosystem necessary to keep locally the commercial outputs of critical science and technology investments.

In summary, when making technology investments, it is impossible to separate national security, economic competitiveness, and social welfare (including health, environment, and equity) considerations. To design policies that realize their objectives,

policy-makers need transparency into how different technology and technology policy choices may influence different objectives. Win-win solutions can exist: As our research shows, certain technology transitions in areas critical to national security offer better jobs for hard working high school graduates (Combemale and Fuchs 2020). That said, realism is needed in the time between investment in science and technology research and commercialization of those ideas. Likewise, realism is needed on the dilapidation of the current manufacturing ecosystem, and the significant investments necessary to keep manufacturing of that technology local with local jobs. Nation-wide investments in the infrastructure of the future hold promise not only to improve security, productivity, and equity, but also as pathways to revitalizing U.S. worker skills and manufacturing ecosystems throughout the country -- a critical step toward keeping more of the commercialization outputs of science and technology locally.

Getting these investments right is non-trivial. Some portion of science and technology investments must be focused on national technology strategy. I argue in my 2020 Ways and Means Testimony that this would be best done in a set a nimble science and technology agency with that explicit mission. With jobs and equity as central to our sovereignty as weapons, and technology investments as likely to reduce both as raise them, but done right holding the promise to strengthen both, that agency must be backed by the star-studded data and analytic team necessary to get those decisions right. While the current proposals for changes in NSF and EDA have promising components, if regional investments in research and development, in infrastructure of the future, and local economic development activities remain uncoordinated and lack the necessary data and analytic support these efforts are likely to fail to realize legislators' multiple objectives for those investments. Equally importantly, whether the new technology strategy agency I propose or whatever entity undertakes this mission will need incentives to work with and leverage the expertise across the excellent mission-oriented agencies in our government.

Founded in the aftermath of Sputnik with the goal of preventing technological surprises, DARPA was set up to cut through the rivalry between the military services (Fuchs 2010). To successfully execute, a small, nimble agency focused on national technology strategy, and its analytic arm, will need to be able to work across, coordinate with, and catalyze initiatives within the existing mission-driven agencies.

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Erica R.H. Fuchs is a Professor in the Department of Engineering and Public Policy at Carnegie Mellon University, and a Research Associate with the National Bureau of Economic Research. Her research focuses on the development, commercialization and global manufacturing of emerging technologies, and national policy in that context. She is leading Carnegie Mellon's College of Engineering "moonshot" on national technology strategy in critical technologies, supply chains, and infrastructure. Professor Fuchs was the founding Faculty Director of Carnegie Mellon University's Manufacturing Futures Initiative – an initiative across six schools aimed to revolutionize the commercialization and local production of advanced manufactured products. Over the past decade, Dr. Fuchs has played a growing role in national and international meetings on technology policy, including being one of 23 participants in the President's Council of Advisors on Science and Technology workshop that led to the creation of the Advanced Manufacturing Partnership, and serving on the expert group that supported the White House in the 2016 Innovation Dialogue between the U.S. and China. In 2012 she was selected a World Economic Forum "Young Scientist" (top 40 under 40 globally.) She currently serves on the M.I.T. Corporation's Visiting Committee for M.I.T.'s Institute for Data, Systems, and Society, of which M.I.T.'s Technology Policy Program is a part; and on the Advisory Editorial Board for *Research Policy*. Before coming to CMU, Dr. Fuchs completed her Ph.D. in Engineering Systems at M.I.T. in June 2006. She received her Masters and her Bachelors degrees also from M.I.T. in Technology Policy (2003) and Materials Science and Engineering (1999), respectively. Dr. Fuchs spent 1999-2000 as a fellow at the United Nations in Beijing, China. She grew up and attended K-12 in the Reading Public School District in Reading, PA. Her work has been published among other places in *Science,* the *Nature* journals, *Research Policy*, and *Management Science;* and has been covered on National Public Radio, by Bloomberg, and in the *New York Times*.

Chairwoman STEVENS. Thank you, Dr. Fuchs, and we're glad to hear from you in Congress today, and we're hoping the White House has you on speed dial too. And, with that, we'll hear from Ms. Nas.

TESTIMONY OF MS. PAULA NAS,
DIRECTOR, OFFICE OF ECONOMIC DEVELOPMENT,
UNIVERSITY OF MICHIGAN—FLINT

Ms. NAS. Hello to Chairwoman Stevens, Ranking Member Lucas, and Ranking Member Waltz, and distinguished Members of the Subcommittee, including Congressman Kildee, who represents my home State. Thank you for the opportunity to testify before the Subcommittee today. My name is Paula Nas, and I serve as the Director of the Office of Economic Development at the University of Michigan in Flint, where the U of M-Flint EDA University Center for Community and Economic Development is housed. It is an honor to share my views——

Ms. MOORE. Madam Chair, I can barely hear her. Is——

Chairwoman STEVENS. Yeah. Thank you. Congresswoman Moore is recognized. I have 20/20 vision. I don't know what the hearing is. I was having a little problems hearing too with you, Ms. Nas, so maybe you could just speak a little bit closer to the microphone?

Ms. NAS. OK, sure. Thank you. It is an honor to share my views—are you able to hear me better? It is an honor to share my views about the importance of the Economic Development Administration's support for the development of regional innovation economies. The U of M-Flint EDA University Center for Community and Economic Development coordinates, forms, and contributes to economic development efforts that cultivate innovation, support proof of concept development and commercialization, and provide employer-identified workforce development programs needed to build and sustain a resilient, inclusive economy.

Research on building effective innovation ecosystems points to the importance of interactions among key actors in the region. Typically these include institutions of higher education, industry, government funders in economic development—among others. There's also consensus on a need for other elements, a research and development ecosystem, access to capital, mentors, innovation labs, and training programs. These are all necessary conditions for creating an environment that spurs innovation and contributes to regional economic growth. What is often left out of this equation is the fundamental issue of how one enters this complex system, and what the barriers of entry are. At the University of Michigan in Flint, we think about how we, as key players in the innovation ecosystem, make a concerted effort to minimize, or completely eliminate barriers to entry, and once an innovator has entered the ecosystem, we are mindful of how to best provide them with the tools and knowledge needed to navigate the system.

The development of regional innovation economies can be an engine of economic growth, but if that growth is going to be sustainable, we must provide avenues of access to those who are at risk of being locked out, particularly innovators from underserved communities in both urban and rural areas. Much of the work of U of M-Flint's EDA University Center is dedicated to solving these

issues. Through the U of M-Flint's EDA University Center, we've had the opportunity to serve as an entry point for a diverse group of regional entrepreneurs, delivering services to over 2,000 individuals over the past 5 years. One such individual is a community member named Linda, who was inspired by her deaf mother to create a technology to help deaf and hard of hearing communities. Linda launched an emergent technology company, Bell Tech Communications, which has developed English to ASL (American Sign Language) real time translation software and hardware that removes learning barriers by teaching ASL speakers English grammar and sentence structure, in addition to the ASL equivalent translation. Bell Tech has been supported by our staff through ongoing one-on-one counseling, workshops, and resource connections, including personnel and funding opportunities. Linda is an excellent example of a local innovator who may not have entered the ecosystem without the support of our EDA University Center.

In addition to minimizing barriers to entry in the ecosystem, our EDA University Center is working to build a strong foundation for a sustainable innovation economy by creating programs that foster the entrepreneurial and innovation mindset. We have developed a suite of offerings that introduce campus and community partners of all ages to entrepreneurship and innovation. Through programs on U of M-Flint's campus, such as faculty innovation fellows, an interdisciplinary innovation capstone course, and student innovation competitions, we aim to create a culture of innovation. We also offer a menu of innovation programs for our community partners. We have introduced entrepreneurship at an early age—we've created the Young Sharks and Junior Sharks Curriculum, and pitch competitions for elementary and middle school students, and we are confident that today's efforts to create awareness of the importance of innovation will have long-term benefits for the economy.

As we collectively think about best practices for building strong and inclusive innovation economies, we need to keep in mind the perspective of our population, and what people need in terms of support systems, what they need in terms of making sure that everybody has access to everything they need to move their innovations forward. Through programs like this, we know that we will be able to keep in mind that solutions are not one-size-fits-all. We need to provide entry points into the ecosystem, and supports to ensure that opportunities are shared broadly, so widespread participation involves planning and implementing innovation initiatives. Thank you again for the opportunity to testify today. I look forward to answering your questions.

[The prepared statement of Ms. Nas follows:]

Building Regional Innovation Economies

United States House of Representatives Committee on Science, Space, and Technology

Subcommittee on Research and Technology

Written Testimony of Paula Nas

Director of the Office of Economic Development at the University of Michigan-Flint

June 9, 2021

Chairwoman Stevens, Ranking Member Waltz, and distinguished members of the Subcommittee, thank you for the opportunity to testify today. It is an honor to share my views about the importance of the U.S. Economic Development Administration's (EDA) support for the development of regional innovation economies, as well as opportunities and challenges for expanding this role. I am the Director of the Office of Economic Development at the University of Michigan-Flint, where the UM-Flint EDA University Center for Community & Economic Development[1] is housed. I also hold an appointment as a Lecturer of Economics at the University of Michigan-Flint.

About UM-Flint's EDA University Center for Community & Economic Development

UM-Flint's EDA University Center is one of two EDA University Centers in the state of Michigan, and one of 64 such centers nationwide. The stated purpose of EDA's University Center program is to "enable institutions of higher education and consortia of institutions of higher education to establish and operate University Centers specifically focused on leveraging university assets to build regional economic ecosystems that support innovation and high-growth entrepreneurship, resiliency and inclusiveness. By responding to the economic development needs of their regions, University Center programs are demand-driven by nature."[2]

The University of Michigan-Flint EDA University Center for Community & Economic Development coordinates, informs, and contributes to economic development efforts that cultivate innovation, support proof-of-concept development and commercialization, and provide employer-identified workforce development programs needed to build and sustain a resilient, inclusive economy. The primary service area of our EDA University Center is the I-69 Thumb Region of Michigan, which includes Genesee, Huron, Lapeer, St. Clair, Sanilac, Shiawassee, and Tuscola counties. This 7-county economic development partnership encompasses urban, rural, and suburban areas with diverse populations united by a unique opportunity to drive innovation around regional strengths in manufacturing, education, and healthcare industries. While our mission is focused on the I-69 Thumb Region of Michigan, our reach extends far beyond -- well into Southeast Michigan, and often beyond state borders. Our scope of work is divided into three categories as detailed below.

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[1] https://www.umflint.edu/office-economic-development/eda-university-center-for-community-economic-development/

[2] https://www.eda.gov/programs/university-centers/

Data Collection, Analysis, and Visualization Since the inception of the UM-Flint EDA University Center five years ago, our staff and student research assistants have collected, visualized, analyzed, and disseminated data from numerous and varied sources, including the U.S. Census Bureau, as well as information from our economic development partners throughout the region.[3] With these data we have developed a robust online mapping application along with a series of static maps for the region. We respond to the needs of government, economic developers, non-profits, and the business community by providing research support through a wide variety of projects, including GIS mapping of assets, an annual business climate survey, retail leakage analyses, IMPLAN economic impact analyses, and workforce development studies, among others. The broad range of services we provide has positioned our EDA University Center as a convener for economic development leaders in our region as well as a local data intermediary. In response to the needs of our economic development partners, we are now expanding our asset mapping capabilities so that we will have the tools to perform hazard mitigation analysis of the region to identify adaptive and coping capacities to various stressors including limitations in transportation logistics, access to necessary healthcare resources, broadband, and housing. These findings will be disseminated to regional stakeholders to raise awareness of potential gaps that need to be addressed and to help support a data-driven approach to regional economic development.

Innovation and Entrepreneurship UM-Flint's EDA University Center offers a suite of programs to assist entrepreneurs and innovators from ideation to launch, and eventual commercialization of their innovation. We continue to develop new initiatives to strengthen and foster a more inclusive entrepreneurial ecosystem. The Michigan Wolverine Innovation Network[4] (MWIN), which launched this year, lays the foundation for interdisciplinary student capstone courses and the commercialization of faculty research. MWIN seeks to create a campus culture of innovation, creativity, and the entrepreneurial mindset throughout all academic disciplines. This is achieved through building relationships among faculty, students, and community and industry partners to solve entrepreneur-, community-, and industry-identified problems and leveraging institutional resources for proof-of-concept commercialization. The EDA University Center continues to be a key element in the local entrepreneurship ecosystem, providing counseling and programs for entrepreneurs at all stages, and of all ages, including programs beginning in elementary school. As a trusted partner in the community, our EDA University Center often serves as the entry point for innovators who might not otherwise attempt to move their ideas forward.

Workforce Development As a connector between campus and industry partners, we use a data driven approach to address workforce development gaps in the region. One example is our newly launched Cybersecurity Training Center, which offers Michigan's I-69 Thumb Region opportunities for industry-recognized credentials to prepare individuals of all ages and experience levels for the dynamic digital challenges of the 21st century. UM-Flint is well positioned to address the workforce needs of a population that will need to adapt to the changing

[3] www.mapflint.org
[4] www.mwin.org

labor market by designing certificate programs and curricula that are flexible and nimble as the needs of industry change. As education and workforce development become better aligned with the evolving future of work, this also creates a pathway out of poverty for workers who will have expanded opportunities to explore a broader range of career possibilities.

Regional Innovation Economies

Research on building effective innovation ecosystems points to the importance of interactions among key actors in the region. Typically, these include institutions of higher education, industry, government, funders, and economic development organizations, among others. Likewise, there is consensus on the need for research and development, access to capital, mentors, innovation labs, and training programs. All of these elements are necessary conditions for creating a thriving innovation environment that spurs innovation and contributes to regional economic growth.

What is often left out of this conversation is the fundamental issue of how one enters this complex system, and what the barriers to entry are. How do we, as key players in the ecosystem, make a concerted effort to minimize or completely eliminate those barriers? Once an innovator has entered, how do we best provide them with the tools and knowledge needed to navigate the system? The development of regional innovation economies can be an engine of economic growth, but if that growth is going to be sustainable, we must provide additional avenues of access to those individuals who are at risk of being left out, particularly innovators from underserved communities in both urban and rural areas.

Much of the work of our EDA University Center is dedicated to solving these issues. For example, recognizing the complexities of navigating the vast network of entrepreneurial service providers, we have developed an online tool, MIStartSmart,[5] which provides a streamlined approach for entrepreneurs and innovators at any stage of business to locate and connect with entrepreneurial service providers in our region.

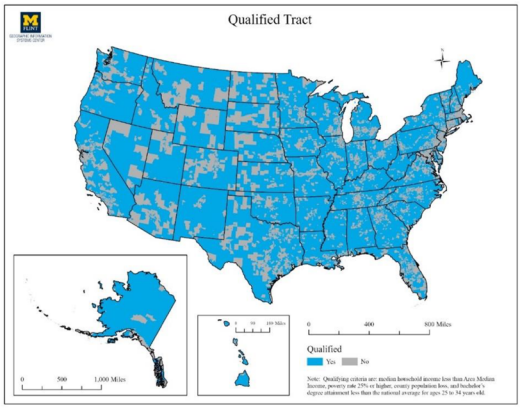
Through the UM-Flint EDA University Center, we have had the opportunity to serve as an entry point for a diverse group of regional entrepreneurs, delivering services to over 2,000 individuals over the past five years. I would like to share one example of an innovator who found an entry point into the ecosystem through UM-Flint's EDA University Center.

A community member named Linda was inspired by her deaf mother to develop technology to help deaf and hard of hearing communities. Linda launched an emerging technology company, Bell Tech Communications, which seeks to meet the needs of the deaf and hard of hearing communities. Bell Tech Communications has developed English-to-ASL real time translation software and hardware that removes learning barriers by teaching ASL speakers English grammar and sentence structure in addition to the ASL equivalent translation. This technology is targeted at young deaf speakers and their families as well as essential service providers and health professionals who might otherwise need interpretation services. Bell Tech has been developing its concept for several years and is currently raising capital and preparing to establish

[5] https://mistartsmart.com

its headquarters in Genesee County. Bell Tech and its founders have been supported by the UM-Flint EDA University Center staff through ongoing one-on-one counseling, workshops, and resource connections including personnel and funding opportunities. Linda is an excellent example of a local innovator who may not have entered the ecosystem without the support of our EDA University Center.

Defining innovation broadly, we also work with government, non-profits, and the business community to support their innovative approaches to problem solving using our research expertise and GIS technology. As an example, in 2018 two U.S. Senators introduced bipartisan legislation in support of post-graduation scholarships. A staff member of one of the Senators contacted the UM-Flint EDA University Center to see if we could use GIS mapping to create an interactive tool to visualize geographic areas that would qualify for the program proposed by the legislation based on the poverty rate, median household income, educational attainment, and population loss. Our GIS Center created static and interactive maps using these data so that the lawmakers would be able to view and demonstrate to others the areas nationwide that would qualify for the program.



There are many more examples that demonstrate the value of our EDA University Center as an entry point in the innovation ecosystem for entrepreneurs, as well as a source of technical assistance for government and community organizations that are overburdened or lack the capacity to complete the research needed to analyze the impact and value of initiatives. Without EDA funding, none of this work would have been possible.

In addition to minimizing barriers to entry in the ecosystem, we have also discovered the importance of creating a culture and foundation for innovation. There is some amount of investment in infrastructure that is needed to support regional economic development. Our EDA University Center provides technical assistance for regional economic development partners as they move forward in planning and implementing these new projects. Moreover, to build a strong foundation for a sustainable innovation economy it is also essential for regional partners to create programs that foster the entrepreneurial and innovation mindset. For example, to address that gap, the UM-Flint EDA University Center has developed a suite of offerings that introduce campus and community partners of all ages to entrepreneurship and innovation. Through

programs on campus, such as faculty innovation fellows,[6] the development of an interdisciplinary innovation capstone course, and student innovation competitions, we aim to create a culture of innovation on campus. We offer a menu of innovation programs for our community partners as well, which are currently in a virtual format, but are typically held in community locations. We have also discovered the value of introducing innovation and entrepreneurship at an early age, so we created the "Young Sharks" and "Junior Sharks" curricula and pitch competitions for elementary and middle school students. The hope is that today's efforts to create awareness of the importance of innovation will have long-term benefits for the economy.

Metrics for Success

Common metrics to measure the success of economic development programs include job creation, job retention, and private investment, among others. Realizing that the impact of some programs is difficult to quantify, particularly in the short run, the EDA recently revised their reporting requirements for non-infrastructure projects. In addition to tracking traditional economic development metrics, this new reporting mechanism provides EDA-funded programs the opportunity to incorporate metrics based on the unique initiatives of each University Center, such as mentoring, coaching, training, commercialization support, events, and networking referrals. There is sometimes a disconnect between the projects and programs that are being implemented and the metrics that are used to evaluate the success of the work. The revised EDA reporting process mitigates this problem by providing University Centers the opportunity to report the broad impact of our programs.

Opportunities in Southeast and Mid-Michigan

The economy of Southeast and Mid-Michigan has tremendous potential for creating a vibrant and well-developed innovation ecosystem. Indeed, in some parts of the region, much of the system is very well developed. However, other areas have been slower to adopt cutting-edge Industry 4.0 and advanced manufacturing technology, and as a result, economic shocks are often felt deeper and with longer recovery times than in other areas. The region has a rich and deep history of manufacturing and innovation, ranging from early roots in auto manufacturing to recent growth in health care technology, artificial intelligence, food processing, and cybersecurity, among others. In Michigan, we are also fortunate to have guidance and support from the Michigan Economic Development Corporation, which provides a range of services through their entrepreneurship and SmartZone programs. More concerted efforts to work collaboratively to create mutually beneficial synergies between campus and industry partners will help spur innovation in technology and lead to economic diversification, growth, and job creation.

A collaborative effort among private and public sector entities, UM-Flint's EDA University Center programs are the culmination of many years of analysis, input sessions, and data collection surrounding the region's holistic economic development and business ecosystem. The

[6] www.mwin.org

focus of this research has been workforce development, the talent pipeline, and the need to diversify the regional economy by fostering an environment that is conducive to commercializing technology by building on regional assets and creating strong ties between campus and community, economic development, and business partners. A guiding principle in all conversations is the need to create strategies that value diversity and inclusion in every stage of the process. It is our view that sustainable economic development and well-functioning innovation ecosystems must include equity and shared prosperity as a priority. Working in tandem with other institutions of higher education, there is tremendous potential in mid-Michigan and Southeast Michigan to complement, leverage, and expand upon existing regional economic development efforts and assets, particularly as we train a workforce that meets the smart manufacturing needs of employers, leading to increased business attraction and job growth.

Colleges and universities play an integral role in the innovation ecosystem as anchors in local and regional economic development. In addition to EDA University Centers, offices of economic development, tech transfer, academic programs, and various institutes help to support economic and community development efforts.

Key to all of this is the willingness and ability to coordinate efforts, and to leverage each other's strengths. Particularly important is the collaboration between industry and university partners. UM-Flint's new College of Innovation and Technology is a prime example of leadership embracing the need for academia to respond to the needs of industry by developing programs and curricula in concert with industry partners. Regional public universities, such as the University of Michigan-Flint, play a critical role in the innovation talent pipeline, particularly since the majority of our graduates remain in the state of Michigan after graduation.

Building on key industries in the region, such as health services, manufacturing, and education, the region is fortunate to have an abundance of assets and potential for developing a skilled workforce and commercializing research that will enable manufacturers to adopt a broad range of Industry 4.0 technological advances. Universities will be able to strengthen their role in local and regional economic development by leveraging university expertise, networks, and physical spaces to address the needs of industry and community partners. For that process to yield results that lead to long-term economic growth, it is essential that we create new avenues for dialogue between universities, industry, and community partners, being mindful to give all potential ecosystem participants a voice in the planning process.

The EDA plays a key role in these efforts, from providing funding to facilitating coordination among programs and agencies. Continued coordination and collaboration with other federal agencies, such as the National Institute of Standards and Technology Manufacturing Extension Partnership, Manufacturing USA, and other science and technology focused Federal agencies will help to establish synergistic relationships that leverage the knowledge and experience of experts in countless areas of expertise. The University Center program helps to support this coordination by acting as neutral conveners and by providing technical support and assistance.

The economy of Southeast and Mid-Michigan is well positioned to continue to develop an innovation ecosystem that creates sustainable and inclusive economic growth. Over the last five years, EDA funding has provided the University of Michigan-Flint EDA University Center with an opportunity to support thousands of individuals and organizations, many of whom would have been left out of the system if it were not for our EDA University Center. Likewise, the EDA has contributed to the regional innovation ecosystem through support of the expansion of the Fast Forward Medical Innovation Hub and the Biomedical Seed Fund at the University of Michigan. As we all collectively think about best practices for building strong and inclusive regional innovation economies, it will be important to continue to keep in mind the need to provide entry points into the ecosystem so that opportunities are shared broadly and to encourage widespread participation in planning and implementing innovation initiatives. The solutions are not one size fits all. Some programs require larger amounts of funding, while other programs can show effectiveness at a smaller, but no less important scale.

Thank you again for the opportunity to testify today. I look forward to answering your questions.

Paula Nas is the Director of the University of Michigan-Flint's Office of Economic Development and has been a lecturer of Economics at UM-Flint for the past 25 years. She oversees several programs, including the EDA University Center for Community & Economic Development, GIS Center, Innovation Incubator, and Cybersecurity Training Center at UM-Flint. She is a graduate of the Honors Program UM-Flint and holds an M.A. in Economics from Michigan State University and a J.D. from Wayne State University Law School. Paula's primary academic fields of interest are Law and Economics and Microeconomic Theory. She also developed the Economics for Educators course and the MPA course in Social Entrepreneurship at UM-Flint. She is currently the PI on multiple grants, ranging in topic from entrepreneurship and economic development to regional asset mapping. Paula is an active volunteer with many organizations, serves on several campus-wide committees, is a member of the Grand Blanc City Council, and services on the Board of the Educational Association of University Centers. Paula is passionate about community and economic development, specifically in connecting faculty and students with economic development, business, education, and municipal leaders through a variety of initiatives. She is proud to work with a team that is dedicated to continuing to expand and broaden meaningful relationships between UM-Flint and community partners in ways that will benefit the region and our students, faculty, and staff alike.

Chairwoman STEVENS. Just fabulous. And, with that, Secretary Pollard.

TESTIMONY OF HON. ELIZABETH HUTT POLLARD, SECRETARY OF SCIENCE AND INNOVATION, STATE OF OKLAHOMA

Ms. POLLARD. Madam Chair Stevens, and Ranking Member Waltz, House Science Committee Ranking Member Lucas, thank you for the opportunity to speak today. My name is Elizabeth Pollard, and I have the honor of serving as Secretary of Science and Innovation for the State of Oklahoma. In addition, I serve as a C Suite Executive, with decades of experience working in Silicon Valley, and understand how to bring capital and investment together to meet market needs. I'm here today to discuss Oklahoma and its expanding innovation ecosystem. There is a confluence of forces within State leadership, industry partners, higher ed, and the philanthropic community to grow Oklahoma's innovation economy. To ensure this vision for our safety becomes a reality, the State of Oklahoma released its new Science and Innovation Strategic Plan. Under the Governor's leadership, this plan outlines the vision for establishing Oklahoma as a global leader in scientific research and innovation through state-of-the-art research facilities, cutting edge technology, and progressive partnerships.

Today our State ranks first among other States in terms of cost of living, second in terms of cost of doing business. Oklahoma also ranks third in economic outlook, with low-income tax rates ranking sixth in the Nation for tax burden per capita, and the State has developed a strategic plan to leverage these assets. The plan is focused on three key sectors where we have expertise. One, energy diversification. Oklahoma has a long and rich history as a leader in oil and gas research and exploration, and continues to lead the way in these areas. Oklahoma is also increasing its focus in environmentally friendly alternative energy solutions to put—support the needs of the changing globe. We're ranked best State to own an electric vehicle, and ranked third in the Nation for electricity generated by wind.

Second, aerospace and autonomous systems. Today Oklahoma is home to FAA's (Federal Aviation Administration's) Mike Monroney Aeronautical Center, Tinker Air Force Base, and the sustainment headquarters of the United States Air Force, and many aviation, aerospace, and cyber-related companies. We have strong university programs across aerospace, including Oklahoma State University's Rocket Test Site, and International Space Station projects through NASA's EPSCoR (Established Program to Stimulate Competitive Research) Program. And third, biotechnology and life sciences. We have had significant biotech research and development activity underway for decades. Some examples include the University of Oklahoma's comprehensive health system and NCI (National Cancer Institute) Cancer Center, Oklahoma State University's Human and Animal Schools of Medicine, with a focus on one health, and many other groups, such as Oklahoma Medical Research Foundation, Oklahoma Blood Institute, Noble Research, and so on.

The Science and Innovation Strategic Plan for the State lays out Oklahoma's innovation opportunities, and recommends seven stra-

tegic goals to ensure solid foundation and serve as a catalyst for growth. First, to establish the Office of Science and Innovation to facilitate meaningful collaborations, and the collection and analysis of data. Second, to focus on these strategic industries and large-scale focus investments and partnerships. Third, establish centers of excellence in research to ensure Oklahoma's economic competitiveness and leadership. Fourth, create superclusters in innovation and support systems, with focus areas in both urban and rural communities to develop as superclusters for innovation. Fifth, establish a federally funded research laboratory. Sixth, invest in education, workforce development, and internship programs to ensure diversity in workforce, and seven, secure public and private financing to fund all of these recommendations.

Today the State funds entrepreneurs, researchers, and companies to help commercialize their technologies and grow their businesses through the Oklahoma Center for the Advancement of Science and Technology, and i2E, a nationally recognized private not-for-profit corporation, and the Oklahoma Manufacturing Alliance. These bold long-term strategies work together to build a dynamic research infrastructure and attract, retain, and empower a diverse and talented workforce in our State. One specific case example is the recently established Oklahoma Pandemic Center, which was created in response to the COVID–19 pandemic, a first of its kind collaborative and immersive campus located in the heart of the U.S., bringing cutting edge science to the fields of human/animal environmental health. As a largely rural and agricultural State, Oklahoma is uniquely positioned to capture the benefits of animal science insights as a tool to improve human health and prevent the spread of disease to humans.

Madam Chair Stevens, Ranking Member Waltz, House Science Committee Ranking Member Lucas, thank you again for the opportunity to speak today. Thank you for your efforts to explore ways Federal agencies can support the development of innovation economies in States like Oklahoma. We urge you to consider funding timelines to better align with smaller States' needs, their legislative cycle, and to invest in diverse States with rural, urban, and tribal representation, like Oklahoma. This is a new era in Oklahoma, one that embraces and leverages our State's unique assets to make Oklahoma a top 10 State for innovation. I appreciate your consideration, and welcome any questions you may have. Thank you.

[The prepared statement of Ms. Pollard follows:]

OKLAHOMA
Office of Science
and Innovation

Testimony by

Mrs. Elizabeth Hutt Pollard
Secretary of Science and Innovation
State of Oklahoma

Presented to

U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Research and Technology

Testimony

Madam Chair Stevens and Ranking Member Waltz, House Science Committee Ranking Member Lucas, thank you for the opportunity to speak today. My name is Elizabeth Pollard, and I have the honor of serving as Secretary of Science and Innovation for the state of Oklahoma. In addition, I serve as a C-Suite executive with decades of experience working in venture tech in Silicon Valley and understand how to bring capital and investment together to meet market needs.

I am here today to discuss Oklahoma, and its expanding innovation ecosystem. There is a confluence of forces within state leadership, industry partners, higher education, and the philanthropic community to grow Oklahoma's innovation economy.

Our state is currently in the planning stages of establishing an Office for Science and Innovation to advance Oklahoma's health, welfare, and prosperity, through scientific discovery and the development of a strong innovation economy. Innovation is the key driver of economic growth and prosperity, and by prioritizing investment in an innovation economy, we will accelerate competitiveness, diversify, and grow our state's economy and create large scale, high paying jobs for Oklahomans.

To ensure this vision for our state becomes a reality, the state of Oklahoma released its new 2021-2026 Science and Innovation Strategic Plan. Under the Governor's leadership, this plan outlines the vision for establishing Oklahoma as a global leader in scientific research and innovation economy, through state-of-the-art research facilities, cutting edge technology and progressive partnerships.

The Oklahoma economy is at an inflection point. Disruptive technology is changing the face of every industry and forcing all states to reassess how best to compete and remain relevant in a knowledge-based innovation economy.

Our state ranks 1st among other states in terms of cost of living and 2nd best in terms of cost of doing business. Oklahoma also ranks 3rd in economic outlook for 2021, with low-income tax rates

ranking 6th in the nation for tax burden per capita. And the state has developed a strategic plan to leverage these assets.

The Oklahoma plan is focused on three key sectors:

- **Energy Diversification**
  - Oklahoma has a long and rich history as a leader in oil and gas research and exploration and the state continues to lead the way in these areas.
  - Oklahoma is also increasing its focus on efficient and environmentally friendly, alternative energy solutions to support the changing needs of the globe.
    - Ranked best state to own an electric vehicle for several years running.
    - Ranked 3rd in the nation in 2020 for electricity generated by wind.
  - Oklahoma's energy expertise extends well beyond traditional energy to geothermal, solar and wind and is leading the way with a diverse energy plan.
  - The OSU Discovery Center will allow researchers and students to collaborate with industry experts to innovate and advance key technologies in engineering for the field.
- **Aerospace and Autonomous Systems**
  - Research and development activity related to aerospace has been underway for decades in the state, and in the most recent decade for unmanned systems.
  - Today, Oklahoma is home to the FAA's Mike Monroney Aeronautical Center, one of the largest FAA organizations and sites outside of Washington D.C. The state is also home to Tinker Air Force Base and the Sustainment Headquarters of the United States Air Force and to many large and small aviation, aerospace, and cyber-related companies.
  - We have strong university programs around aerospace, including Oklahoma State University's rocket test site and international space station projects through NASA's EPSCoR program.
  - Aviation is now – and has always been – an important part of the Oklahoma economy. Oklahoma is well positioned to grow nationally in the aerospace industry.
- **Biotechnology and Life Sciences**
  - Oklahoma has had significant biotechnology research and development activity underway for decades.
  - Some examples include:
    - The University of Oklahoma's comprehensive health system and NCI Cancer Center.
    - Oklahoma State University's human and animal schools of medicine with a focus on a One Health approach (human, animal, agriculture).
    - Biotech and life science related companies and nonprofits (Oklahoma Medical Research Foundation, Oklahoma Blood Institute, Noble Research) that provide the state with a firm foundation for growth.
  - Oklahoma is poised to emerge as a leading state for the biotechnology industry.

OKLAHOMA
Office of Science
and Innovation

The Science and Innovation Strategic Plan also lays out Oklahoma's innovation opportunities and recommends seven strategic goals to ensure a solid foundation and serve as a catalyst for growth.

- **Recommendation #1 – Establish the Office of Science and Innovation** to facilitate meaningful collaborations across industry, academia, government, and nonprofits to create an integrated support system to stand up incubators and accelerators, as well as collection and analysis of data.
- **Recommendation #2 – Identify strategic industries for large scale, focused investments, and partnerships** to ensure investment in the state's higher education, technology transfer of university R&D, public/private partnerships for workforce and technology development, venture capital ecosystem for emerging technologies, and infrastructure.
- **Recommendation #3 – Establish centers of excellence in research** to ensure Oklahoma's economic competitiveness and leadership, developing diverse funding sources: federal, state, university, industry, and nonprofits.
- **Recommendation #4 – Create superclusters of innovation and support systems** to ensure Oklahoma has a leading mindset which leverages our universities and the States growing incubators and accelerators ecosystem. As part of our plan to create more opportunities across the state, we have identified focus areas in both urban and rural communities to develop as superclusters for innovation. This includes locations from Tulsa and OKC to Stillwater and Fort Sill.
- **Recommendation #5 – Establish a federally funded research lab** anchored in our state, leveraging the unique technology capabilities of Oklahoma.
- **Recommendation #6 – Invest in education, workforce development, and internship programs** to ensure critical access to an educated and diverse workforce.
- **Recommendation #7 – Secure public and private financing to fund recommendations** to modernize and transform the state economy to meet the challenges of a technologically driven global economy.
    - The State of Oklahoma funds entrepreneurs, researchers, and companies to help commercialize their technologies, launch, and grow new businesses, and access capital through entities like the Oklahoma Center for the Advancement of Science and Technology (OCAST), i2e — a nationally recognized private not-for-profit corporation, and the Oklahoma Manufacturing Alliance.
    - Oklahoma also has several emerging boutique venture capital firms. However, our state needs to develop more capital to launch and grow capital-intensive startups from idea to impact.

These bold, long-term strategies work together to build a dynamic research infrastructure and attract, retain, and empower a diverse and talented workforce in our state. We believe a key component to ensuring lasting, positive societal impact is providing all Oklahomans — rural, urban, and tribal — access to immersive STEM education and skills training. Through fueling the

state's innovation environment, and modernizing the way we teach and learn science, we are setting the stage for a decade of advancement with new discoveries, products, and services.

The Oklahoma City Innovation District, Tulsa Innovation Labs, the OSU Discovery Building, and the Oklahoma Pandemic Center for Innovation and Excellence also known as OPCIE are recent examples of Oklahoma's commitment to creating an environment that embraces and nurtures innovative thinking.

One specific case example is the recently established OPCIE which was created in response to the Covid-19 pandemic — a first of its kind collaborative and immersive campus located in the heart of the U.S., bringing cutting-edge science to the fields of human, animal, and environmental health. With innovation at its core, it leverages partnerships between public and private entities to bridge the gap between laboratory and clinical practices, to create improved public health response while incorporating the unique needs of rural, urban, and tribal communities. Through a One Health approach, recognizing the health of people is closely connected to the health of animals and the environment, the OPCIE will be a global leader in promoting and preserving public health.

The OPCIE will serve as an anchor in the nation's future pandemic response efforts and is an emerging leader in improving health outcomes, positioning Oklahoma as a Top 10 state in health science and innovation. Partnerships with global bioscience leaders will attract bright minds and top talent together in one place to live, study and solve the world's most pressing public health threats through experiential, hands-on research and development efforts. With in-house support from the state of Oklahoma, this organic lifestyle-campus will be able to improve our ability to measure health outcomes in the state, nation, and across the globe.

As a largely rural and agricultural state, Oklahoma is uniquely positioned to capture the benefits of animal science insights as a tool to improve human health and prevent the spread of animal disease to humans. Oklahoma's central location and position as a top livestock producing state means we play a key role in stopping the spread of disease in a potential outbreak scenario. Investing in protection of agriculture in our state results in better protection for Oklahomans and all Americans, our economy, and our natural resources — and this comprehensive approach to public health has garnered broad-based support.

Dynamic partnerships are vital to achieving our mission — such as the Department of Commerce, Congress, federal and state agencies, higher education collaborators, private-sector partners, industry stakeholders, nonprofits, and the public. To become a national and global leader in science, technology and innovation, we must engage new stakeholders and collaborations, as well as leverage existing capital and partnerships. Additional investments will ensure the successful development and expansion of our state's innovation ecosystem to achieve our goal of becoming a Top 10 State.

Closing

Madam Chair Stevens and Ranking Member Waltz, House Science Committee Ranking Member Lucas, thank you again for the opportunity to speak today.

Thank you for your efforts to explore ways federal agencies can support the development of regional innovation economies in states like Oklahoma. We urge you to consider funding timelines to better align with smaller states' needs, their legislative cycles, and to invest in diverse states with rural, urban, and tribal representation — like Oklahoma. This is a new era in Oklahoma, one that embraces and leverages our state's unique assets to make Oklahoma a Top 10 state for innovation. I appreciate your consideration and welcome any questions you may have.

Elizabeth Hutt Pollard

Secretary of Science and Innovation
Governor Kevin Stitt appointed Pollard as Secretary of Science and Innovation on June 29, 2020. In this position, Pollard places a strategic emphasis on enabling science and innovation to impact health, commerce and stem education for Oklahoma. Prior to her appointment by Governor Stitt, Pollard served as Deputy Secretary of Science and Innovation under Secretary Kayse Shrum.

In addition to her cabinet role, Pollard is Executive Chair of Applied Silver, a materials science health-tech company located in Silicon Valley addressing infection control and antibiotic stewardship. She is a C-Suite veteran and has extensive global experience scaling businesses, building commercial and academic partnerships, and bringing to market highly specialized technology and solutions, including software and microfluidics, for healthcare, pharma, diagnostics and life science research. Because of her expertise in genomic tools and test development, Pollard serves as an advisor to the Oklahoma Department of Health's Covid-19 testing response and has been instrumental in fostering commercial technology partnerships for the state's Covid-19 testing. In addition, Pollard advises several early-stage healthcare companies and has held board director roles in public, private and non-profit organizations. Most recently, Pollard has been named to the 2020-2023 YPO Global Board of Directors and serves on the finance committee. YPO's 31,000 executive leaders represent businesses that together account for the world's 3rd largest GDP. Pollard is a past member of the National Association of Corporate Directors (NACD), Women Corporate Directors (WCD), and the American Chemical Society (ACS).

Pollard moved to Oklahoma in 2018 from California because of her appreciation for the state's infrastructure, culture and values. She and her husband, Dennis, reside in Edmond. She is a native Michigander and received her BA in Chemistry from Michigan State University and MS in Administration from Central Michigan University.

Chairwoman STEVENS. Thank you. Thank you so much, and we know SSTI is very familiar with your i2E Program, and a lot of your best practices. So, with that, after these phenomenal testimonies, we're going to begin our first round of questions. Chair's going to recognize herself for 5 minutes.

And, Mr. Berglund, I wanted to start with you. In your written testimony, which I encourage my Committee Members to review—all 12 pages. I wanted to reference something that you touch on at the beginning of your written testimony, with Dr. AnnaLee Saxenian's book, *Regional Advantage*, where, quote—she said—you know, she describes the origins, growth, and differentiators of Silicon Valley and Route 128. Silicon Valley and Route 128 were—or—were not planned as technology hubs, but they did not happen by accident either.

And so I wanted to draw down on that, and something else that you said in your testimony, which is you talked about the need for flexible funding. And I'm just wondering if you could describe that nexus between flexibility at the Federal level and the intentionality that comes from a region? Because we talk a lot about not being too top town and prescriptive, so if we're going to fund these regional innovation clusters, how do we meet what the needs are at the local level? So I'll let you start, and I—you know, Ms. Nas wants to get into it, you know, I know you're touching some of that as well. That'd be great.

Mr. BERGLUND. Thank you, Chairwoman Stevens, for the question. In terms of flexibility, I think the issue, really, is that there's just very—great variation between the regions. So, using some of the examples from my written testimony, if you look at what Georgia did in the Georgia Research Alliance (GRA), at the creation of GRA, part of this fate's concern—part of the business community's concern was that they didn't have the research capability, and so they invested first in building up their intellectual infrastructure. And then, as time progressed, as that strength emerged, it then invested in bringing the technology from the university into the marketplace. And then, as they were successful at that, they evolved again to setting up seed funding for the resulting companies. So I think we need to meet the regions where they are with their particular strengths.

Infrastructure, from a physical infrastructure viewpoint, may be very important in some regions, but in other regions, that won't be important, that they have an excess of available space, or are able to find funding from other sources. So the Youngstown Business Incubator, for example, took advantage of a weakness of the community, that they had a lot of empty office space, and turned it into an asset, by using it as space for startup companies.

Chairwoman STEVENS. Ms. Nas, did you have anything you wanted to contribute to that?

Ms. NAS. Yes, Chairwoman Stevens, thank you. Following up on Mr. Berglund's statement about meeting people where they are, regions where they are, in the work we do we're very intentional about meeting people where they are. I mean that literally—so that might be creating a business boot camp out in the community—in a community center—it might be us going into an art classroom to talk about entrepreneurship, or it might be our Youth Entrepre-

neurship Program, where we bring innovation and entrepreneurship into the elementary school classroom. We're really thinking intentionally about how we get to entrepreneurs and innovators that we normally wouldn't get to.

Chairwoman STEVENS. Yeah. And giving you the freedom to be able to do that, right? Without being so overly prescriptive about the program requirements. And, a minute left, but, with Dr. Fuchs, and your testimony, particularly focusing on supply chain, and manufacturing diversification, and some of the weaknesses, I just wonder, in terms of this—it—and it's not going to do it justice in a minute left, so we might have to do it for the record, or get more comments from you, but I'm just chewing on what you talked about with some of these weaknesses in our supply chain, and being dependent on one country, and then also recognizing that there are some things in our supply chain that we don't even produce.

So let's circle back to that, because I want to do that justice, and we've only got 14 seconds, and I've been gabbing for a while, and we've got some really great Committee Members here who have questions, so I'm going to put a pin in that for that you, but, you know, this is just—this is the start, with a bunch of stakeholders in this innovation ecosystem world that we're working on with EDA. And so, with that, Mr. Waltz, I'm going to turn to you for 5 minutes of questions.

Mr. WALTZ. Yeah, thank you, Madam Chairwoman. And I'm not 100 percent sure who's best to answer this question, so, Ms. Pollard, I'll go to you. And I'm relatively new in the last couple of years to this Committee and to this position, so I'm just kind of asking a level-setting question. I'm trying to get my mind a round what the EDA does, and its various innovation activities, versus what the Small Business Administration has done, and is doing, historically, and where are those—and I can describe some of them, but I'm assuming that you're relatively familiar. You know, where are those duplicative, where are they complimentary? Just trying to understand that dynamic. So, Ms. Pollard, I'll throw it over to you. Mr. Berglund, if you want to chime in, or anyone else, on that question.

Ms. POLLARD. Thank you. I really don't believe I am the best person on the panel to answer that specific question, coming from the vantage point of wanting to drive a discussion about how to set up innovation within a State. But, having said that, I'd like to have one of the other panel members respond accordingly, specifically around EDA and Small Business Administration. Thank you.

Mr. BERGLUND. So I'd be happy to do that, if that's all right——

Mr. WALTZ. Sure.

Mr. BERGLUND. So, broadly speaking, the Small Business Administration (SBA) tends to focus on financing of individual companies. They also play an important role, through their Small Business Development Centers, as serving as an entry point for any person that might be interested in starting a company, but that can be a mom and pop type franchise, so—a Subway store, for example. I think of them as the large part of a funnel in helping potential entrepreneurs think about whether they should start a business. EDA tends to focus on physical infrastructure because of its authorizing statute, the large part of it. However, they also have a section that

is the Regional Innovation Strategies Program, which is now called the Build to Scale Program. These are smaller projects, about 750,000, a million dollars in size, that last for a shorter time period.

So—not a lot of time to go into the level of detail. I'd be happy to follow up with you or your staff in more detail, but I'll pause here so you have the opportunity to ask other questions, or—of other panelists.

Mr. WALTZ. Sure. Dr. Fuchs, you had a comment there?

Dr. FUCHS. I was just going to add that research on the Small Business Innovation Research Program has—by Josh Lerner and others has suggested that it is quite effective in the commercialization of emerging technologies, particularly in areas that have existing good venture capital. There may be room for growth in other areas, but it is important in that role. It's interesting in its history. It actually originated out of something called RAN, historically, which was about research in areas of national need, and commercializing them domestically, coming back to some of our conversations today.

Mr. WALTZ. Thank you for that, Dr. Fuchs. If I could just follow up, you said in your testimony, "Increases in science and technology funding alone will be insufficient to ensure U.S. technology competitiveness without a strategy for how to ensure that those investments realize our national objectives." Can you just flesh that out a bit more, and the role of a national strategy for science and tech can play in promoting a more even nationwide distribution of science and tech education funding commercialization?

Dr. FUCHS. Yeah. Thank you very much. So I think there's threefold there. One is that we need to—we have limited resources, in the end, and we need to think about how to invest those resources, but at the same time, it can be confusing, as I read in my testimony, exactly how to do that well. So I'm not arguing for choosing technology winners, but—rather than choosing the right goals, right? So in the semiconductor industry, which I've studied extensively, right now, in the next 10 years, we are going to have a problem of not having hardware to continue to advance computational capabilities, not having the device. I would argue that funding the last—the Commodity Semiconductor of today may be far less important than changing the game, and making sure we lead in the computational capabilities of the future that even our AI (artificial intelligence) aspirations require. So getting that right is not trivial, and there are strategic national security and economic prosperity setup objectives in that context.

Two is that, when I speak of infrastructure, and infrastructure of the future, I mean reinvigorating the country's infrastructure, from broadband, to electric grids, to—the entire system. That can serve as a platform for innovation, but also for developing the manufacturing skills we need for the future, and the firms that we need to manufacture. I was stunned when we've been studying firms that pivoted under COVID–19, that—they—some of them come from being formerly garbage distributors, and then construction workers of buildings, and now they're like, "Wow, manufacturing's great. It's not smelly, and it's inside. I love this job." So we need to figure out how to make those crosswalks in—but by doing the

infrastructure of the future, we can buildup our dilapidated manufacturing ecosystems to have that firm capability as well.

Mr. WALTZ. Well, thank you for that, and, Madam Chairwoman, thank you for allowing her answer to go over our time. And I couldn't agree with you more, Dr. Fuchs. I hope that all of our colleagues can reach a deal on what infrastructure is, and how to best support it. Thank you so much. I yield.

Chairwoman STEVENS. Yeah, thank you. And, just as a point of reference, the Economic Development Administration will be coming to see this Subcommittee for a deeper dive either in the form of—sometimes we do internal meetings, but certainly as part of ours for the record and hearing process. And it is a great question about understanding the differences in the investment, and I will note to my obligation of fiscal responsibility that a proposed $20 billion investment in EDA is much higher than its average levels of 300 million, right? And it's an agency that for every $1 into an economic development project—some of which are public works, and it hangs out in the Transportation and Infrastructure Committee, right? We have oversighted of their innovation programs, but for every $1, seven jobs created or retained. But it is absolutely worth us being, you know, the authorizing stewards of this agency to really analyze and address the suggested plus-up in funding, and what we could get out of it. Certainly with Route 128 and Silicon Valley, it remains immeasurable.

And, with that, we're going to go to just, you know, an incredible Member of this Committee, Mr. Tonko from the nice State of New York.

Mr. TONKO. Thank you, Chair Stevens. Can you hear me? OK. Thank you for holding today's important hearing, focused on economic development and further involvement of regional innovation strategies. NIST (National Institute of Standards and Technology) has two programs that are focused on building manufacturing capabilities in regions across the United States, Manufacturing USA, and the Hollings Manufacturing Extension Partnership (MEP). Certainly the network of 11 New York MEP centers cultivate the growth of high tech industry, and certainly help smaller manufacturers to modernize. These independent not-for-profit organizations share a common commitment to providing direct, strategic assistance to companies in the areas of entrepreneurship, technology commercialization, product development, high tech business incubator management, and technology transfer services.

New York State, and the Capital Region of New York, are strong examples of where these programs have helped facilitate the integration of innovation and technology throughout the region's economic development efforts. It's estimated that in Fiscal Year 2020 New York's MEP programs saw the creation or retention of over 5,000 jobs and over $214 million in new client investments. So, Mr. Berglund, what do you see as the role of the Manufacturing USA Program, and the Manufacturing Extension Partnership, in regional innovation efforts?

Mr. BERGLUND. Thank you, Representative Tonko, for that question. I think both of them are critical organizations, or can be critical organizations. I have much more familiarity with Manufacturing Extension Partnership Program, which, full disclosure, SSTI

receives funding from MEP, so a strong familiarity with the work that they're doing on the local level. Part of what we try to do is see where there are opportunities for the MEP Centers to work with some of the entrepreneurship and technology commercialization activities that are occurring in a region. So, good example in Pittsburgh area of connecting entrepreneurs working on hardware startups with local manufacturers to help design the influence of that product so that it'll be manufactured here in the U.S., rather than in China.

Mr. TONKO. And do you see these MEP Centers as necessary partners in building new regional innovation economies?

Mr. BERGLUND. Oh, absolutely, and in particular the MEP Centers have a national reach, and—into rural areas of the country as well, where it's much more difficult for the technology economy to take root, so critical actors.

Mr. TONKO. So what can we at the Federal level do to best support these programs so that they can continue to benefit the communities in which they are located?

Mr. BERGLUND. Well, I would say the—I think one next step is on this regional technology hubs legislation that the Senate's approved, that, as Chairwoman Stevens has talked about, there's more of an intentionality with this program on creating a whole innovation ecosystem. So part of what the Federal Government has done well is in funding individual programs that support individual activities, manufacturing competitiveness, workforce development. The regional tech hubs, in my mind, would be able to tie all of these different elements together to deliver results in an area.

Mr. TONKO. And in your testimony you mentioned that evaluation requirements for new investments in technology hubs should follow the lead of the Manufacturing Extension Partnership, and some of the NSF funded centers that do these given evaluations annually, what do you think the MEP is a good model for—why do you think they're a good model for evaluating programs that invest in regional innovation economies?

Mr. BERGLUND. In part because it's ingrained in the MEP system culture that the evaluation is going to happen. It's going to be an external evaluation, where external evaluators are contacting the companies to get the results. And MEPs also, historically, have been interested in experimenting with different forms of evaluation as well.

Mr. TONKO. Thank you so much. Madam Chair, I yield back.

Chairwoman STEVENS. Great questions, thank you. And with that we will turn to Ranking Member Frank Lucas.

Mr. LUCAS. Thank you, Madam Chair. Secretary Pollard, in some estimates Oklahoma currently ranks near the bottom of States with respect to innovation. In your testimony you State that Oklahoma should prioritize resources to grow the airspace and autonomous systems, biotech, life sciences, and the energy diversification sectors to maximize their current investment, and I believe that's very logical. So could you discuss for a moment how can the Federal Government help connect the pieces to bolster innovation in these key sectors?

Ms. POLLARD. Thank you. Excellent question. I think that it's critical that we align funding with technology—regional centers

have core capability. The State of Oklahoma being those three areas is critical, where we have a strong foundation, and linking up that adaptable capital such that it's available based upon the needs of that region or State, and also is available in alignment with legislative cycles so that matching can appropriately happen at a time when it's needed most. Funding lags innovation, and we need to figure out how to provide funding in a way that is more timely and meets the needs of those unique technology areas. I also think that focusing on public/private partnership is—how do we leverage relationships that exist around core technology areas? Whether that is with our military, whether that's with private companies, and align those kind of partnerships, and enable those with the right kind of funding sources to make them really go.

I would also then just also add that, thinking about this in regard to rural and urban, as we begin to expand our urban centers out toward rural communities and create these technological centers, we begin to enable rural communities in a way that have not been in our past. And so how do we begin to—technology clusters or hubs outside of urban centers that begin to grow our rural capability and footprint, and improve how we are providing education opportunities to rural communities? Thank you.

Mr. LUCAS. Continuing with you, Secretary, STEM occupations are some of the fastest growing and higher paying jobs, compared to non-STEM occupations, and innovation economies rely on steady and a consistent flow of STEM workers to be successful. What can States do to attract the STEM workforce necessary to drive the economic growth?

Ms. POLLARD. I think that our STEM programs, and our programs through our higher ed and career tech might need to actually be aligned with the State strategies around technology development, or the region strategies around technology and development, so that you have a diverse workforce ready and able to respond as economic development opportunities are presenting themselves.

One of the real opportunities is thinking about not just how do we create the best engineering program, but how do we also create engineering technician programs within career tech to provide support to workforce diversity within companies that are developing, or moving in or out of a State or region. And I think if we can do a better job of aligning those programs with capabilities of that region or State, we will have a much better output in regard to a workforce that's prepared, and ready, and able to support.

Mr. LUCAS. One last quick thought. You know Oklahoma has a large portion of the population residing in rural communities. How can we make sure that rural communities are not left behind, and have the same opportunities to grow their local economies when it comes to these issues?

Ms. POLLARD. Absolutely. I do believe it is creating technology pillars outside of urban centers, and looking at States and regional areas that have the capability to exploit what they already have in an urban center out to those rural communities. I think that also expands to tribal communities as well, which are really important, and sometimes overlooked, and I think it's one of the reasons Oklahoma is a very unique area for this kind of expansion that we're

going through right now and at this time. So, you know, thinking about how you can leverage setting up clusters, technology hubs, in those urban and rural communities so that they're linked together through partnership.

Mr. LUCAS. Thank you, Secretary. Thank you, Madam Chair.

Ms. POLLARD. Um-hum.

Chairwoman STEVENS. All right, thank you. And with that, the Chair will recognize the gentleman from Illinois, Dr. Foster.

Mr. FOSTER. Thank you. Audible and visible here?

Chairwoman STEVENS. Yeah, yeah. You're great.

Mr. FOSTER. OK, great. All right. Well, first off, thank you for having this really important hearing. You know, this is something that I've personally struggled with for years. I guess I'm best known around here as being the, you know, the Ph.D. physicist in Congress, but I'm also a businessman who's actually accomplished pretty much exactly what we're all struggling to mass produce here. When I was 19 my little brother and I started this company in our basement with 500 bucks from my parents, and it now manufactures about 70 percent of the theatre lighting equipment. Our company was born at the birth of the microprocessor era, so we had the bright idea of using that to control theatre lights.

And so our company now, you know, employs about 1,500 people, and manufactures in suburban Madison, Wisconsin. And the location of our company is an interesting—well, it's something that we've been thinking about since its very birth. It was born—our company was born because of the University of Wisconsin, where a lot of the intellectual property came from, and my brother and I got heavily subsidized educations from the State of Wisconsin, that they've collected on many times. But a lot of the touch labor for our manufacturing comes from the nearby rural areas. And so, for example, our—one of our biggest assembly factories is in Mazomanie, Wisconsin, which I would bet I'm the only person who's heard of, but is a very nearby rural town.

And so it strikes me, as we've thought of where to locate things, that the natural scale of this is commuting distance. You know, our—most of our R&D happens in the near suburb of Madison, where you can really get recent graduates. We've, you know, prospered with a chain of recent graduates who, you know, they had a spouse who was—had a high-tech job, and had to stay in Madison, or near Madison. And then the—when you're talking about, you know, the touch labor, you know, the good middle class jobs that everyone loves so much, those, you know, those happen and work best for people who can live in low-cost areas, with low-cost housing and so on, in nearby rural areas. But that's a very limited thing. When we think of the possibility of relocating our company to Northern Wisconsin, where you're many commuting distances away, it just stops working. When we think of, you know, it won't work because of, you know, all the reasons I just went through.

So how do you think about what's realistically possible physically, in terms of how geographically dispersed we can really accomplish this when we're trying to combine, you know, a range of skills in this? Or what's the history of trying this? You know, Mr. Berglund, I thought you looked like you have the battle scars from, you know, a generation of efforts at this, and where—you know,

what does—really works, and, you know, what should we be hoping for? What does success look like?

Mr. BERGLUND. I think, Representative Foster, you described it very well. It's a very challenging issue, and I think the best connections—and maybe some of the other panelists will have more specific suggestions, but I think some of the research indicates that where we can make manufacturing connections between research hubs and rural areas, that is the opportunity for best connection in all rural—in rural areas. Manufacturing just plays such an important part in rural counties that being able to strengthen those rural manufacturers is critically important.

Mr. FOSTER. Yeah—sort of divide rural into rural areas that are within—two commuting distances of, you know, a city, and those that are truly rural. You know, I represented, for years, extremely rural areas, and it was—you know, it's just tough sledding trying to get companies with tech needs to move into those extremely rural areas.

Mr. BERGLUND. If I could—I would just say there are good examples of small companies in the Upper Peninsula of Michigan, in the central part of Pennsylvania, that maybe are $20 million in sales, which doesn't sound significant to people on the coast, but in terms of employment, is a significant employer in that region. So it's also keeping in mind what size company actually makes a difference in a region.

Mr. FOSTER. And, Madam Chair, could I ask for 30 seconds for Dr. Fuchs to say what she had intended to?

Chairwoman STEVENS. Absolute——

Dr. FUCHS. This is one of the reasons I believe we need to use procurement. We need to build to build, and procurement of futuristic infrastructure. If we did that in all rural areas, I believe that we start to create the jobs to rebuild skills. And I'm happy to talk about—I've been studying the offshoring of manufacturing for the majority of my career in shop floors, first here and then overseas, and—delighted to talk about that further. But I've become—come to believe that's essential.

Mr. FOSTER. Thank you. Yield back.

Chairwoman STEVENS. Great. And, with that, Dr. Baird is recognized for 5 minutes of questioning, from the very nice State of Indiana.

Mr. BAIRD. Thank you, Chairwoman Stevens, appreciate that. And, Ranking Member Waltz, I really appreciate the opportunity to be a part of this important hearing, and I appreciate the witnesses all being here. And I appreciate the emphasis that many of our witnesses have expressed about the rural areas, and how significant their growth and development is, because I come and represent a large rural area in West Central Indiana, so I appreciate those comments. I guess my question will be directed to Secretary Pollard to start with.

You know, I have Purdue University in my district. I have had the opportunity to see firsthand just how the regional innovation efforts benefit the Hoosier State, and directly affect the rest of the country. So just yesterday I met with a startup company. They were wishing to potentially set up a learning center associated with Purdue, and when I think about building regional innovation

economies, companies like this and partnerships like this come to mind. They really wanted to have the access to students, faculties, laboratories, and researchers, and in order to start a pipeline, as their company grows, to have employees to continue that continued growth of that company.

So I guess my question comes down, Secretary Pollard—what do you think Congress should take into consideration to come up with realistic and sustainable proposals to support the development of these new regional innovation economies, particularly in these rural areas?

Ms. POLLARD. Certainly. I think it is investing in technology infrastructure outside of urban areas. We tend to look solely at urban areas, or the large population areas where, you know, technology has already been developed. One of the examples we have here in Oklahoma is now this new Pandemic Center, where we chose to move our Public Health Lab and that Pandemic Center's establishment outside of Oklahoma City, about an hour and 15 minutes away to Stillwater, where there's still infrastructure from a higher ed perspective, but it begins to leverage the broader rural locations within the State, and fosters a center of collaboration. This facility is unique in that it is meant to be a shared resource facility not only for technology, but also for research and development and education. And so working on broader public health education programs for both degrees, as well as for continuing education. And so in this way, as we establish more of those across our State, whether that be in health tech, or whether that's in, you know, aerospace and autonomous, we create this opportunity to meet a broader group.

I would also then add that I think that COVID–19 has taught us a lot. One of those is the opportunity for virtual learning and virtual collaboration, as we are doing today, and so ensuring that broadband infrastructure is across all of our rural regions to enable that kind of learning and collaboration is critical.

Mr. BAIRD. Well, thank you for that. And you know, one other thing that you mentioned here today is the fact that animal agriculture and animal research can be an important aspect of contributing to the kind of technology that we need in other areas, so I really appreciated you mentioning that. I think I have about 1 minute left, Madam Chair, and I'd like to go to Dr. Berglund, because he mentioned the rural areas as well, and the emphasis there. So I just give you the opportunity to stress the points that you made in that area.

Mr. BERGLUND. Yeah. I think one point that I haven't made yet, but I should mention, is the original proposal on those regional technology hubs was for maybe eight to ten hubs located in the U.S. And I have to say, we endorsed the original legislation, but we did it somewhat unenthusiastically because of that. We like this version of the legislation because it doesn't put a limit on the number of hubs, so rural areas should be able to benefit from it, smaller metro areas should be able to benefit from it, as long as they're focused on the activity areas outlined in the legislation.

Mr. BAIRD. Thank you. And I apologize for not being able to get to the other two witnesses, but, Madam Chair, I yield back.

Chairwoman STEVENS. Yeah. Well, this is absolutely one of the instances where 5 minutes for questions with this fabulous group just does not seem like enough. And, with that, allow me to recognize Congresswoman Ross from the wonderful State of North Carolina for 5 minutes of questioning.

Ms. ROSS. Thank you very much Madam Chair, and I agree. I have seven questions, and somehow I don't think we're going to get to all of them. But thank you, and thank you to the Ranking Member for holding this very important hearing today. I represent a district that includes much of the Research Triangle Park (RTP) in North Carolina, the largest research park in the United States, and a premiere global innovation center, but it wasn't always that way. The Triangle now is an ecosystem of hundreds of companies, government agencies, academic institutions, startups, and nonprofits that work in concert to attract talent, bolster the local economy, provide research, and lead on clean energy.

Last week I held a roundtable in my district on regional innovation, and the beginning of the park, when really the people from our institutions of higher education were going to other States, and so it was created to avoid the brain drain from our institutions of higher education, including our HBCUs (historically Black colleges and universities), because we have a very strong HBCU network. And, as a matter of fact, the former mayor of Durham, who came back to North Carolina entirely because IBM was in RTP, talked about how our African-American scholars left the South in the 1950's and 1960's, and it was only things like the Research Triangle Park that brought them back.

The success is due to the combination, though, of the universities, local government, just giving land, unused land, setting up the infrastructure for that, and then, of course, our business community. And one of the things they pointed out is that, in order to succeed in the future, there were two things they emphasized, and one was from a former mayor of Raleigh, that people no longer want to drive to a big office park where there's not even anywhere to have lunch, and they—what they want is a live, work, play environment. It does not have to be in the center city, but the center city will draw the people because it has the stuff there. So now Research Triangle is reinventing itself by adding housing, places to eat, places to exercise. So that was one thing. The second thing is having that talent pipeline that comes from our people starting K through 12. So not just the universities, but having kids get interested in things like robotics, and particularly reaching out to communities of color and women to create that pipeline. Those were the two big things that were identified.

And we know it's a success now, but it wasn't initially a success, so I'd like any of the folks to respond to this. We would love for people to learn from what happened in the Research Triangle Park, but, make no mistake, we're still needing to reinvent ourselves, and attract that indigenous pipeline of talent. So any of you to respond to this and how it can help others?

Ms. NAS. I'd be happy to take that one, Representative Ross. Thank you for the question, and thank you for acknowledging that we have to create that foundation at a very young age. I mean, to use a sports analogy, you don't expect somebody to become an NFL

football player having touched a football for the first time when they're 25 years old, right? So how is it that we're going to expect our youth, when they grow up, to be able to become innovators and commercialize technology if they haven't been exposed to it at an early age? And that's exactly why we developed the curriculum we did, knowing the importance of exposure to STEM curriculum, of innovation and entrepreneurship curriculum, at a young age. But the gap there was really thinking about the economics and the business that goes with STEM education, because you can be an innovator, but you may not know the business aspect of innovation, so that's part of reasons to develop that.

Ms. ROSS. And it—yeah, it looked like Secretary Pollard had something to say.

Ms. POLLARD. Yeah. I would just like to add that I think there's a huge opportunity for K through 12 educators to partner with, you know, the private sector to really develop, you know, boot camps, science and technology boot camps, where students can get immersed in what is happening out in the commercial world, and understand how they can apply learning to that, and also help set the stage for them making their choices as they move to, you know, that next degree that they're interested in pursuing post-K through 12.

Ms. ROSS. Thank you, Madam Chair, I yield back, but I look forward to getting to ask my other six questions at some other time.

Chairwoman STEVENS. Yes, well said, Ms. Ross. And, with that, allow me to recognize fellow Michigander Mr. Peter Meijer for 5 minutes of questions.

Mr. MEIJER. Thank you, Madam Chair, and Ranking Member Waltz, and to all of our experts here today for joining us. I am excited on this topic. Just yesterday oversaw, and was there for the delivery of two world class cyclotrons to the Michigan State University College of Human Medicine in downtown Grand Rapids, so—I will not bore you with the details of the theragnostics cancer tracing and remediation technology that's being pioneered, but when we start to talk about some of these regional innovation efforts taking place outside of those 15 counties that were mentioned in the beginning remarks.

You know, coming from a place that can be derided frequently as flyover country, it's very important that, you know, we don't have that sense of failure to recognize how smaller companies, you know, the $20 million company in the Upper Peninsula that Mr. Berglund mentioned, that can be vital to that economy, but also can create really positive network effects, where you can have that intermixing of research and technology, of applied and basic efforts, and figuring out how to better—not just commercialize, but hopefully lead to some really impressive innovation as well. So I'm excited to boast and brag about the great things happening in Michigan's Third District out here, but I also wanted to ask Ms. Nas, again, a fellow Michigander on this panel, and—wanted to get your perspective from Flint. You know, would love to have these be questions we go over in a Committee hearing room in D.C., but I think we're both in Michigan for this, but on other sides of the State.

You know, in this Committee we're very focused on the importance of STEM education, obviously, and this has come up in conversations before. You know, one of the key elements that we've been missing, and this comes up time and again in my conversations with employers who are in these more research-oriented fields, is how to build out that pipeline of students, how to get that interest at an early age. Some are already going into, you know, middle schools to try to encourage students to be thinking about pursuing a career in science, showing them graduate students, you know, professionals who look like them, who have gone through that same experience to show them what is possible, and show them how they can kind of get to that point. But how do we, from an EDA standpoint, or from a Federal Government standpoint, continue to support and create that culture of encouraging innovation just from those earliest years on, and from all corners of the community as well?

Ms. NAS. Thank you, Representative Meijer. I applaud what you're doing in your district as well. You have a lot of really creative innovation programs in your district. It's a good point. I think we need more support of the K–12 level to provide curriculum, to provide opportunities for our K–12 educators, particularly in elementary schools, to create curriculum, to implement curriculum, during their school day that allows students to learn the innovation mindset, to establish that foundation at a very, very young age. Similar to learning a foreign language, let's start early. Let's do the same thing with innovation, and I would say economics as well, and entrepreneurship. Because, again, with those skills the kids learn about critical decisionmaking. They learn to think as entrepreneurs, as businesspeople. They learn how to build teams. They learn how to pivot, if their business idea doesn't work. Those are skills that will carry with them throughout their entire life, even if they don't wind up starting a business—I think teachers need that.

We developed our curriculum so that it would correspond with what teachers already need to teach during the school day, because we realize that teachers are already overburdened with all the content they have to teach, so I integrated very carefully State of Michigan content standards within that Young Sharks curriculum. We need to do that. We need to bridge that gap in between STEM education, and then that business/economic/entrepreneurship part of it. We need to put those two together, and encourage teachers to do the same thing.

Mr. MEIJER. And then you touched on half of what was going to be my follow-up question, but just the other half—I mean, what are the best practices to leverage, you know, the involvement of the private sector in that as well, as one of those likely career path opportunities?

Ms. NAS. So one thing we like to do is we like to bring entrepreneurs, business owners, industry right into the classroom, whether that's our K–12 students, students on campus here, or with the business boot camp that we do out in the community. We always try to have a local innovator serve as a mentor to whatever age group we're working with. I think it's key for people to be able to see people doing that work that they could be doing in the fu-

ture, or that they're already doing. So if you can see somebody like you doing it, you know that you can do it.

Mr. MEIJER. Yeah. And the mentorship aspect is critically important, and I appreciate that. And, with that, Madam Chair, I yield back. Thank you.

Chairwoman STEVENS. Fabulous. With that, I want to recognize a Member of the Committee for 5 minutes of questions who I brag about being on this Committee, and that is Ms. Gwen Moore from the other Great Lakes State of Wisconsin.

Ms. MOORE. Well, thank you so much, Madam Chair and Ranking Member, and I just—and other Members of the Committee, who have asked such excellent questions. It's been really a treat there—here this morning. I'm going to try to get in as many questions as I can. And, Mr. Berglund, you mentioned in your written testimony that the Water Council in Milwaukee, Wisconsin was an example of these research technology regional hubs, and I would like you to lean into—and, you know, these are huge corporations that have formed this, but talk about the importance of the involvement of the EDA, the involvement—and, you know, bursting the myth somehow that the private sector can just do this on its own without government support. And, Professor Fuchs, I also—you know, you were—you lacked in enthusiasm in your testimony, but I did get you wanted to collaborate, collaborate, invest in infrastructure, invest in intelligentsia, invest in technology, invest in economic development. What do you say to people who say that we are in a deficit situation, and we can't afford to invest? And, Ms. Nas, I want you to close us out by talking about those who are left behind. And you don't have to mention Dan Kildee, we already know he's left behind. And I would yield for those responses.

Mr. BERGLUND. I—you've given three questions. I will try and take no more than a minute so that the other panelists can respond. I think the Water Council's a great example of the private sector coming together initially and saying, "We have common problems, we need to work on those", but recognizing that they needed to bring in government partners as well. And so, for the Water Council specifically, they benefited from funding from SBA in the Regional Innovation Clusters Program. Part of the strength of that program is that it was a 5-year worth funding commitment that gives more of a ramp to be able to spend the money. One of the disadvantages of current EDA projects is they tend to be shorter term projects, and so can't have the sustained impact. With that, I will yield to the other panelists.

Dr. FUCHS. If we don't invest, we're not going to have the revenues to get out of the deficit. That would be my answer, very, very short. And then I'm going to give two short examples. The one is, in advanced semiconductors, our research looked at Beyond CMOS (complementary metal-oxide-semiconductor), the ability to continue computing. That led to 50 percent of growth in the United States and worldwide in the 1990's, the—Moore's Law. We are spending an order of magnitude less today on solving that problem, which is a sort of basic physics level challenge that needs to make its way rapidly to commercialization, than we were spending on 1 to 3 year equipment upgrading under—so we're, like, not spending the right

orders of magnitude, and that was an—we had access to the archives. That was an industry internal dialog.

But the second is on infrastructure. Our infrastructure is getting a grade of D, right? So when I travelled just now through Pennsylvania, up north, there are houses there that don't have broadband, there are houses—I mean, our electric grid is not at its latest—it's not ready for—our infrastructure is not ready for climate disaster. We have a road that's lower than the river here in Pittsburgh. We need to invest to have the platform and the worker skills to innovate off of.

Ms. NAS. Thank you for the question, Representative. I think it's really important that we remember that if we keep leaving people out, we can't have sustainable economic growth. We can fund programs, sure, but if we leave people out, it's not sustainable. That could be a neighborhood entrepreneur who enters, but gets lost in the system. Or it might be a high school student in Flint who isn't aware of the full menu of opportunities that are available. Maybe that person doesn't know about cybersecurity programs, for example. And if we don't continue to train and to provide opportunities, then there's no way that we can continue the economic growth that we're all hoping to attain.

Ms. MOORE. Our legislation needs to reflect those values. We can't just trust that people are going to give people the opportunity. We've got to be really intentional about it.

Ms. NAS. Yeah, I agree with you on that, and it's difficult, and it takes time. Many of you have mentioned it today that, you know, first of all, it's not one-size-fits-all. We need the very large investments, and then sometimes we need some of the smaller investments. And we know that the payoff might not be today, but if we can establish that foundation for innovation, I do believe the payoff will come in 20 years.

Ms. MOORE. Thank you, and I yield back, Madam Chair.

Chairwoman STEVENS. Great. We're through with questions. I'd be open to doing another round, if anybody on the other side of the aisle wants to do it, or we can close, and just, you know, maybe, you know, kind of wrap it up in conversation. You know, we were supposed to go to noon, so we've got about 22 minutes left, but I don't know if Rep. Baird or Rep. Meijer would want to do another—you're going to—Dr. Baird, are you OK with questions?

Mr. BAIRD. I'm OK.

Chairwoman STEVENS. OK, good. Great. Well—and we've made a bunch of new friends, which is wonderful, so—and, you know, this is just the start of our process in the house, and we want to thank Mr. Berglund for bringing up what's cooked out of the *Endless Frontiers Act* in this regard because, you know, for maybe the first time ever, the Senate's, you know, taken lead and doing the work on this, and that's, you know, nice to see. We've been at this for years, and we'll see what they kick over to us, and this hearing's going to be very, very instrumental, not only in terms of how we think through addressing and answering some of these incredible challenges that we are facing as a nation, responding to a chip shortage, turbulence coming out of the COVID–19 pandemic, and our supply chain writ large, but also how we continue to harness the capabilities of American innovation across the board. Not over-

looking any region or any population, but harnessing the talent writ large, and then also determining, from our Federal perch, making the recommendation as authorizers, what we should invest as a nation into these innovation ecosystems.

It came up certainly in Dr. Fuchs's statement about the competition that we are in with China. Mr. Berglund also touched on this. It's been a sincere privilege to have an area that is incredibly diversified, that has overcome some of the, you know, effects of deindustrialization, while also remaining committed to industrialization, with Ms. Nas being here from Flint. And then, certainly, very profound to hear from Secretary Pollard, who, from her perch in Oklahoma, is connected to Silicon Valley, and playing the game with Silicon Valley while she continues to harness the full capabilities of a State with incredible assets like Oklahoma.

And so what we're going to do is we're going to have the record remain open for 2 weeks for additional statements from Members, and I really encourage the Members to include these statements, and ask additional questions, because we're going to go back to this record. I know, as Chair, I go back to the record, particularly when we're stitching up in amendments and passage of bills through our Subcommittee into the Full Committee, and, you know, we're continuing to encourage the public engagement with what we are doing in this Committee, because certainly it feels as though we are so polarized and stuck as a Federal lawmaking body, that—all folks need to do is look at what we are accomplishing, and achieving, and deliberating on here on the Science Committee, as we have great representation throughout this country, and certainly the Great Lakes region, as we answer these questions, and make the proposals of the day about how America will continue to innovate.

Certainly that has been a part of our 21st century plight, and it has been one whopper of a start to this century, with 9/11, a Great Recession, and this pandemic. But coming out of all of these things, our plight of innovation has not only doubled down through, you know, the principles of Moore's Law, but has continued to transform the global economy. So we are dedicated and committed to continuing to ensure the success of regions across this country. We thank you all for being here. I'm going to excuse the witnesses; I'm going to gavel us out. The hearing is now adjourned. Thank you all so much.

[Whereupon, at 11:42 a.m., the Subcommittee was adjourned.]

Appendix

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Dan Berglund

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August 13, 2021

Chairwoman Haley Stevens
Subcommittee on Research and Technology
Committee on Science, Space, and Technology
2321 Rayburn House Office Building
Washington DC 20515-6301

Dear Chairwoman Stevens:

Thank you for the opportunity to testify before your subcommittee on June 9, 2021 for the hearing entitled "*Building Regional Innovation Economies.*"

I appreciate the opportunity to respond to the questions for the record which were contained in your recent letter. My answers are attached.

If I can provide any additional information, please do not hesitate to ask.

Sincerely,

Dan Berglund
President and CEO

1. Mr. Berglund, a region's K-12 education system will be a significant factor for many who might consider picking up and moving to new hubs. How have past Federal and state programs to promote regional innovation addressed local K-12 education systems? Should a region's plan for its K-12 education systems be a consideration in determining locations for new regional development programs?

I should note that there really have not been federal programs that have been designed to create regional innovation economies; this is what makes the Regional Technology Hub approach unique and exciting. Past efforts on the federal level have dealt with individual elements of a regional innovation economy (e.g., research base, workforce, financing), but there has not been anything on the federal level to try to tie all of the individual elements together. State programs, too, have been focused primarily on the individual components of an innovation economy rather than the system as a whole.

Because a region can encompass many different local K-12 educational systems that can vary even within a short distance of one another, it is difficult to generalize to the entire region. What we do know is that thriving economies rely on an educated workforce. As the economy continues its shift to a knowledge economy, there is greater demand for workers who have higher levels of skills in innovation. Although we frequently cite the need for graduates in the science, technology, engineering and math fields to fill the increasingly complex roles in the innovation economy, a healthy educational system that builds to those roles and feeds the curiosity of young minds is important. Research has shown that exposure to specific kinds of innovation in a student's early years may be important in determining how they select their eventual fields of study, and can shape their decisions to become inventors. Opening these pathways to more students can increase innovative output.

The location of new regional development programs may help spur such connections between industry and schools, but we envision that as a symbiotic relationship and not a pre-determining factor in locating new regional development programs.

2. Mr. Berglund, in your written testimony you point out that we need to learn from previous work building up regional innovation economies such as RTP. As my district of Wake County continues to attract talented students, professionals, and families to the RTP, it also faces a growing affordable housing crisis. The housing supply has been unable to keep up with demand from new workers in other metro areas of the country as well and by 2016, the housing prices in the top three cities in the U.S. were 3 times as high as other cities. This trend has pushed people further away from the cities, increased commute times, and displaced vulnerable populations. How might the federal government learn from its past investment to better strategize and plan for more equitable growth in future hubs? Would you care to comment on whether and how housing should be a consideration for EDA in awarding regional innovation grants?

I agree that the housing crises are limiting the innovation capacity of many regions across America. They are a result of several systemic market failures and myriad federal, state and local investment decisions, policies and regulations that are beyond the size and

scope of the regional innovation hub legislation under consideration presently and outside my area of expertise. That said, there should be every effort to ensure the program does not exacerbate the existing problems of affordability, accessibility and distribution of the full spectrum of housing needs across any region.

It is the nature of a market economy that the most desirable locations will attract the highest prices and that wealthier individuals and businesses will be in a position to pay those. Controlling sprawl, traffic congestion, commute times and gentrification require public policy intervention. Very often, policy has worked to add to the problems rather than address them. Transportation, housing, and economic development investments need to be integrated as much as possible with each other and with energy/utility, R&D, innovation, community development, education, environmental conservation and all other system-level public policy areas affecting a region.

Presently, federal support for state and local planning regarding these topics is more separated than integrated. With the current structure of congressional committees, the corresponding executive branch departments, and multiple layers of state and local jurisdictions and authorities makes integration toward shared regional goals challenging at best, but the regional technology hubs could play a role in helping break down walls within a region.

3. Mr. Berglund, you mention in your testimony that RTP did not show visible results until 15 years after conception. Considering that timeline, and that different regions have disparate goals and unique qualities that lend to their successes, what kind of common performance standards might you recommend for the Department of Commerce and EDA to gauge success? Can you elaborate on your testimony for how Congress or the agency implementing a regional innovation program should measure the success of an innovation economy?

As the question notes, every region has a different economic and research composition and more than likely are at different points along a development timeline. Therefore, we should also expect the set of investments and activities undertaken by each region to vary as well, and by extension, the metrics for success will vary as well. For example, a region with a research enterprise that has emerging strengths, but still lags behind leading technology hubs may begin with an initial focus on building their research capabilities; appropriate metrics in this scenario would be seeing increases in research and development spending in the region, industrial funding of research and development at institutions of higher education, and reputational excellence in targeted fields. As that region's research base improves, one would expect to see the region to do more to convert research into new products, processes and companies; appropriate metrics here would include an increase in the number of start-up companies and seed funding. Once the companies are in a position to grow, the region may introduce initiatives to encourage the companies' growth, and metrics for this stage would include the amount of follow-on investment in the companies, sales and employment and an increase in each of those measures.

Far more research and work needs to be done on what the appropriate metrics are and how they can be collected, which is why we are pleased that the committee added a section to the bill that would create the Critical Technology and Innovation Analytics Program. Most of the work that has been done over the last four decades on measuring the results of programs designed to build regional innovation economies has come from individual states and programs paying for external studies out of their own stretched budgets and individual academic researchers. We need a much more robust approach that could be led by this new program.

This program will benefit from the work that is being done by the Hollings Manufacturing Extension Partnership and was done by the Innovations Systems Research Network in Canada funded by the Social Sciences and Humanities Research Council (SSHRC), the National Research Council (NRC) and the Natural Sciences and Engineering Research Council (NSERC).

4. North Carolina has the largest manufacturing workforce in the Southeast. The majority of NC manufacturers are small businesses. As I mentioned, local business buy-in is crucial to a successful stand up of a regional innovation economy. How might the Department of Commerce further engage small businesses in the process of developing these regional innovation economies? What role can anchor universities have in facilitating that engagement and furthering equitable regional growth?

One approach that I am particularly excited about is work that Innovation Works in Pittsburgh has done in bringing the regional manufacturing community together with the technology startup ecosystem. Their Scalable Innovation program serves two primary purposes: (1.) creating local supply chains for hardware start-up companies, so that the growth of the start-ups translates to growth for local manufacturing suppliers; and (2.) helping small manufacturers become more entrepreneurial by prioritizing innovative product and process development. On the supply-chain front, Innovation Works has found that connecting entrepreneurs who are designing physical products with local manufacturers early in the product development cycle and coaching both parties on how to work together leads to a much higher likelihood that the final product will be manufactured by those local suppliers rather than overseas. This brings new high-growth customers to the manufacturers, while ensuring that the start-ups are focused on quality, speed and cost of manufacturing. As for helping manufacturers become more entrepreneurial, the Scalable Innovation program also provides Innovation Adoption Grants to small manufacturers as an incentive for those companies to prioritize innovative product or process development projects that might otherwise not happen. Small manufacturers often don't prioritize innovation because it is hard to finance through cash flow. These grants move innovative projects to the front burner, ensuring that manufacturers are focused on maintaining a competitive technology advantage in their industry. Innovation Works has engaged with a number of other organizations around the U.S. to replicate parts of this initiative in other regions.

When I worked for the Ohio Department of Development from 1985 to 1992, the state funded a series of non-profit centers, Edison Technology Centers, which brought together universities and companies to develop new technology and improve the competitiveness of companies. In general, those centers received $4 million as start-up funding (the equivalent of $10 million in 2021 dollars) and $2 million every two years. Centers were incentivized to raise private sector funding, which was one way we measured their market relevance, in the form of cash for membership or funding research projects. One of the lessons learned was that centers would naturally focus on large corporations because they could provide more financial resources and that as the centers became more established we used the state funding as leverage to ensure small companies were being serviced. The Department of Commerce should be prepared to do the same with the regional technology hubs.

Anchor universities and other organizations can also provide assistance by helping small manufacturers develop new products and services. The Maryland Industrial Partnerships (MIPS) run by the University of Maryland, for example, provides funding, matched by participating companies, for university-based research projects that help the companies develop new products. According to the program, in the 32 years since it started, 444 faculty researchers have worked with more than 600 Maryland companies to help develop new products. MIPS-supported products have enabled Maryland companies to directly create more than 7,150 new, high-paying, long-term, high-tech jobs throughout the state.

5. A strong research university is the cornerstone of any successful regional innovation economy. Silicon Valley has Stanford and the UC system. Massachusetts has MIT. North Carolina has NC State, UNC Chapel Hill, and Duke, which form the corners of the Research Triangle. How can research universities strengthen their role in helping to anchor local and regional innovation economies?

There are a variety of approaches that research universities can use to encourage regional innovation economies. Foremost, though, is a vision that is accepted at all levels of the university—from the board and funders, to the president and executive leadership, to the faculty—that it *should* play a role supporting the regional innovation economy. Having a strong research institution does not automatically translate to a strong regional innovation economy.

Much has been written about the role that universities can play (as I did in my written testimony, I'll highly recommend *Regional Advantage* by Annalee Saxenian for a brilliant recounting of the creation and evolution of Silicon Valley and Route 128), but a few examples include: generous leave and sabbatical policies to permit faculty and staff the flexibility to create and work for start-up companies and to return to their position at the university; intellectual property policies that make the process of licensing technology as simple as possible; establishing obvious "front doors" to universities, so industry knows where to go for help and can get to those resources quickly; and, programs to connect students with companies.

One final item I will suggest which is not typically discussed is that universities (and all other actors in a regional innovation economy) should approach their involvement with humility and recognize that while they might be the anchor of the regional economy that does not mean that they should be the lead on every activity. For example, while the instinct might be to have the university create training programs or provide support to entrepreneurs those functions might be better performed by other organizations in the community. The university's role, then, is as a supporter of the other organizations. While this might seem obvious on paper, it unfortunately does not occur in practice as often as it should.

Responses by Professor Erica R.H. Fuchs

U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Questions for the Record to:
Professor Erica R.H. Fuchs
Department of Engineering and Public Policy
Carnegie Mellon University
Submitted by Representative Deborah Ross

1. Dr. Fuchs, you highlight the importance of investing in transition pathways to ensure we have the human capital to match and maintain industry growth. The House recently passed multiple bills led by members of this committee in support of early career researchers, students at colleges and universities, and funding for MSIs and HBCUs, all of which is critical to our nation's research enterprise. But we have also recognized that STEM education needs to start earlier. In terms of K-12 education, what can Congress and Federal science agencies do to support and accelerate early STEM education initiatives and ensure equity is at the forefront?

In the context of my testimony, I believe there are exciting opportunities for regional innovation hubs and infrastructure investments to offer opportunities simultaneously provide opportunities for innovation (and technology commercialization) and provide real-world on-the-job training for high school students, community college students, and life-long learners. As I discussed in my testimony, nation-wide investments in the infrastructure of the future hold promise not only to improve security, productivity, and equity, but also to revitalize the U.S. worker skills and manufacturing ecosystems necessary to manufacture the products of the future. The mason, foreman, engineer, and computer science skills relevant to intelligent transportation and urban infrastructure systems have corollaries in resilient grid infrastructure, privacy-preserving health infrastructure, and intelligent manufacturing. Our investments and training should be strategic to leverage these overlaps, and career transitions between them.

I am not myself an expert in K-12 education, but it is clear that preparing communities for jobs in manufacturing and STEM starts in K-12. There is substantial expertise and empirical evidence on pre-K and K-12 education for congress to draw upon, and congress should clearly look beyond me for these insights. Research findings of which I'm aware include the importance of pre-K programs as a way to help children increase their school readiness and later success in elementary school particularly for disadvantaged children; the importance of the quality of a child's elementary school in maintaining the "pre-school boost;" that increased per-pupil spending (holding all else equal) increases high school graduation rates, educational attainment, earnings, and family incomes for children - with larger effects for low-income children; and that making high-opportunity neighborhoods affordable to low-income families can have significant positive outcomes in terms of longer-term social mobility. In addition, in the case of STEM careers, research suggests that exposure to innovation is an important predictor of subsequent innovation, particularly among women, minorities, and children from low-income families; and that lifelong education may be particularly important in retaining relevant skills in STEM careers. In our own work, we are leveraging new tools to quantify the skills required for

emerging technologies before large-scale investments are made, including the skills required of high-school educated operators and technicians, and to better understand skill crosswalks that enable firm pivots from areas like waste management and construction to manufacturing and individual skill and job transitions. I would love to see more research on how to leverage on-the-job apprenticeships in both vocational and college programs and early-life experience with building, construction, and STEM to revitalize regional capabilities in manufacturing and innovation.

2. Dr. Fuchs, your testimony touches on many different facets of manufacturing in the United States. NC State, in my district, is directly involved in 7 Manufacturing USA institutes. North Carolina also has the largest manufacturing workforce in the Southeast. Though perhaps not a direct causation, manufacturing capability is clearly a major factor in the state's capacity for and continued leadership in innovation. What do you think is the role of the Manufacturing USA program and the Manufacturing Extension Partnership in regional innovation? Are there changes you would recommend for either or both of the programs that you believe would better position them for success in coming years? What do you think are the most successful aspects of these programs and what lessons can we learn that could be applied to other regional innovation efforts?

Manufacturing USA is a national network created with the goal of securing U.S. global leadership in advanced manufacturing through large scale public-private collaboration on technology, supply chain and workforce development." The 16 manufacturing innovation institutes (sponsored by either the U.S. Department of Commerce, Defense, or Energy with equal or greater funding from local governments and private companies) each focus on a different transformational capability in advanced manufacturing relevant across a wide range of sectors. Examples include additive manufacturing, robotics, digital design, photonics, flexible electronics, high-performance textiles, biomanufacturing, among others. These institutes each bring together private manufacturers of all sizes and academia to work on major research and development projects relevant to industry and train people on advanced manufacturing skills. More recently several assessments have been completed of their progress, including by the Government Accountability Office (see GAO 19-409 and GAO 22-103979) and the National Academies of Science Engineering and Medicine, including specifically the long-term role for the Department of Defense in the eight institutes it sponsors. These reports suggest that stakeholders find high value in the institutes, at the same time there are opportunities for improved collaboration across the institutes, more effective assessments of how well individual institutes are working (including decisions to continue, expand or shut down individual institutes), and a need for greater sharing of best practices across institutes. The Manufacturing USA institutes also provided a unique role during COVID, including America Makes serving as a hub for open-sourced designs of 3D printed PPE, supporting small companies producing PPE in passing testing certification, developing ventilator parts, and supporting the COVID testing supply chain. That said, while the Manufacturing USA institutes helped reduce constraints they were alone insufficient in overcoming substantial bottlenecks early-on in respirator supply chains, and subsequently in testing supply chains, given the dilapidation of the existing manufacturing ecosystem and lack of data on nation-wide company activity. Going forward, particularly important for the Manufacturing USA institutes may be learning from the

Semiconductor Research Corporation (for academic assessment and insights see Khan, Hounshell Fuchs 2014), and identifying narrow market-focused pillars around which to coalesce specific member companies in specific consortium under each larger institute umbrella. Member companies (and government) could then buy into one or multiple of these specific institute consortia, according to their market interests and needs.

The Manufacturing Extension Program is a public-private partnership focused on supporting manufacturing capability upgrading in small and medium sized businesses. It is administered by the National Institute of Standards and Technology (NIST) and has Centers in all 50 states and Puerto Rico dedicated to serving small and medium-sized manufacturers. Federal appropriations pay for half of each Center's costs, with the balance for each Center funded by state / local governments and/or private entities, plus client fees. Academic research (see for example Shapira 2001, McEvily and Marcus 2005; Whitford 2006) as well as studies by the GAO broadly find that manufacturing extension programs are effective in supporting small and medium sized enterprises in upgrading and acquiring new competitive capabilities. In the future, there may be an opportunity to expand these MEP programs to support small and medium sized firms in enhancing their flexibility to pivot into new product spaces, particularly during crises -- whether pandemics like COVID-19, war, or natural disasters. In expanding MEP programs to support small and medium sized firms in pivoting into new product spaces and manufacturing flexibility, there are significant lessons from COVID, including the need for a single, centralized source of trusted information on suppliers, designs, and manufacturing, as well as how to enter new markets with high entry barriers, such as medical markets with required regulatory certifications and whose sales are dominated by large hospital distributors. Other markets with similar challenges may include aerospace markets (relevant for military concerns and war). MEPs may also be able to play an expanded role in building real-time situational awareness of small and medium sized firm capabilities and entrepreneurial activities during crises, by keeping a more active list of state SME manufacturing companies beyond those participating in MEP networks. This later activity might be undertaken in coordination with the Economic Census.

3. North Carolina has the largest manufacturing workforce in the Southeast. The majority of NC manufacturers are small businesses. As I mentioned, local business buy-in is crucial to a successful stand up of a regional innovation economy. **How might the Department of Commerce further engage small businesses in the process of developing these regional innovation economies? What role can anchor universities have in facilitating that engagement and furthering equitable regional growth?**

I believe there may be an important opportunity for universities to lead innovative infrastructure investments across the country. Through competitions similar to the Department of Transportation's Smart City Challenge, partnerships between universities, local governments, and private companies could be funded where universities could help envision innovative new investments in cyber-secure resilient, equitable smart cities, smart grids, and otherwise, with test implementations across different geographical areas including both urban and rural settings. Engineering and computer science researchers at universities could not only help catalyze innovative new solutions, but also social scientists enlisted to quantify the economic and social

impacts of the programs' implementation and how they differed by technical solution and local context.

In addition, my research shows that the globalization of production makes it harder for U.S. innovators to bring their ideas to market. When firms move manufacturing to developing countries, it reduces the costs of the old products, making innovative, new products have to be that much better to compete. This phenomena is particularly true for advanced material and process technologies at the technical frontier where the science behind successful production output is still being discovered. Examples of such technologies exist in high-end optoelectronic semiconductors for communications, batteries for energy storage, metal additive manufacturing for aerospace, novel pharmaceutical products, and many other contexts (Fuchs and Kirchain 2010; Fuchs, Field, Roth, Kirchain 2011; Fuchs 2014)

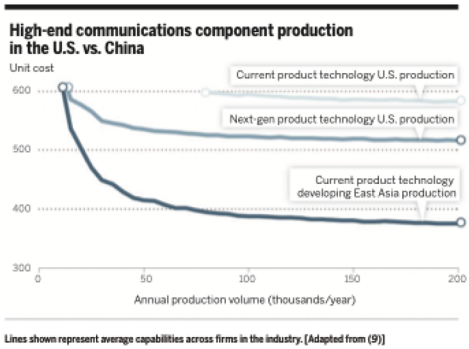

Figure 2: Globalization means that the valley of death is getting larger for certain advanced material and process technologies - when firms move manufacturing overseas to developing countries, such as China, Singapore, Malaysia, and otherwise, it can become unprofitable for firms to pursue innovative new products and technologies. Source: Fuchs 2014, adapted from Fuchs and Kirchain 2010.

We need to help U.S. innovators in these domains leap over this valley of death through mechanisms such as increased and extended *Small Business Innovative Research* (SBIR) (for the positive outcomes associated with SBIR see Lerner 1999, Fuchs 2014). Given the traditionally high capital expenditures required, long concept to development timeline, and dearth of venture capital funds in advanced manufacturing (c.f. Combemale, Glennon, Whitefoot, Fuchs 2020), *SBIR funding may also need to be more and longer specifically for advanced materials and processes*, given their unique nature.

4. A strong research university is the cornerstone of any successful regional innovation economy. Silicon Valley has Stanford and the UC system. Massachusetts has MIT. North Carolina has NC State, UNC Chapel Hill, and Duke, which form the corners of the Research Triangle. How can research universities strengthen their role in helping to anchor local and regional innovation economies?

As noted by Maryanne Feldman, universities can be important, but are by themselves not sufficient for technology-based economic development. There are many places with strong research universities that have not been able to create new firms and new jobs in their locations. In addition, as noted in my testimony, science funding is a long-term investment, and even when that investment comes to fruition jobs will not necessarily follow unless investments are made to also build locally the ecosystem -- including the surrounding firms, access to capital and operator, technician, engineering, and management skills -- necessary to also commercialize that invention locally. Here, investment in innovative local infrastructure of the future may be particularly important in building the skills and firms needed to subsequently build out later in building locally the manufacturing of the future.

Responses by Ms. Paula Nas

Building Regional Innovation Economies

United States House of Representatives Committee on Science, Space, and Technology

Subcommittee on Research and Technology

Responses to Questions for the Record by Paula Nas

Director of the Office of Economic Development at the University of Michigan-Flint

1. *North Carolina has the largest manufacturing workforce in the Southeast. The majority of NC manufacturers are small businesses. As I mentioned, local business buy-in is crucial to a successful stand up of a regional innovation economy. How might the Department of Commerce further engage small businesses in the process of developing these regional innovation economies? What role can anchor universities have in facilitating that engagement and furthering equitable regional growth?*

   As the fundamental component in a regional innovation economy, small business owners must be central to all planning within the innovation ecosystem. To best engage local small businesses in the planning process, they will need to be incentivized to participate in planning sessions and roundtable discussions that bring industry, higher education, government, K-12, and community partners together. If there is an existing comprehensive economic development strategy (CEDS) plan, it is important to demonstrate to small businesses how they benefit from proposed programs and initiatives outlined in the planning document. In the absence of a CEDS plan, the region may consider developing one, which will encourage collaboration among small businesses and other key stakeholders in the region.

   As neutral conveners in the innovation ecosystem, universities play a key role in facilitating engagement among partners. University faculty and staff have the breadth and depth of knowledge in multiple disciplines to engage in meaningful discussions while at the same time deferring to the expertise of those who are working on the ground. Universities often house programs that work directly with small businesses to provide technical support and to help new businesses launch and grow. For example, if there is an Economic Development Administration (EDA) University Center in the area, their staff can serve as a point of contact, source of data, and connector to other regional stakeholders. Likewise, regional public universities traditionally have an economic and community development mission grounded in serving the needs of the local and regional community. As such, these institutions will be a critical component in efforts to further equitable growth by providing an entry point for innovators and entrepreneurs who may not otherwise find their way into the innovation ecosystem.

2. *A strong research university is the cornerstone of any successful regional innovation economy. Silicon Valley has Stanford and the UC system. Massachusetts has MIT. North Carolina has NC State, UNC Chapel Hill, and Duke, which form the corners of the Research Triangle. How can research universities strengthen their role in helping to anchor local and regional innovation economies?*

   Research universities play a key role in anchoring local and regional innovation economies through acting as a driver for innovation, entrepreneurship, and economic development. This takes many forms, ranging from academic technology transfer, patents, and licensing, to housing an increasing number of programs focused on fostering the entrepreneurial mindset both on campus, and with community and industry partners. Historically, research universities have been a valuable source of scientific discovery and have led to the development of new technologies. There is a growing trend toward encouraging faculty and students to commercialize their research, which has great potential for strengthening the role of universities in regional innovation.

   All universities, regardless of size, play a key role in educating and training the workforce and innovators of the future. This is not limited to traditional college students. Rather, universities also have the capacity to upskill and reskill workers to meet the demands of employers who are faced with growing talent shortages. This could be achieved through granting college degrees, industry-recognized certificates and credentials, or a combination of both. By providing multiple points of access to students, universities are in a position to foster a more inclusive talent pipeline, thus strengthening regional innovation and enabling more equitable economic growth.

   Recognizing the need to be part of the development of regional innovation ecosystems, universities are increasing partnerships and collaboration with the private sector. Traditionally, this has taken the form of industry-driven research, advisory boards, and internship programs. Many forward-thinking programs are making concerted efforts to work directly with industry partners to develop curriculum that meets the needs of employers. Likewise, the expansion of internship and learn-to-work programs is leading to greater collaboration between the private sector and universities. These programs require time and resources to develop, so universities will need to reallocate scarce internal funding or take advantage of external funding opportunities to fully develop these innovative solutions.

Responses by Hon. Elizabeth Hutt Pollard

1. **How can states help strengthen their research universities' capacity to support increased regional innovation?**

The first step any state can take is the creation of a strategic plan that evaluates their own unique strengths, built resources and opportunities to attack long-standing barriers that may have prevented previous attempts to expand support. This ensures alignment within all state agencies who often converge to work on innovation expansion projects within their own focused scope but lacking a more big-picture alignment, while also maximizing the allotment of resources granted to the state for increased regional innovation and reducing redundancy of effort among all state public/private sector partners.

One such example is the 2021-2026 Strategic Plan for Science and Innovation, introduced last year in Oklahoma, a copy of which is included in this response. This plan evaluates Oklahoma's unique resources and built strengths within the changing regional and global landscape to produce three key areas of strategic investment with which to focus the states' efforts. It also includes several key recommendations which are supported by a case study analysis of similar work in other states, which if implemented will rapidly enhance the innovation ecosystem in Oklahoma.

By identifying a singular strategic plan, states can then begin to align all willing partners toward the goals outlined and focus their resources in a way that maximizes their capabilities to support a regional innovation ecosystem. More specifically, defining success in how a state will know it has enhanced innovation through metrics (such as increased support of regional initiatives in key strategic investment areas), ensures everyone is on the same page throughout the duration of the strategic plan's lifecycle.

2. **How might the Department of Commerce further engage small businesses in the process of developing these regional innovation economies?**

As outspoken advocates for small business, the Dept. of Commerce traditionally serves as the link between said business and state resources in a multitude of areas. In order to enhance these engagements, I believe a department of commerce must diversify its general approach to supporting small business and create expertise in specialized areas. By collaborating within the business community and training their staff to understand the unique and varied needs of the largest industries within the regions it focuses its efforts on, the Dept. of Commerce can expand beyond its general willingness to support all business and offer specialized support (when needed) to ensure longer term viability to burgeoning industries that have the capability to rapidly expand in todays' dynamic business environment. Specifically, an area of need identified in Oklahoma was inadequate ability by the state to invest in early stage product development and commercialization to support the entrepreneurial ecosystem and develop regional innovation economies. This was remedied by the creation of the Oklahoma Center for the Advancement of Science and Technology (OCAST) in 1987. OCAST is a state agency who, by statute, has the unique ability to use appropriated funds to make equity investments in private sector companies. More information about OCAST can be found here: https://oklahoma.gov/ocast.html.

In addition, funding is a necessary component of nurturing any small business to a place where it can create sustainability. Leveraging the previous approaches outlined above, I believe creating adequate strategic program funding opportunities that require strategic planning efforts for the state in which the recipient resides to ensure resource alignment creates a force momentum that can expand small business opportunities and further develop regional innovation economies.

3. **What role can anchor universities have in facilitating that engagement and furthering equitable regional growth?**

Commonly referenced as the incubators from which some of the best ideas spring, anchor universities play a fundamental role in the innovation ecosystem. Too often, Universities lag in their ability to offer programs that match the ever-changing needs of the business environment outside their doors. As we are all aware, for any business to survive and thrive, it needs a well-trained and sustainable workforce supported by a focus from anchor universities on easing the path from idea to commercialization. This can be accomplished by a concerted effort of anchor universities to streamline their Intellectual Property (IP) and Technology transfer policies, and collaborating with other universities within their geographical areas of influence to ensure alignment and diversify the resources available to the entrepreneur.

As is evidenced in the case study analysis conduced in the 2021-2026 Oklahoma Strategic Plan discussed above, states with anchor universities containing strong academic training programs aligned with the business industries achieving the most success within their borders (e.g. The University of Texas' engineering program) are more successful in creating incubation opportunities for small businesses. But the workforce opportunities should not begin and end within the confines of a 4 year academic institution. In order to achieve maximum equity, anchor universities must be willing to explore options outside the traditional learning environment (such as career tech/vocational tech) to ensure it meets the work-ready population it serves where they are. By tailoring the training/education to match the needs of the businesses within the state, anchor universities can become another resource to ensure a sustainable human capital. As part of the aforementioned strategic plan, flagship universities within Oklahoma have begun the process of simplifying their IP/T transfer policies while also increasing collaboration within their respective academic research offices to further support the goal of creating a robust regional innovation economy.

In addition, anchor universities can play a fundamental role in facilitating state/federal funded programming designed to enhance business opportunities in an equitable fashion through utilization of its existing networks, campus locations, alumni partners and the multitude of other resources it deploys to ensure its status within communities all over their respective state.

4. **How can research universities strengthen their role in helping to anchor local and regional innovation economies?**

By evaluating their definition of research and (if warranted), expanding it to include the ability to commercialize a product, service or innovation being created by the researcher. Too often, academic research and the funding that supports does not contemplate any return on investment for the state/federal entity financing the project. While certainly not all research is designed to create a commodity, there is often more weight granted social service research than that which may produce a business value to the state.

As we see the academic landscape change, research universities can take a more intentional approach by:

- evaluating the workforce needs of the surrounding businesses and tailoring educational programming to meet these needs.
- engaging and support strategic planning efforts conducted by the state (as both the University of Oklahoma and Oklahoma State University have done), and
- Strengthening financial support to business incubators such as OK Catalyst (https://www.okcatalyst.com) at the University of Oklahoma to ensure a firm connection from the research to commercialization pipeline.



2021-2026 Science & Innovation Strategic Plan

Developing an Innovation Economy in Oklahoma

OKLAHOMA Science and Innovation

ELIZABETH HUTT POLLARD
Oklahoma Secretary of Science and Innovation

MAY 2021

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EXECUTIVE SUMMARY

The Oklahoma economy is at an inflection point. Disruptive technology is changing the face of every industry and forcing all states to reassess how best to compete and remain relevant in a knowledge-based innovation economy. In this strategic plan, we examined three states that have been successful at developing an innovation economy: Texas, Ohio, and Massachusetts. These three states invested early and aggressively in creating an innovation ecosystem to compete with Silicon Valley, the birthplace of innovative startups. Ohio invested $2.3 billion, Massachusetts invested $1.6 billion, and Texas invested over $1 billion. These three states have been able to transform and modernize their economy by embracing a host of common principles including:

- Long-term state investments in research, education, and innovation infrastructure;
- Visionary leadership of regional leaders who aggressively pursued state and federal investments in strategic research, including federal research centers;
- Presence of top research universities that produce world- class research outputs, as well as a highly skilled workforce;
- Industry investments in research;
- Concentration of pioneering, research-intensive companies;
- Strong collaboration among state, philanthropy, industry, and academia; and
- Established infrastructure for high tech entrepreneurship including early- stage and late stage capital, incubators and accelerators for startup companies, and programs to support technology transfer and commercialization of research.

Oklahoma should leverage on the experiences of Texas, Ohio, and Massachusetts to create a roadmap to develop an innovation economy in Oklahoma. At present, Oklahoma ranks in the bottom 10th percentile with respect to innovation. The Milken Institute's 2020 State Technology and Science Index ranks Oklahoma #45 with respect to innovation, placing us in in the bottom 10th percentile. This strategic plan puts forth a number of recommendations to alter Oklahoma's innovation trajectory and catapult us to the forefront of the innovation revolution. It outlines the necessary steps that Oklahoma should take to create an economy that is ready and able to compete with other states for capital, businesses, and jobs. While Oklahoma has a multitude of industry sectors in need of investments, leadership must prioritize our limited resources and allocate them to three targeted strategic areas where we will have the greatest probability of generating maximum return while leveraging on our existing strengths. These three areas are biotech/life sciences, aerospace and autonomous systems, and energy diversification. Oklahoma should coalesce its resources to bolster and grow these three strategic industry areas.

The time is now to invest heavily in and plan long-term for Oklahoma's future. The Texas, Ohio and Massachusetts models show that it can take anywhere from 20 to 30 years for innovation to generate a return on investment, but the upside is undeniably substantial. The executive and legislative leadership in Oklahoma must have the political will to invest big and bold in innovation and to make this multigenerational commitment. They must also have the discipline to stay the course for the long haul. With vision, discipline, focus and determination, Oklahoma can transform our state economy to an innovation economy that reflects the pioneering, entrepreneurial and resilient spirit of our state.

WHY INNOVATION MATTERS

Innovation is the key driver of economic growth and prosperity. Innovation matters to Oklahoma's future. Our state must invest in innovation for four principal reasons: to grow our state economy, accelerate our state's competitiveness, diversify our state economy, and create large scale, high paying jobs for Oklahomans.

1. Economic Growth. Oklahoma lags other states in growing our economy. From 2015 - 2019, Oklahoma's GDP grew by 1.8%, for an annualized rate of .4%. In contrast, the U.S. economy expanded by 9.8% for an annualized rate of 1.9%, growing 375% faster than Oklahoma's economy. Neighboring states also outpaced Oklahoma in GDP growth for that same period: Colorado's annualized rate of growth was 3.48%, Kansas' was 1.81%, Texas' was 1.65%, Missouri's was 1.3%, New Mexico's was .95%, and Arkansas' was .80%. As innovation's role in driving economic growth continues to amplify, Oklahoma risks falling further behind unless we take decision actions to change the trajectory of our state economy and modernize it to reflect the changing economic and technological trends.

2. Competition. Competition is the basis of a capitalist market economy. States compete with each other to attract investments by creating a favorable environment for business investments. Oklahoma must compete to retain existing companies and to attract new companies and private capital to Oklahoma. States compete for businesses by offering economic incentives, creating business-friendly policies, and leveraging on their resources such as natural resources, human capital, and research assets. As demonstrated recently by Oklahoma's efforts to recruit Tesla and Saab to Oklahoma, Oklahoma must outcompete other states to attract high tech and advanced manufacturing businesses to Oklahoma. Oklahoma is an excellent state to do business. Our state ranks 1st among other states in terms of cost of living. We also rank 2nd best in terms of cost of doing business. We also have low-income tax rates ranking 6th in the nation for tax burden per capita. However, where we are less competitive is in education and research. The Milken Institute's 2020 State Technology and Science Index ranked Oklahoma dead last in education at #50. In terms of research, Oklahoma ranks #36 based on data collected by the National Science Foundation for total research and development expenditures in 2017.

3. Diversification. The collapse in oil prices that took place in 2014 and that occurred again in 2020 has underscored Oklahoma's over dependence on oil and gas as the crux of our state economy. Oklahoma's GDP hit an all-time high of $209 billion in 2014 and tumbled to $188 billion by 2016 due to the downturn in the oil and gas industry, a decline of 10%. The mining industry's share of Oklahoma's gross domestic product (GDP) increased to 14% in 2018, compared to just 4.6% in 1997, a rate that is now one of the highest in the nation, surpassing those of Texas (9%) and New Mexico (12%). Furthermore, as the global auto industry moves away from fossil fuels, Oklahoma state leaders need to be mindful that petroleum-powered vehicles will decline over time, reducing the demand for oil and gas. While oil and gas has been and will continue to be a pillar of Oklahoma's economy for some time, Oklahoma needs to plan long-term and diversify our state economy to be less dependent on the oil and gas industry.

4. Higher Paying Jobs. The innovation economy currently drives high paying job creation and depends on a consistent and steady flow of STEM workers. According to the U.S. Department of Commerce STEM Jobs 2017 Update, employment in STEM occupations grew much faster than employment in non-STEM occupations over the 2000 – 2010 period (24.4% versus 4%, respectively), and STEM occupations are projected to grow by 8.9% from 2014 to 2024, compared to 6.4% growth for non-STEM occupations. STEM jobs also command higher wages, earning 29% more than their non-STEM counterparts in 2015. With a median household income of $54,449 based on 2019 Census data, Oklahoma has one of the lowest median household incomes in the nation ranking at #44, putting us in the bottom 15th percentile. Median household income is a strong indicator of a state's populace's spending power and economic status. By investing in an innovation economy, Oklahoma can help raise the state's median household income and average annual wages through the creation of higher paying STEM jobs.

OKLAHOMA'S CURRENT CHALLENGES IMPEDING INNOVATION

To develop a roadmap to create an innovation economy, it is important to understand current challenges impeding Oklahoma's ability to create an innovation economy. To assess what measures need to be put into place to create an innovation economy, it is important to evaluate Oklahoma's current standing in the following four key areas that are critical to the creation of an innovation economy:

- Education and human capital;
- Research;
- Integrated support systems; and
- Startup capital and financing.

1. Education and Human Capital**.** Talent is one of the key assets of an innovation economy. A state's innovation economy is tied to the quality of its educational systems from primary and secondary schools to colleges and universities. High tech companies require access to a skilled labor force. One of the reasons why Austin and Boston have become epicenters for innovation is due to their abundance of readily available talent from high-quality public-school systems to excellent private and public colleges and universities. Companies often cite the strengths of a state's well-educated workforce as one of the qualifying reasons for their site selection. Unfortunately, Oklahoma's standing in education is poor. The Milken Institute's 2020 State Technology and Science Index ranked Oklahoma dead last in human capital investment at #50. There have been several instances where corporations have passed Oklahoma over as a place to invest due to concerns about the local workforce. In 2021, startup Firehawk Aerospace chose north Texas over Oklahoma to establish R&D facilities, citing access to aerospace engineers as the driving reason. In 2020, Tesla chose Austin over Tulsa, a city where 46% of the adult population have at least a bachelor's degree compared. In 2019, the Saab Group chose Indiana over Oklahoma City due to concerns over its ability to access a highly skilled workforce to staff its plant in Oklahoma City. Companies have repeatedly expressed serious concerns about workforce challenges in Oklahoma.

2. Research**.** Scientific research conducted at our universities is vital for developing new discovery that leads to groundbreaking innovations. These innovations drive our state's economy, creating new products, processes, and services to enhance the quality of life of Oklahomans. Strong research programs also provide educational opportunities for students and attract high caliber faculty. The amount of research and development (R&D) taking place is an indicator of a state's ability to generate new knowledge and to attract research funding to develop innovative products and services. In 2017, Oklahoma ranked #36 in the nation in total R&D expenditures according to data collected by the National Science Foundation. With the exception of Arkansas, neighboring states outcompeted Oklahoma in R&D expenditures with Texas at #3, Missouri at #21, Colorado at #22, New Mexico at #24, and Kansas at #29. State, federal, university and industry make up the main sources of R&D funding with the bulk of R&D activities conducted by industry and universities.

3. Integrated Support System**.** Oklahoma currently lacks an integrated system to support innovation activities and an overarching organizing structure to develop, coordinate and oversee startup and track research activities. At present, pockets of innovation and entrepreneurship activities exist throughout the state, operating in silos and not cross pollinating or creating

synergy which is critical to fostering innovation. Small scale incubators are scattered throughout the state with few making any significant traction. Accelerators are practically non-existent and business plan competitions are confined largely to the university setting targeting primarily student entrepreneurs. The state's top research universities also lack an efficient and functioning framework to partner with industry to conduct research, transfer technology and commercialize research. As a result, efforts at developing an innovation economy in Oklahoma are uncoordinated, fragmented, and ineffective. To successfully build an innovation economy, stakeholders in government, academia, industry, and philanthropy need to work together to build a cohesive and comprehensive innovation ecosystem to nurture high tech startups and innovative enterprises.

4. Startup Capital and Financing**.** To transform innovative ideas and technology into market opportunities, innovative businesses need access to capital in the form of grants, loans, angel investment, venture capital and private equity. Currently, Oklahoma is not competitive in seeking early-stage funding. The number and value of Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards that go to Oklahoma's businesses are good indicators of the ability of the R&D in Oklahoma to attract proof-of-concept capital. SBIR/STTR programs are federal grant programs that offer small technology companies some of the broadest forms of early-stage capital. Participants in the SBIR/STTR programs can use the credibility and experimental data developed through research to design commercial products and to attract strategic partners and investment capital. From the 2013 – 2017 period, Oklahoma ranked #35 in the number of SBIR/STTR grants awarded, averaging 17.8 awards each year.

   Start-ups in Oklahoma experience difficulty in accessing venture capital in Oklahoma. The National Science Foundation maintains a database of venture capital disbursed by state and compares across states by measuring the amount disbursed per $1 million of state GDP. In 2018, Oklahoma ranked #36 in disbursing venture capital. Over the 2010 – 2018 period, Oklahoma ranked last among surrounding states for venture capital disbursement.

Table 1: Average Venture Capital Disbursed per $1 million of State GDP[3]

	1995-1999	2000-2009	2010-2018
Oklahoma	$11	$174	$228
Arkansas	$38	$64	$343
Kansas	$26	$230	$526
Louisiana	$99	$69	$395
Missouri	$725	$472	$931
New Mexico	$237	$909	$700
Texas	$581	$1,819	$1,445
Oklahoma Rank	**7 of 7**	**5 of 7**	**7 of 7**
US Average	**$399**	**$1,214**	**$1,712**

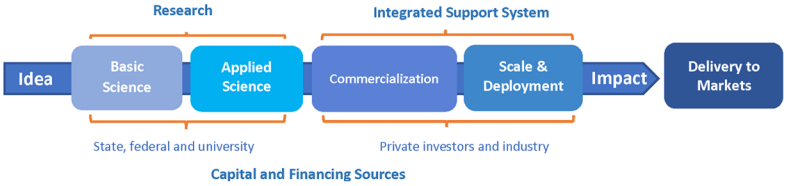
Source: National Science Foundation

   Oklahoma has made efforts to grow its venture capital base through the creation of the Oklahoma Capital Investment Board and i2e. The Oklahoma Capital Formation Act was passed in 1991 and created the Oklahoma Capital Investment Board (OCIB). The mission of OCIB is to mobilize equity and near-equity capital for investment to create jobs and diversify and stabilize the economy of the State of Oklahoma. OCIB does not directly fund any company or business but invested in other venture capital funds that demonstrated a commitment to serving

entrepreneurs within Oklahoma. OCIB has the authority to raise capital and sold $100 million in transferrable tax credit to raise funds. Unfortunately, due to poor returns and lack of strategic direction, tax credits authorized for use by OCIB expired on July 1, 2020, and no action was taken to continue to fund OCIB, allowing it to be gradually phased out.

The State of Oklahoma funds i2e through appropriations via OCAST. i2e is a private not-for-profit corporation that invests in entrepreneurs who are building high growth companies in Oklahoma. i2e works with entrepreneurs, researchers, and companies to help them commercialize their technologies, launch, and grow new businesses, and access capital. It is difficult to measure the impact of i2e in helping to grow the state's startup capital base due to lack of data and tracking of its investments. Oklahoma also has several emerging boutique venture capital firms. However, our state lacks the critical mass of capital needed to launch and grow capital-intensive startups from idea to impact.

Innovation Pipeline: from Idea to Impact



5. OCAST. The Oklahoma Center for Advancement of Science & Technology (OCAST) was established in 1987 as a technology-based economic development agency and is the only agency focused on the development, transfer, and commercialization of technology. OCAST is tasked with creating an innovation pipeline for Oklahoma. Saddled with the statutory requirement to fund eight programs on a modest annual budget of $14 million, OCAST has struggled to make a meaningful impact on the state economy since its inception. While there are anecdotal success stories over the past three decades, OCAST has been unable to lead the charge in creating large-scale high paying, high tech jobs for Oklahomans and in developing and commercializing research on a consistent and scalable basis. For OCAST to be successful and to fulfill its intended goal, its mandated scope will need to be restructured to allow for nimbleness and agility and its investment in research need to be more strategic, focused, disciplined, and meaningful.

PATHWAY TO INNOVATION: RECOMMENDATIONS

To create a strategic plan for building an innovation economy in Oklahoma, we examined the successes of Texas, Ohio and Massachusetts and compiled the following recommendations.

Recommendation #1 – Establish the Office of Science and Innovation

Given the critical role that innovation plays in the future of Oklahoma's economy, the Governor and the Oklahoma Legislature should establish the Office of Science and Innovation (S&I Office) and fund it appropriately with an annual budget of $800K to allow for staffing, programming, and marketing. The Governor should designate the Secretary of Science and Innovation to lead the development of innovation-friendly policies and statewide strategies to drive innovation and economic growth. The S&I Office would facilitate the development of meaningful collaborations across industry, academia, government, and nonprofits to create an integrated support system to stand up incubators and accelerators, hosting business plan competitions, and partnering on research endeavors. This Office would also be responsible for creating a system to collect innovation-pertinent data which is currently non-existent). Data that should be tracked include:

- Number of new high-tech companies founded in Oklahoma
- Number of new high-tech companies coming out of public universities in Oklahoma
- Number of new high-tech companies founded on university-originated patents and licenses
- Number of faculty and graduates from Oklahoma universities who have founded high tech companies. Number revenue generated, jobs created, and amount of venture capital investment received by start-ups in Oklahoma.
- Amount of venture capital received by industry sectors, by stages (seed, early, expansion and late) and by exits (IPO or M&A)
- Return on investment for any state investments in start-ups via i2e, OCAST or any other state-supported agency

Additionally, a data analytics team would need to be established to collect, analyze, provide data-driven updates, and make data-driven recommendations to the Governor and Oklahoma Legislature. An annual operating budget of $800K would allow for $475K in staffing (an executive director and five support staff members – one administrative assistant and four program managers (to carry out each of the four recommendations listed below), $125K in programming, and $200K in marketing.

Recommendation #2 – Identify Strategic Industries for Large Scale, Focused Investments and Partnerships

As we look to position Oklahoma to advance to a top 10 state in innovation and economic growth, science and technology investment in the state's higher education, technology transfer of university R&D, public/private partnerships for workforce and technology development, venture capital ecosystem for emerging technologies, and infrastructure to accelerate early-stage companies, is critical. While we have a multitude of industry sectors worthy of investments, we must prioritize our limited resources and support industry sectors with the greatest probability for large scale job creation and maximum return on investment. Oklahoma can leverage on three key technology areas where our state already has established significant infrastructure and know-how and where a top 10 ranking can be achieved. These three areas are aerospace and autonomous systems, biotechnology/life sciences, and energy diversification.

Aerospace, Autonomous Systems, and Defense. Research and development activity related to aerospace has been underway for decades in the state, and in the most recent decade for unmanned systems. Oklahoma's legacy of aviation leadership includes aviation pioneers like Clyde Cessna and

Wiley Post, and it was leadership from Oklahoma U.S. Senator Mike Monroney that led to the creation of the Federal Aviation Administration (FAA) in the 1950s. Today, Oklahoma is home to the FAA's Mike Monroney Aeronautical Center, one of the largest FAA organizations and sites outside of Washington D.C. The state is also home to Tinker Air Force Base and the Sustainment Headquarters of the United States Air Force and to many large and small aviation, aerospace, and cyber-related companies. Oklahoma prides itself in having one of the nation's eight spaceports -- the Oklahoma Air & Space Port with a corridor that stretches 152 mile-long and 50-mile wide. Aviation is now – and has always been – an important part of the Oklahoma economy. Leveraging this, with Oklahoma's leadership in weather and atmospheric research at the National Weather Center in Norman, OK, provides much-needed weather information and data to enable research and public safety to support this technology/industry area. The State of Oklahoma has research and development strengths, and most importantly – the vision and leadership to emerge as a leading region for growth of the autonomous systems and aerospace industry.

Biotechnology/Life Sciences. As in aerospace, Oklahoma has had significant biotechnology research and development activity underway for decades. Home to the University of Oklahoma with a comprehensive health system and NCI Cancer Center, Oklahoma State University with human and animal schools of medicine and a focus on a One Health approach (human, animal, agriculture), numerous other Universities/Colleges with life science curriculum, the Oklahoma Medical Research Foundation (OMRF), the Oklahoma Blood Institute (OBI), The Noble Research Institute, and many biotech and life science related companies, provide Oklahoma with a firm foundation for growth in this sector. Additionally, like the establishment of the National Weather Center, Oklahoma has recently announced the opening of the Oklahoma Pandemic Center for Innovation and Excellence (OPCIE). This center is the first of its kind in the US for public health response and education for human, animal and environmental pathogens and looks to establish public and private partnerships across all areas of biotechnology to address its mission. Oklahoma is poised to emerge as a leading state for the biotechnology industry.

Energy Diversification. Oklahoma has a long and rich history as a leader in oil and gas research and exploration. The state continues to lead the way in these areas. As the need for energy consumption and the environmental concerns around it continue to grow globally, the State has increased its focus on efficient and environmentally friendly methods and alternative energy solutions to support the changing needs of the globe. These efforts span the state's higher education institutions and the many energy companies that already exist within the state ecosystem. The OSU Discovery Center (previously the Baker Hughes Energy Innovation Center) will allow researchers and students to collaborate with industry experts to innovate and advance key technologies in engineering for the field. Oklahoma's energy expertise extends well beyond traditional energy to geothermal, solar and wind and is leading the way with a diverse energy plan. Currently, the state ranks #3 in installed wind capacity and has >40% of Oklahoma's electricity generated from renewable resources. Along with having one of the lowest electricity rates in the country, in 2019, the state became #1 in the nation for electric vehicle charging. Focusing more resources on these and other energy diversification areas will help the State develop and maintain leadership across all areas of energy.

Recommendation #3 – Establish Centers of Excellence in Research

Research universities play a central role in the innovation process. The Governor and the State Legislature should invest in Oklahoma's research universities. State investment in research is essential to Oklahoma's economic competitiveness and leadership. Investments should be made to the three strategic areas (aerospace and autonomous systems, biotechnology/life sciences, and energy diversification) and sustained in a consistent manner to achieve effectively long-term goals.

Oklahoma needs to rethink its approach to funding scientific research. Funding sources for research originate from five principal sources: federal, state, university, industry, and nonprofits. To encourage increased investments in research, Oklahoma should replicate Texas' funding research model. In 2018, total R&D expenditures in Texas equaled $5.6 billion compared to Oklahoma's $517 million. The State of Texas alone appropriated $847 million to fund research in 2018. Texas has established a number of university-earmarked research funds that receive annual appropriations from the Texas Legislature. Oklahoma should consider replicating three Texas funds which are structured to offer incentives for universities to secure research dollars – The Texas Research Incentive Program (TRIP), the Governor's University Research Initiative (GURI), and Performance-Based Research Operation. TRIP provides state matching funds to encourage universities to secure private gifts and endowments to enhance research activities. GURI awards matching grants to assist in recruiting distinguished researchers such as Nobel Laureates from institutions outside of Texas with the goal of enhancing Texas' national and global economic competitiveness. The Performance-Based Research Operation offers a base match according to the average annual research expenditures and a tiered performance incentive match over the increased expenditures over the previous biennium. The State of Oklahoma needs think creatively on how best to offer incentives for Oklahoma universities to be more competitive in seeking federal and private research dollars by leveraging state investment. In addition to increasing funding for research, Oklahoma also needs to offer incentives for universities to partner with industry and establish a legal framework to commercialize research seamlessly. Both OU and OSU should operate on a standard set of rules with respect to IP ownership, technology transfer, and revenue-sharing agreements that is conducive for growing public-private research partnerships.

Key performance indicators for this recommendation include:

1. Increase in state R&D expenditures
2. Growth in university research faculty numbers in key strategic investment areas
3. Growth in number of university faculty members invited to join nationally touted academies such as the National Academy of Medicine, National Academy of Sciences, and the National Academy of Engineering
4. Growth in university investments in high-tech infrastructure
5. Percentage in state GDP growth coming from the high tech industry
6. Growth in the number of venture-backed deals
7. Growth in the total amount of federal research dollars in key strategic investment areas

Recommendation #4 – Create Superclusters of Innovation and Support Systems

Superclusters of innovation are economic hot spots with high concentrations of new technologies in particular fields germinating at a rapid rate and where pools of capital, expertise, and talent foster the development of new industries and new ways of doing business. Silicon Valley, Austin and Boston are examples of super clusters of innovation. Superclusters tend to share the following ingredients: excellent universities, successful entrepreneurs, a pool of talent, access to financing and shared resources like incubators and accelerators. Once super clusters are formed, entrepreneurs, companies' capital and talent will gravitate to these clusters to gain better access to specialized knowledge high paying jobs, supply chains, and new products and ideas. Oklahoma needs to develop a comprehensive strategy to create an innovation ecosystem to nurture new concentrations of growth industries centered on the three strategic areas of investment: aerospace and autonomous systems, biotechnology/life sciences, and energy diversification. We recommend the following investments to create vibrant innovation clusters:

- As the highest priority, innovation clusters that span all three strategic areas should be developed in the most densely populated centers: Oklahoma City and Tulsa. Oklahoma City's cluster should leverage the OKC Innovation District and the nearby OSU Discovery and OU Research Park infrastructure. Tulsa's cluster should leverage the Tulsa Innovation Labs, the burgeoning medical corridor, and Tulsa operations of both OU and OSU (Schusterman Center, OSU Medicine, Helmerich Research Center, etc.).
- As the next priority, several single-sector clusters should be developed in conjunction with key state assets/investments, such as FISTA/Fort Sill in Lawton (defense technologies), the OPCIE in Stillwater (One Health), and the Oklahoma Space Port in Burns Flat (commercial space flight).
- In addition to resources deployed directly at the cluster sites, the economic development and commercialization infrastructures at both OU and OSU should be resourced to collaborate on additional services to the clusters. Likewise, the respective research parks at OU Norman and OSU Stillwater can serve as both supports to, and overflow from, all the clusters.

Once a strategy is developed, state agencies, corporate leaders, higher education, charitable foundations, and nonprofits should coordinate and pool their resources and organize their programs within the framework of the overarching strategy to build shared facilities for manufacturing prototyping, wet labs for experiments and testing, incubators, and accelerators. In addition to shared facilities, Oklahoma must also nurture a risk capital community that is supportive of early-stage as well as later-stage financing for start-ups to ensure that emerging firms can grow and scale in Oklahoma. Lastly, state leaders should liaise with our congressional delegation to determine if funding is available from the U.S. Departments of Energy, Commerce, Defense, Agriculture, Labor, and Education to support regional innovation clusters.

Key performance indicators for this recommendation include:

1. Total amount of federal funds (e.g., SBIR, STTR, etc.) secured by Oklahoma companies supported by the clusters
2. Total number of R&D contracts between companies supported by the clusters and Oklahoma research institutions
3. Total number of jobs created by companies supported by the clusters
4. Total amount of capital from private partnerships

Recommendation #5 – Establish a Federally Funded Research Lab

Innovation regions are often anchored by federally supported research lab such as a Federally Funded Research and Development Center (FFRDC) or a University Affiliated Research Center (URAC). Silicon Valley has the Lawrence Berkeley National Laboratory and the SLAC National Accelerator Laboratory. Boston has the Lincoln Laboratory. Texas has NASA which receives close to $2 billion in federal dollars annually to fund operations, programs, and research in Houston. Texas also has U.S. Department of Defense and Human and Health Services district labs and research units, which combined bring in another $2 billion in federal dollars to Texas. Oklahoma should work with our federal delegation to develop proposals to develop a federally funded research lab based on the three strategic investment areas -- aerospace and autonomous systems, biotechnology/life sciences, and energy diversification. Possible federal partnerships could be formed with the U.S. Department of Defense for unmanned aerial systems and aerospace, the Defense Advanced Research Projects Agency, the U.S. Department of Energy for energy diversification, the U.S. Department of Health and Human Services for opioid research and the National Institutes of Health. Oklahoma should also leverage on our military installations (Tinker

Air Force Base, Fort Sill Army Base, Altus Air Force Base, and Vance Air Force Base) to forge research and innovation partnerships with federal agencies.

To achieve the goal of establishing one or more federally supported research labs in Oklahoma, Governor Stitt should create an Energy Diversification Council and a Life Sciences/Biotech Council similarly to the already established Aerospace and Autonomous Systems Council. The Energy Diversification Council should be charged with the goal of landing a U.S. Department of Energy-funded research center focused on clean energy. The Life Sciences/Biotech Council should be charged with the goal of landing a U.S. Department of Health and Human Services or National Institutes of Health funded research center. All three of the envisioned Councils (Energy Diversification Council, Life Sciences/Biotech Council, and Aerospace and Autonomous Systems Council) will be responsible for securing federal grants in their respective area.

Key performance indicators for this recommendation include:

1. Amount of federal and non-federal funding
2. Number of patents, publications
3. Creation of Student/workforce training opportunities
4. Amount of entrepreneurial investment and commercialization of products
5. Usage of traditional energy vs. clean energy
6. Number of jobs created, average salary compensation, and percentage in population growth
7. Number of companies recruited to Oklahoma

Recommendation #6 – Invest in Education, Workforce Development, and Internship Programs

One area that our state will need to shore up to develop an innovation economy is to increase investments in education in every segment of the from K-12 to post-secondary education (vocational, undergraduate, and graduate education). Access to an educated workforce is a critical component of an innovation economy. Being ranked #50 in the nation for education by the Milken Institute's 2020 State Technology and Science Index serves as a deterrence for innovative companies looking to relocate to Oklahoma. Texas' and Massachusetts' education funding models serve as good examples for Oklahoma. In 1854, the Texas Legislature had the foresight to create the Texas Permanent School Fund (PSF), $2 million endowment to benefit public schools and public higher education systems in Texas. In 1876, legislators stipulated in the Texas Constitution stipulated that certain lands belong to the PSF and proceeds from the sale and mineral-related rental of these lands including royalties belong to the PSF and would form the corpus of the PSF. As of August 2020, the Texas Permanent School Fund had a market value of $48.3 billion, providing a predictable stream of revenue to support public education and higher education in Texas. Massachusetts which ranks #1 by the Milken Institute for overall in innovation and for education decided to double down on its investment in education. In 2019, Republican Governor Charlie Baker signed landmark legislation to strengthen public education by boosting investments in public schools by $1.5 billion annually for the next seven years. The State of Massachusetts realized that its vast pool of talent is what fuels its innovation economy.

The envisioned Office of Science and Innovation would work with the Science and Innovation Council to develop a long-term strategic plan and sustainable funding model to address Oklahoma's educational shortfalls. Cutting up and redistributing pieces of the pie cannot be the solution. The size of the pie for education in Oklahoma needs to grow if we want to grow our economy and transform it into an innovation fueled economy. Oklahoma could dedicate a portion of incoming federal funds to establish a

substantial Permanent School Fund and identify additional revenue streams. The Fund should be structured similarly to TSET's funding formula and safeguards to deter the State from tapping into the Fund in the event of budget shortfalls. Additionally, a statewide apprenticeship program with corporate partners should be established. Lastly, Oklahoma needs to develop a strategy to encourage more students to pursue STEM degrees, offering incentives for community colleges and regional and research universities to graduate more students in STEM. Oklahoma could also expand the number of STEM workers by replicating talent recruitment programs like Tulsa Remote where the state offers financial incentives for STEM workers to relocate to Oklahoma.

Key performance indicators for this recommendation include:

1. Legislation passed to create a Permanent School Fund and apprenticeship program
2. Legislation passed to increase in public education funding per student
3. Legislation passed to increase funding for post-secondary education (career tech and higher education)
4. Increase in academic achievement as measured by performance in science and math 4th and 8th grade testing
5. Number of corporate partners participating in the apprenticeship program
6. Increase in the number of STEM degrees awarded by Oklahoma institutions

Recommendation #7 – Secure Public and Private Financing to Fund Recommendations

A number of states have invested billions of dollars into modernizing their state economy and transforming it to meet the challenges of a technologically driven global economy. Ohio invested $2.3 billion, Massachusetts invested $1.6 billion, and Texas invested over $1 billion. More recently, the State of Indiana was one of the more recent states to invest massively in innovation by creating a 10-year, $1 billion innovation initiative to jumpstart its innovation economy. Oklahoma should assemble a 6-9-person task force made up of legislators, academic experts, and industry leaders to perform a 6-month assessment to determine the level of investment needed and identify potential public and private funding sources to implement these recommendations with at minimum a 10-year commitment to funding. The cost to implement this strategic plan could be substantial. However, the price of not investing is even higher. Failure to invest substantially in the three strategic industries will lead to Oklahoma falling further and further behind in growing our state economy.

APPENDIX: CASE STUDIES – TEXAS, OHIO, AND MASSACHUSETTS

Texas Case Study: Diversifying and Expanding the Texas Economy Through Innovation

For the last 3 decades, the Texas economy has been gradually changing from a resource-based economy to a knowledge-based economy. Due to thoughtful and intentional long-term planning, Texas has become a state known not only for oil and gas production and cattle ranching, but also for its concentration of high-tech companies. The high-tech sector has been one of the fastest-growing segments of the Texas economy since the 1990s. Since the oil crash of the 1980's, Texas has been diversifying its economy to reduce the impact of the oil industry's volatility on the state's economy. In 1982, the oil sector's share of state GDP was 19%. In 2018, the oil and gas industry accounted for only 9% of the Texas GDP. As a result of government leadership, the Texas economy has evolved from one overly dependent on oil and gas to one that boast one of the most diversified state economies in the nation. Today, with 57 companies with corporate headquarters in Texas, Texas is home to the 2nd highest number of Fortune 500 companies with high tech giants like Tesla, Oracle, and Hewlett-Packet re-locating to the Lone Star State. How has Texas managed to transform and diversity its state economy?

In the mid 1990's, Texas took a number of important steps to grow its high-tech industry. In 2003, the Texas state legislature established the Texas Enterprise Fund (TEF) with an initial investment of $295 million. Through TEF, Texas committed $25 million to attract a new Center for Advanced Diagnostic Imaging in Houston, which hastened the development of new commercially marketable biomedical imaging technologies and create 2,200 new jobs. In 2005, under the leadership of former Governor Rick Perry and with support from the state legislature, Texas created a $200 million Texas Emerging Technology Fund (TETF) to invest in research, development, and commercialization of emerging technologies. The goal of TETF was to create jobs and develop the Texas economy. Legislative sessions in 2007 and 2009 increased investments to the fund bringing the total amount of funds under management to approximately $500 million. TETF focused on three main investment areas:

1. *Incentives for Commercialization Activities*: early-stage technology investment funds designed to assist companies in transforming ideas, concepts, and prototypes into commercially viable products.
2. *Research Award Matching*: funds create public-private partnerships which leverage the unique strengths of universities, federal government grant programs, and industry.
3. *Acquisition of Research Superiority*: funds for Texas higher education institutions to recruit the best research talent in the world.

Texas places a top priority on research investments. In 2019, Texas higher education institutions recorded $5.6 billion in total research expenditures, ranking third in the nation in R&D in total investments behind California and New York. Federal research dollars accounted for 40% of the research expenditures, with 20% coming from industry, and another 17% form state and local funds. From 2009 through 2015, the Texas Legislature has invested hundreds of millions of dollars in research by creating several funds to support university-generated research, some of which are:

- Texas Research University Fund (TRUF) provides funds to Texas' two top research universities: The University of Texas at Austin and Texas A&M University to recruit and support faculty to ensure excellence in instruction and research. The average annual funding for TRUF is $70 million.

- Core Research Support Fund (CRSF) provides funds to emerging research universities in Texas to support and maintain educational activities that promote increased research capacity. The CRSF Fund allocates $59 million each year to eight emerging research universities.
- Texas Research Incentive Program (TRIP) provides matching funds to assist emerging research universities in leveraging private gifts for the enhancement of research productivity and faculty. Matching funds are awarded based on private gifts and endowments to enhance research activities. From FY 2010 through FY 2021, the TRIP provided a total of $361 million in matching funds to Texas universities.
- Governor's University Research Initiative (GURI) provides matching grants to public universities and health-related institutions to assist in recruiting distinguished researchers, such as Nobel laureates and National Academy members, from institutions outside of Texas to enhance the state's national and global economic competitiveness. As of 2020, $54 million has been invested in GURI.
- Texas Comprehensive Research Fund (TCRF) provides funds to Texas public institutions that are neither research nor emerging research universities. $7 million is made available annually to 25 institutions.
- National Research University Fund (NRUF) provides funds to Texas emerging research universities seeking to achieve national prominence as major research universities. The average annual funding per institution is $8.3 million.

Texas views its talent pool as an economic strategic asset. High-tech firms are re-locating to Texas to tap into the vast pool of skilled labor clustered in Austin and the Dallas-Fort Worth area. The availability of a skilled labor pool is often ranked as the most important factor for a firm's decision to relocate to Texas. Because high-tech companies are expanding in Texas, skilled workers from other regions are attracted to Texas in search of high paying jobs, thereby further expanding the state's skilled labor pool. Texas has adopted innovative educational programs to ensure that its public schools produce an abundance of talent for technical and STEM careers such as:

- **Early College High School**. This program blends high school and college coursework to provide students who are at risk of not graduating, students who are historically underserved, and students who wish to accelerate their learning with the opportunity to earn an associate degree and/or 60 hours of college credit tuition free. Early college opportunities include the Pathways to Technology Early College High Schools (P-TECH) program, an open-enrollment program that provides students with work-based education. In the 2017–18 school year, 198 schools were designated early college high schools, including P-TECH.
- **Texas Science, Technology, Engineering, and Mathematics Initiative (T-STEM)**. This initiative creates secondary schools that focus on improving instruction and academic performance in science and mathematics–related subjects and increasing the number of students who study and enter STEM careers. In the 2017–18 school year, 132 campuses were designated a T-STEM Academy.
- **Industry Cluster Innovative Academies**. Launched in 2017, this program provides opportunities for work-based learning and college course credit within targeted industry clusters and focuses on graduating students with industry certifications and 60 hours of college credit and/or an associate degree. There are 18 Industry Cluster Innovative Academies scattered across Texas.

The Texas public school system and public universities also benefit from a steady stream of funding. In 1854, the Texas Legislature had the foresight to create the Texas Permanent School Fund (PSF) with a $2 million endowment to benefit public schools and public higher education systems in Texas. In 1876, the

Texas Constitution stipulated that certain lands belong to the PSF and proceeds from the sale and mineral-related rental of these lands including royalties belong to the PSF would form the corpus of the PSF. As of August 2020, the Texas Permanent School Fund had a market value of $48.3 billion, providing a predictable stream of revenue to support public education and higher education in Texas.

The relocation of large tech firms to Texas such as Apple and Google have had a rippling effect on the Texas venture capital ecosystem. In 2019, Austin made it into the top 10 venture markets bringing in more than $1.8 billion in venture capital funding. Austin also ranked #7 in the number of deals in 2019. Tech savvy individuals and entrepreneurs are flocking to Austin to work for startups or to start their own. Innovative companies such as Capital Factory have helped make Texas a destination of choice for high tech entrepreneurs. Capital Factory was founded in 2009 when Austin's startup scene was still nascent. It offers an accelerator program and access to venture capital. Its strength lies in its ability to build bridges among startups, funding sources, corporate partners, and government agencies and to create a supportive community where entrepreneurs can work near each other and share best practices and challenges.

The availability of a highly educated labor force, quality education, access to capital, a favorable tax and business environment, and relatively low cost of living has made Texas an in-demand location for high tech firms, professionals, and entrepreneurs.

Ohio Case Study: Rebuilding Ohio's Economy Through Innovation

During the first half of the 20th century, Ohio's economy was buoyed by its steel, auto, rubber, and aerospace industries. By the 1970s, many of these key manufacturing industries faced growing competition from abroad and increased automation. At the same time, Ohio failed to invest sufficiently in the university infrastructure and in emerging industries such as electronics and biomedicine. The industrial decline in Ohio resulted in job and population losses and stagnant economic growth. During the recession of 2009, Ohio lost 376,500 jobs and suffered some 89,000 housing foreclosures. Ohio became one of the clusters of midwestern states negatively branded as part of the Rust Belt, with rust referring to deindustrialization, economic decline, population loss, and urban decay.

In 2002, the state government took decisive action to reverse Ohio's economic decline by rebuilding its economy and shedding its attachment to the old economy way of doing business. The state created the Ohio Third Frontier, an unprecedented $1.6 billion bond commitment by the state and passed by voters to create an "innovation ecosystem" that supports the efficient and seamless transition of great ideas from the laboratory to the marketplace. In 2010, Ohioans voted to increase funding for the Third Frontier by another $700 million and extend it for another five years, bringing the state's total investment in the Third Frontier to $2.3 billion. The $2.3 billion initiative has supported applied research and commercialization, entrepreneurial assistance, early-stage capital formation, and expansion of a skilled talent pool that can support technology-based economic growth.

Ohio's Office of Technology Investments administers the Third Frontier programs, which provides funding to state-based, technology-oriented companies, universities, and non-profit research organizations to create new companies, industries, products, and jobs. Amendments to the state constitution approved by Ohio voters lifted a constitutional ban on state investments in private business with respect to the Third Frontier program. Furthermore, the Third Frontier program has been the largest contributor to the Ohio Research Scholars Program, which funds university efforts to attract researchers who bring with them federal research dollars to Ohio. State legislation was also passed to allow university faculty to become stakeholders in startups to commercialize their research findings. This change in legislation led to an increase in university start-ups.

Philanthropic organizations in Ohio also stepped to help turn the states' economy around. Philanthropic foundations pooled their resources to create Fund for Our Economic Future with a $20 million investment to back small nonprofit economic development organizations that function as catalysts for innovation-based economic revitalization, forming innovation clusters and establishing incubators and accelerators.

One highly successful nonprofit economic development organization is the BioEnterprise Corporation, a business formation, recruitment, and acceleration initiative established in 2002 through a collaborative partnership among the Cleveland Clinic, University Hospitals and Case Western Reserve University and supported by government, private and foundation sources. BioEnterprise houses a life science incubator that provides clients with access to wet and dry lab space and state of the art laboratory equipment. It also provides its clients with workstations, office space and conference rooms. By 2004, start-ups supported by BioEnterprise had raised $62 million in capital. By 2009, BioEnterprise had supported 89 biomedical companies in Ohio raising $859 million in capital and generating 1,900 jobs.

Today, Ohio has experienced an innovation-based economic turnaround. The state's unemployment rate which peaked at 11% in 2010 dropped to 4.8% in 2018. Ohio also added 540,100 private sector jobs from 2011 – 2018.

Ohio continues to build upon its investment in innovation with particular emphasis on research. Over the span of a year from March 2020 – March 2021, the state established three innovation districts: the Cincinnati Innovation District in March 2020, the Cleveland Innovation District in February 2021, and the Columbus Innovation District in March 2021. Each innovation district will focus on a specialty in partnership with local universities and health systems.

- The Cincinnati Innovation District which will receive $100 million in state funding is a partnership between the state, the University of Cincinnati, and the Cincinnati Children's Hospital Medical Center to focus on increasing 15,000 STEM graduates and developing and commercializing research focused on pediatric diseases.
- The Cleveland Innovation District, which will receive $265 million in state funding, is a partnership between the state, the Cleveland Clinic, Case Western Reserve University, Cleveland State University and University Hospitals to focus investments on researching infectious diseases and pandemics. The goal is to create 20,000 jobs in Ohio over a 10-year period, capitalizing on Cleveland's academic and clinical care assets.
- The Columbus Innovation District is a $1 billon collaboration between the state, Ohio State University and Nationwide Children's Hospital. The state will invest $100 million with Nationwide Children's Hospital contributing $350 million and Ohio State University contributing $650 million. The focus of the Columbus Innovation District is to develop gene and cell therapies and conduct cancer research.

Ohio's investments in innovation over the past two decades demonstrates its commitment to embrace a knowledge-based economy. Its state leadership is willing to be bold by-passing innovation-friendly legislation, investing in partnerships with universities to advance cutting edge research, and committing substantial state dollars to create an innovation ecosystem.

Massachusetts Case Study: Leveraging Innovation to Be a Global Biotech Hub

In 2008, Massachusetts set its sight on competing with Silicon Valley to become the world's leading biotech hub by launching the Mass Life Sciences Initiative (MLSI). Through MLSI, the state committed to investing $1 billion over 10 years in the life sciences sector. In 2018, Governor Charlie Baker reauthorized the initiative. He committed an additional $623 million to drive education, research and development and workforce training in the life sciences industry.

The $2.3 billion funding to grow the state's life sciences sector is managed by the Massachusetts Life Sciences Center (MLSC). The MLSC is an economic development investment agency dedicated to supporting the growth and development of life sciences in Massachusetts. MLSC supports innovation, research, commercialization, and manufacturing activities in the fields of biopharma, medical device, diagnostics, and digital health. MLSC makes these investments through a combination of grants, loans, capital infrastructure investments, tax incentives and workforce programs.

Massachusetts has made a concerted effort to create a biotech supercluster to compete head on with Silicon Valley. In Boston and Cambridge, a high concentration of hospitals, leading universities, and private companies exist in a small geographic area. State leaders leveraged on this concentration of top tier universities from Harvard to MIT and world-renowned hospitals such as Massachusetts General Hospital, Dana-Farber Cancer Institute and Brigham & Women's Hospital to create the Kendall Square biotech supercluster. Kendall Square, which has been labeled "the most innovative square mile on the planet," has over 120 biotech and life sciences companies and research institutions, including Moderna, Biogen, Amgen, Novartis, and Pfizer.

Massachusetts has been incredibly successful at creating the necessary infrastructure for biotech start-ups to launch and thrive. In Boston alone, there are more than 50 biotech and life sciences incubators and accelerators, some of which received operating grants from the state's Collaborative Workspace Program which awards over $1 - $2 million annually to organizations that fuel community-based innovation. In February 2021, MLSC announced a partnership with Thermo Fisher Scientific, Waters Corporation, and Astellas to create LabCentral, a fully functional life sciences laboratory with a focus of helping more advanced stage start-ups scale-up bio-manufacturing. Massachusetts state leadership continues to spearhead innovative initiatives to sustain and grow the state's life sciences sector.

The nonprofit sector has played a significant role in fueling Massachusetts' aspiration to become a life sciences juggernaut. The Massachusetts Biotechnology Council (MassBio), a nonprofit trade association, was founded in 1985 by six start-ups, Biogen, Genzyme, BioTechnica, Genetics Institute, Damon BioTech, and Integrated Genetics to help make Massachusetts home to the world's leading life sciences supercluster. Today, MassBio has over 1,100 members comprising of biotech companies, academic institutions, disease foundations, and hospitals. In addition to providing networking opportunities for entrepreneurs, business leaders, and scientists, MassBio also offers its members value-added services. For example, through its MassBio Edge, MassBio pools the buying power of its member companies to purchase goods and services, such as lab and office supplies, that biotech and life sciences companies need to do innovative work and develop new therapies.

University leadership is one of the primary reasons for Massachusetts phenomenal biotech success. Kendall Square is home to two of the world's leading research universities -- Harvard and MIT. In addition to conducting cutting edge research and producing biotech talent, both MIT and Harvard play an active role in making Kendall Square a biotech supercluster. Both universities operate incubators and

accelerators. In particular, MIT has been at the helm in the creation of Kendall Square. Starting in the 1960's, MIT grew its real estate portfolio by purchasing surrounding properties around the Kendall Square area. Kendall Square was formerly an abandoned industrial area adjacent to the MIT's campus. In 2013, MIT embarked on a massive $1.3 billion redevelopment plan to transform 26 acres of property that the university owned around Kendall Square into commercial, residential and laboratory spaces to support the area's burgeoning biotech sector and affluent employees.

Federal research dollars have also been a key building block in Massachusetts' innovation economy. Massachusetts consistently ranks #2 behind California in the total amount of federal research dollars received, taking in a $28 billion haul in 2018. The state is home to five of the top hospitals in the country that receive the most National Institutes of Health (NIH) funding. That track record is significant because NIH is the largest public funding source of biomedical research worldwide. In 2019, Harvard University alone received $560 million in federal research dollars. MIT is also home to Lincoln Laboratory, a federally funded research and development laboratory sponsored by the Department of Defense. The Lincoln Laboratory has an annual operating budget of $1 billion, the bulk of which is funded by federal dollars, and employs over 3,500 MIT employees. Lincoln Laboratory supports a division dedicated to biotech and human systems research.

Since 2010, the Milken Institute has ranked Massachusetts #1 in its State Technology and Science Index, powered by the state's strong R&D inputs and aggressive human capital investments. The state consistently ranks #1 or #2 in public education by the U.S. News & World Report and WalletHub, spending $17K per pupil. However, Massachusetts continues to invest in public education to protect its pole position in educational strength. Recognizing that the availability of a highly educated workforce in Massachusetts is the state's most valuable asset in maintaining its economic competitiveness, Governor Baker signed into law landmark legislation in 2019 to commit an additional $1.5 billion over seven years to fund the state's public education system.

From investing in public education to collaborative partnerships between government, academia, health systems, and the private sector, state leaders have transformed Massachusetts into the world's top biotech hub. And their targeted investments have paid off handsomely. In 2012, venture capital firms poured in $900 million into Massachusetts. In 2020, Massachusetts-based biotech companies raised a record-breaking $5.8 billion in venture funding. Furthermore, 21 Massachusetts biotech companies had IPOs, raising an additional $3.9 billion in public equity.

Massachusetts serves as model example of the incredible gains that can be made when government, industry, and universities collaborate towards a shared vision. Many attribute Massachusetts overwhelming success in spurring on innovation to the state government's leadership and commitment to partnering with industry, academia, and nonprofits to advance the state's biotech aspirations and in its commitment to funding education.

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