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Council on
Competitiveness

National Commission on Innovation & Competitiveness Frontiers

A Compendium of Working Group
Virtual Dialogues
March–May, 2020

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Letter From the President

Dear Colleagues,

In today's environment, leadership and expertise are needed now more than ever to accelerate and sustain U.S. economic and national security—as well as global competitive advantage. The National Commission's Working Groups comprise such leaders—each of whom has dedicated time and knowledge this Spring to prioritizing critical policy platforms and nascent recommendations for the National Commission.

Following the August 2019 launch of the National Commission—and a multi-month recruitment process to identify Working Group members—the Commission kicked off strongly in 2020, with a January “National Commission Community Launch Conference” at Arizona State University, hosted by its President—and the Council's University Vice Chair and Commission Co-Chair—Dr. Michael Crow. There, the Commission's Working Group members—as well as a few of our Commissioners, their Advisors and Outreach/Engagement leaders—met en masse for the first time. Nearly 200 leaders in total gathered to begin a series of deep conversations around three critical themes designated by the National Commissioners:

1. **Developing and Deploying at Scale Disruptive Technologies**—This group is charged with, among other things, mapping promising, strategic technology pathways to enhance productivity and economic growth for the United States.

2. **Exploring the Future of Sustainable Production and Consumption, and Work**—This group is examining the ever-evolving disruption underway in the production and consumption of goods, as well as the rapid evolutions unfolding in the American workforce.
3. **Optimizing the Environment for the National Innovation Ecosystem**—This group is exploring ways to optimize the entire system in which the nation's innovators and enterprises operate—from capital costs, intellectual property, standards and regulations, etc.—and examining the critical roles the private sector, and local, state and federal governments must play.

Unknown to everyone leaving the successful ASU launch conference was the exponentially escalating global health crisis that has, to this day, completely transformed how we all conduct our daily business. Empowered by an online collaboration portal and a mantra to conduct business in a more innovative fashion, the Commission Working Groups quickly transformed in scale and scope—moving away from a model of in-person mini-summits and workshops to regularly recurring, twice-a-week, moderated online dialogues. In the first eight to nine weeks of stay-at-home orders, the National Commission's Working Groups have engaged in nearly 50 virtual deliberations and dialogues, engaging hundreds of leaders.

During this period, Working Group members deliberated over numerous policy areas, raised many to urgent an priority status, began to articulate potential recommendation pathways, and highlighted critical issues that will require further, deeper analysis. In the near term, COVID-19 and the virus economy have demonstrated the need to strengthen U.S. resiliency, secure U.S. supply chains, and bolster the nation's capacity to innovate, create and make. For longer-term competitive advantage, Working Group members emphasized the needs to invest in critical technology platforms—from basic research to development and deployment; and, to create pipelines of opportunities for innovation, engaging many more Americans from diverse backgrounds—from the earliest levels of education to the highest—in the nation's innovation economy.

In the following pages, the Council is providing an in-depth look into this rich Commission Community conversation—sharing summaries from each of the Working Group sessions, with the intention to provide insight into the genesis of the key priorities of “Phase One” in 2020; and to shine the light on the path forward in “Phase Two,” as the Working Groups hone ideas into actionable recommendations and help shape the Commission's year one call to action.

We are grateful for the support, expertise, time, and leadership of the Working Group members during these challenging times. Together we will chart a path toward a more inclusive, creative, resilient and innovative economy.

Sincerely,



A handwritten signature in black ink that reads "Deborah L. Wince-Smith". The signature is fluid and cursive.

Deborah L. Wince-Smith
President & CEO
Council on Competitiveness

Working Group 1: Developing and Deploying at Scale Disruptive Technologies

Working Group 1 Summary

The virtual Working Group sessions began on March 31st and completed this first phase on May 22nd. This 'Phase I' of the Working Group sessions yielded insights and areas for further assessment ahead of the National Commissioner's meeting on June 16th. Below are highlights and themes from each of the Working Groups.

The Developing and Deploying at Scale Disruptive Technologies Working Group considered if the United States is maintaining a competitive advantage globally in developing and deploying disruptive technologies. In order to maintain competitive advantage, the Group determined it needed take an inventory of U.S. strengths and weaknesses pertaining to disruptive technology. Federal research and development (R&D) funding is at a 60 year low with R&D spending at 0.6 percent of U.S. GDP and 2.8 percent of total federal outlays in fiscal year 2019. With this decreasing focus from the U.S. government, the nation's public and private sector communities are facing challenges in determining how best to lever resources and drive long-term innovation capacity.

- Working Group members agreed that the United States is facing growing challenges to its technology supremacy in multiple, critical arenas—especially from China. This potential loss of long-term tech supremacy poses severe risks and challenges to U.S. innovation. The United States must take a hard look at key technology areas, and ask on a case-by-case basis which are crucial for domestic development and production.

Key technology areas discussed include advanced microelectronics, artificial intelligence, advanced computing, quantum information sciences, communications, energy, biotechnology and material science based applications.

- Working Group members also discussed a shift in focusing from single technologies to streams or pillars of key capabilities that would combine to drive productivity growth and disruptive innovation across sectors. Platform-based capabilities could yield innovations in this regard as advances could enable, for example, expanded prototyping and experimentation efforts to accelerate technology maturation. This would also provide access and resources for innovators outside the traditional channels of scientific research—breaking down traditional stovepipes in scientific research and deployment to the marketplace.
- Regarding the challenge of scaling, Working Group members stressed the importance of geography and resources. Without addressing the concentrated nature of funding—including but not limited to venture capital—by industry and geographic region, most of the country will lack the capacity to scale up innovation in a meaningful way. An additional challenge with scaling technologies relates to intellectual property, especially negotiation of technology transfer agreements between academia and industry. The current COVID-19 pandemic has motivated some stakeholders to develop solutions because of the critical importance of timely response.

- Working Group members also identified a potential opportunity in lowering the barrier for innovation activities by calling for broadening and deepening of entrepreneurship initiatives at universities. While many universities have expanded entrepreneurial programs in recent years, scaling is still needed to include a more diverse base of potential innovators and entrepreneurs, additional incubators and accelerators, faculty externships at companies, and executives-in-residence.
- The development of novel, agile organizational designs are needed at universities to improve innovation outcomes—amplifying atypical combinations of talent and resources often at the heart of transformational/disruptive innovation.

To view video and read full transcripts of each Working Group session, log in to the National Commission Community Online Portal. Video and transcripts are available within Working Group Rooms.

Working Group 1 Calls March 31

Overview from ASU

Ms. Kathy Trimble summarized the discussions the Working Group had at the January launch conference at Arizona State University. Among important topics discussed were the overall state of the economy, America's industrial base, and the degree to which America's investment in new technologies should be guided by a national strategic plan. The conference goers agreed that America has many regional economies, and what works in one place may not scale or work well in another. They also felt it was important for the U.S. to prioritize which emerging technologies to focus on, as U.S. government and industry may not be able to invest in every

disruptive innovation. There was strong consensus around the need for greater partnership, including transparency and collaboration via public-private partnerships. Particular fields the Working Group felt it important to focus on were manufacturing, biogenomics, and semiconductors for next-generation microelectronics. Participants stressed the need to identify how to engage in those spaces, whether through incentive programs, funding, regulatory policy, or other tools. Finally, the ASU participants discussed the tradeoffs between data sharing, openness, and transparency on the one hand, and national security on the other, particularly regarding academic research and international students and academics.

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Dr. Bernard Arulanandam
University of Texas-San Antonio

Mr. Bill Briggs
Deloitte

Mr. Mike Cassidy
Emory Biomedical Catalyst

Mr. Eric Cylwik
Sundt Construction

Mr. Robert Dixon
PepsiCo (Emeritus)

Ms. Hanna Dooley
Arizona State University

Mr. Andre Doumitt
Aerospace Corporation

Mr. Ryan Haines
Sundt Construction

Ms. Maggie Hallbach
Verizon

Dr. Paul Hommert
Sandia National Laboratory (Emeritus)

Dr. Kelvin Lee
University of Delaware

Dr. Fred Mannering
University of South Florida

Dr. Charles Riordan
University of Delaware

Dr. Gene Robinson
University of Illinois

Mr. Guy Snodgrass
Defense Analytics

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Dr. James Weyhenmeyer
Auburn University

Dr. Neal Woodbury
Arizona State University

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswald

Mr. Tim Planert

Ms. Carol Ann Meares

Concept of Industrial Policy

Participants in the call had questions about the connotations of the term “industrial policy” to describe a national strategy for emerging technology. Mr. Bill Briggs of Deloitte asked whether the focus was primarily on enabling technologies or the end-use products and innovations that disruptive technology enables. Ms. Kathy Trimble noted there was debate among the Launch Conference attendees over this matter, and that the two were interconnected. Dr. Paul Hommert, formerly Director of Sandia National Laboratory, questioned whether “objective” would better describe a national strategic plan than something connoting specifics, like “policy.” He also cautioned against replicating models from competitors with vastly different political and economic systems. He cited the defense industry’s interaction with the federal government as an example to follow in framing strategic investments, characterizing it as a “meta-policy space.” Dr. Tony Tether, formerly Director of the Defense Advanced Research Projects Agency (DARPA) asked for specific examples of what a national strategy might entail, citing the 1960s Moon Mission as an “objective” rather than a “policy.” The Honorable Deborah L. Wince-Smith cited the Council’s recent engagements on developing a strategy for manufacturing next-generation microelectronics to obviate Moore’s Law as one such case. She also stressed that semantics were less important than the discussion of the issue.

COVID-19

Mr. Andre Doumitt of the Aerospace Corporation asked if the Commission should adjust its focus in light of the significant disruptions to the economy stemming from the COVID-19 pandemic. Mr. Chad Evans responded that it was likely the Commission would primarily focus on longer-term challenges, but that the upcoming meeting of the Council’s Board, which includes the co-chairs of the National Commission, would be discussing the Council’s response to COVID-19 among other topics shortly, and that the Council in general and National Commission in particular would likely weigh in if its work was especially relevant. He cited questions of resiliency and sustainability as examples. Dr. Hommert predicted that an event as significant as the pandemic would inevitably have long-term consequences that would naturally intersect with the Commission’s work. He distinguished between immediate responses to the crisis, knowledge and experience gained from the crisis, and the process of extending and applying those lessons to other emerging scenarios in the future. Ms. Trimble noted that the pandemic provides a case study of the challenges and opportunities in deploying advanced technology to address a crisis. Mr. Evans cited a discussion between Council leadership and Chairman Dr. Mehmood Khan on the structural issues facing the nation going forward that can be addressed with innovation.

Education and Technological Focus

Mr. Guy Snodgrass of Defense Analytics brought up the issue of education and training, both for workers and executives, as an emerging issue in developing and scaling technologies. He described his time working as a special assistant to General James Mattis at the Department of Defense, and how the directors of the Artificial Intelligence program Project Maven cited a shortage of AI-literate workers as their major obstacle, ahead of technology and data. Dr. Robert Dixon, formerly of PepsiCo, urged the group to focus on specific technologies to identify as candidates for scaling, arguing that doing so would make it much easier to develop specific recommendations. He pointed out that some technologies may be held back currently because of issues of worker training, others by insufficient or inadequate partnerships, and so on. He recommended prioritizing no more than three areas. Ms. Trimble welcomed detailed suggestions by the group on technologies to invest in, and Mr. Evans mentioned the Council's collaboration with Deloitte in producing a report on advanced manufacturing technologies, and the challenges and opportunities facing U.S. firms in maintaining or establishing leadership in each of them.

Supply Chain Security/National Security

The final major participants discussed was the security of America's advanced technology supply chains, and of the role of national security considerations in shaping the Working Group's work. Mr. Snodgrass

cited the need for executives to trade off between profitability and security in their offshoring decisions, but believed that thoughtful and deliberate decisions by business leaders could strike an appropriate balance. Dr. Bernard Arulanandam of the University of Texas, San Antonio noted that the COVID-19 pandemic has illustrated the urgency of addressing supply chain security issues by demonstrating America's reliance on multinational supply chains during periods of crisis. Dr. Tether stated that national security threats have historically driven American technological innovation, using the examples of semiconductors, designed to protect the guidance systems on missiles, and AI, designed to reduce human error in Sonar detection caused by fatigue. Dr. Hommert expressed concern that the predominance of private industry in research investments made collective national focus on strategic priorities more difficult, while Dr. Tether believed it still provides a powerful incentive. Dr. Gene Robinson of the University of Illinois at Urbana-Champaign emphasized the need for the country to incorporate predictive functions into advanced technology, as the current pandemic was predictable but still caught the nation off-guard.

Next Steps

Ms. Trimble and Mr. Evans encouraged the participants to continue their discussions online via the online collaboration platform, and went over the schedule and topics for the remaining calls for the group, including another introductory call for the Working Group on Thursday afternoon.

Working Group 1 Calls April 2

Recapping Arizona State University Community Launch and Setting the Stage

The Honorable Deborah L. Wince-Smith welcomed the group and praised the discussions at the Arizona State Launch Conference in January. She encouraged participants going forward to think about the ways the COVID-19 pandemic might be relevant to the group's discussions, including issues of supply chain resiliency, cyber security, and work and unemployment. Mr. Chad Evans set the stage for

the group's upcoming milestones, including a virtual Commissioners' meeting in June, possible in-person Commissioners' meeting in August or September, and the National Competitiveness Forum in December when Year 1 findings will be released. Mr. Bill Bates discussed the ongoing Advanced Computing Roundtable and University Leadership Forum, and highlighted the similarities in the topics being discussed between these groups and the Working Group.

WORKING GROUP PARTICIPANTS

Dr. Thomas Campbell
Future Grasp LLC

Mr. Dave Copps
Worlds Enterprises

Ms. Candace Culhane
Los Alamos National
Laboratory

Dr. Jennifer Curtis
University of California, Davis

Ms. Leah Guzowski
Idaho National Laboratory

Dr. Alan Hevner
University of South Florida

Dr. Nathan Hillson
Lawrence Berkeley National
Laboratory

Mr. Gerardo Interiano
Aurora Innovation

Ms. Sara Lawrence
RTI International

Dr. Laurie Locascio
University of Maryland

Dr. Theresa Mayer
Purdue University

Mr. Mark Minevich
Going Global Ventures

Mr. Gregory Morin
Argonne National Laboratory

Lt. Col. Stewart Parker
Center for a New American
Security

Dr. Albert Pisano
University of California, San
Diego

Dr. Gary Pratt
Kansas State University

Dr. Arun Rai
Georgia State University

Dr. Neil Thompson
MIT

Dr. Gilroy Vandentop
Intel

Mr. David Vasko
Rockwell Automation

Dr. Bogdan Vernescu
Worcester Polytechnic
Institute

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswald

Mr. Tim Planert

Mr. Gourang Wakade

Ms. Kathy Trimble summarized the discussions from the January Launch Conference. The first theme was the economy as a whole, including how to scale and deploy disruptive technologies across the ecosystem given the challenges and opportunities in the economic landscape. Not all solutions that work in one region or local economy will scale or be successfully replicated elsewhere because of the diversity of local conditions. The Working Group should survey what does and doesn't work around the country and determine what solutions are transferable. A related issue is that of access to capital, which includes not only money, but also the education pipeline, training, standards, regulations, and other structural issues. The second theme was strategic priorities. Should the United States develop a list of emerging technologies, or enabling structures, to prioritize for investment and scaling? It is possible that the country will not be able to invest fully in every new technology, so identifying which innovations, such as 5G or Artificial Intelligence, require an all-of-nation strategic approach to steer funding and research. The final theme was America's industrial base. Which elements of the national level infrastructure are most crucial to supporting key sectors of the economy, and how can they incorporate the entire research and development ecosystem? Ms. Trimble also suggested topics for "deep dive" discussions centered around developing or maintaining U.S. leadership in key areas, including manufacturing, biogenomics, and semiconductors. She also encouraged discussion of the balance between openness of research and national security, and of partnership and contract models to facilitate collaboration and technology transfer from labs and universities to the market.

Technologies vs. Applications

The group debated whether its focus should be on specific end-use technologies, or whether it should focus on market and application spaces and platforms that allow for the deployment of multiple technologies. Mr. Dave Copps of Worlds Enterprises characterized AI as an apex technology that will be part of nearly every future disruptive innovation, and cited both AI and 5G as areas for greater

investment and collaboration between the private and public sector. Dr. Al Pisano of the University of California, San Diego highlighted sustainable smart mobility as an application space that ties in AI with other emerging technologies. Mr. Mark Minevich of Going Global Ventures advocated the development of specific solutions that impact government, society, policy, and industry, rather than specific technologies. He stressed the need for American companies and venture capitalists to be pioneers in adopting disruptive technologies across all sectors to create a vibrant digital economy. He estimated that the digital economy could add \$17 to \$19 trillion annually in value from greater productivity and innovation across the world, and characterized the Commission as essential to ensuring the United States captures a substantial share of that added value and remains a leader in disruptive technology.

Mr. Evans noted the Council's emphasis on innovation as the driver of productivity growth that is key to long-term prosperity for all Americans. He characterized the Working Group's mission as being focused on solutions for driving productivity growth through the development and scaling of new technology. He cited as an example the need for a replacement technology for semiconductors due to the looming end of Moore's Law. He encouraged the group to focus on the portfolio of technologies and application spaces that will set the next generation of Americans up for success in the global marketplace. Ms. Wince-Smith added that the group needed to focus on both technologies and business transformation. She cited the example of the Council's creation of the first "critical technology" list in the 1980s, which helped shaped public investments in R&D and public-private partnerships.

Interdependence

Dr. Arun Rai of Georgia State University characterized the key theme in the group's deliberations as that of interdependence. He initially identified three dimensions of interdependence: between foundational technologies, such as AI, and their application level deployment, such as smart cities; between the

public sector and private or university sector; and between technology and people, as disruptive innovations disrupt skills and needed skill sets in addition to industries. Later, he noted the interdependence between patenting and other forms of intellectual property protection on the one hand, and the dynamism and innovativeness of open-source data, as in software development, on the other.

Prototyping

Dr. Pisano suggested the group identify promising innovation platform technologies and advocate for them at a national level. He cited the example of the MOSIS program for semiconductor research, and said such a platform would provide 24/7 internet access, design tools, and baseline technology to allow innovators from around the country to collaborate and work from a shared infrastructure. He noted its particular utility in the current COVID-19 pandemic, when innovators don't have access to labs and could make use of virtual collaboration spaces. It would also provide access to resources for innovators outside the traditional channels of scientific research. Ms. Trimble agreed with the suggestion and characterized it as the "connective tissue" that would provide platforms and help identify promising sectors for investment going forward.

Short- and Long-Term COVID-19 Recovery

The group discussed the short- and long-term weaknesses in the country's economic system and infrastructure exposed by the ongoing pandemic, and how to use the lessons learned from the crisis to fuel a dynamic recovery that makes use of disruptive technology. Dr. Thomas Campbell of Future Grasp noted that because of the huge spike in unemployment, the government will be preoccupied with short-term solutions, and the leveraging of technology without having to go back into the lab for further research. However, when the pandemic is passed,

the economy will look very different, and require a new set of long-term solutions to address this sudden reorganization. Ms. Sara Lawrence of RTI International summarized this perspective with the phrase "short-term rejuvenation, long-term transformation," and said it the group would be remiss in not addressing the immediate disruptions caused by COVID-19. Dr. Laurie Locascio of the University of Maryland pointed out how the crisis has exposed weaknesses in America's manufacturing supply chains, which began experiencing disruption even before the pandemic reached the United States because of their reliance on international suppliers. Mr. David Vasko of Rockwell Automation said that the pandemic has shown the dire need for universal broadband access in the United States, as well as the importance of telehealth in addressing basic medical problems. Dr. Pisano concurred and added 5G as another technology that needs to be made universal to adjust to new economic realities. Mr. Minevich warned that cash-strapped firms were discussing scaling back their R&D efforts, and urged the Council to help illustrate how to address the supply chain weaknesses exposed by the pandemic through human and digital resources. He spoke of the need to stop the momentum away from "moon shot", and of the need for companies to avoid becoming solely dependent on China for their supply chains. Ms. Wince-Smith noted the overlap between this discussion and the discussions held by the Future of Sustainable Production and Consumption, and Work group, as well as the Optimizing the Environment for the National Innovation System group. In addition to supply chain resiliency, she cited the vulnerability of digital infrastructure to cyberattacks, the Defense Production Act and industry's ability to rapidly shift production in response to emergencies, and the role of smart manufacturing in enabling rapid production shifts, as important issues for all three groups to consider. She predicted the three Working Groups would need to engage in significant cross-pollination to fully explore these issues.

Semiconductors, Moore's Law, and Productivity

Ms. Trimble asked what the cost-benefit balance was from innovation spurred by crisis, and noted that semiconductors were facing such a crisis with the end of Moore's Law. She asked what the priority technology areas should be within the semiconductor space. Dr. Neil Thompson of MIT echoed the need for a long-term replacement technology as Moore's Law stalls out, and noted that none of the potential candidates, including carbon nanotubes, light-based computing, or quantum computing, is close to deployment. He stressed the importance of leadership in semiconductor technology to America's economic competitiveness, and said that in the intervening time, bridging technologies will be crucial. He specifically mentioned specialized processors, such as Graphics Processing Units for machine learning, that offer a processing speed improvement equivalent to several extra years of Moore's Law. He also highlighted the importance of productivity in long-term economic growth, and the drop in productivity growth in the U.S. economy since the mid-2000s, which is connected to stagnating standards of living. He characterized this slowdown as being driven by the continued separation of a small group of highly productive firms from the majority of companies, which are seeing stagnations in their productivity. Dr. Thompson urged the group to study this issue and apply lessons from it. Mr. Minevich advocated taking an even broader perspective, asking how technology impacts not just productivity, but society as a whole. He urged the group to be both comprehensive and predictive in analyzing the impact of new technologies and how they could be used to drive productivity improvements. He stressed the necessity of making Americans more digital-savvy, especially as digital and remote work grow, and asked how to combine human capital with autonomous systems to improve both lifestyle and workforce productivity.

Competition with China

Competing with China for leadership in disruptive innovations, as well as securing American intellectual property, data, and information, was a major focus of the group. Dr. Gary Pratt of Kansas State University expressed concern at the lack of funding for enforcement of new intellectual property standards, and emphasized the importance of securing American IP in the race to innovate. Ms. Trimble concurred and noted that this issue had come up in all three Working Groups. Dr. Pisano noted that in China, innovation only occurs in pockets across their economic landscape, and suggested magnifying America's advantage in this area with a national Innovator Corps that could counter China's dominance of global supply chains. Ms. Wince-Smith expressed grave concern over China's nationalization of 3M's Chinese plants, and its predatory attempts to acquire startups in the United States that are impacted by the COVID-19 pandemic and facing funding problems. She urged greater funding for the Committee on Foreign Investment in the United States (CFIUS), and mentioned Dr. Michael McQuade of Carnegie Mellon University's warnings for academia and industry to rethink research and collaboration. Mr. Capps echoed this sentiment, revealing his company had turned down an offer from a Chinese investor and that Chinese investors are now trying to acquire licenses to technology before building a company around that license. He also noted China's control over Greece's economy through its investments in its shipyards and ports.

Next Steps

Ms. Trimble discussed the schedule and topics for the next three weeks of calls, and reminded the group that topical "deep dives" will begin next week. She also asked for group members to send along any suggestions for topics for focused discussions.

Working Group 1 Calls April 7

Setting the Stage

Ms. Kathy Trimble and The Honorable Deborah L. Wince-Smith welcomed the group to the discussion. Mr. Chad Evans announced the Council is closing in on a schedule for this summer and fall. Ms. Trimble then introduced the kickoff speaker for the session, Dr. Tom Campbell of Future Grasp, LLC.

Kickoff Remarks

Dr. Campbell's remarks focused on U.S. leadership in emerging technology. He noted that while the United States remains the global leader in disruptive technological innovation, it is beginning to falter in that role. He mentioned the National Academies' attention to this trend in their "Gathering Storm" report,

and characterized this slippage as a combination of declining funding for science and technology relative to inflation in the United States, as well as increased investment by foreign competitors, especially China. Citing China's "grand plans" for nearly every emerging technology and U.S. slippage in biotechnology, 5G, and artificial intelligence, Dr. Campbell urged the United States to engage more deeply in science and technology. He called for more public-private partnerships and for bridging the "gulf" he observed in priorities, knowledge, and attitudes between Silicon Valley and Washington, DC. Noting that policy makers often lack crucial scientific knowledge to inform their decision making, Dr. Campbell called for greater scientific pedagogy within the government, and for both venture capital and policy makers to focus on long-term, strategic funding decisions over short-term, tactical ones.

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Dr. Thomas Campbell
Future Grasp LLC

Ms. Candace Culhane
Los Alamos National Laboratory

Dr. Paul Hommert
Sandia National Laboratory (Emeritus)

Ms. Sara Lawrence
RTI International

Dr. Fred Mannering
University of South Florida

Dr. Ravi Prasher
Lawrence Berkeley National Laboratory

Dr. Charles Riordan
University of Delaware

Dr. Robie Samanta Roy
Lockheed Martin

Mr. Guy Snodgrass
Defense Analytics

Dr. Roland Stephen
SRI International

Dr. Neal Woodbury
Arizona State University

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

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Ms. Carol Ann Meares

Dr. Campbell also urged greater investment in 5G and broadband technology domestically, as the number of people working from home due to the COVID-19 pandemic will accelerate trends toward digitalization and the importance of telecommunications. Dr. Paul Hommert, formerly of Sandia National Laboratory, asked what the key differences are between basic research and investment in moving “up the value chain” toward productization. Dr. Campbell, while praising the research going on in venture capital centers like Silicon Valley, Boston, Austin, and even Washington, DC, focused on the need to secure funding for startups in the “Valley of Death” between prototyping and scaling. He described the countless startups with great ideas that failed due to lack of funding, and the Chinese government’s co-option of their ideas and innovations, including manufacturing via 3D printing. Ms. Wince-Smith asked what could be done to get hedge funds and other entities sitting on idle capital to deploy them in strategic investments. Dr. Campbell said he did not see significant movement in this direction during the COVID-19 pandemic as likely, and suggested the Council would be well-suited to work on identifying solutions to this problem. He also cited the issue of corporations offshoring their earnings rather than paying taxes in the United States as a contributing factor. Ms. Wince-Smith said that the current venture capital model will not be sufficient to encourage these long-term investments, and that the Commission should focus on incentives, the regulatory environment, and other solutions. In particular, she mentioned pension funds as having a role as a source of long-term investment capital, and warned that the policy community cannot “go in circles” on this matter.

Opportunities for Leadership and Emerging Challenges

Dr. Hommert suggested that the Working Group address technologies where the United States as an opportunity to seize a leadership role spanning the entire value chain, as well as identifying future opportunities that leverage America’s strengths in foundational research. Mr. Evans highlighted the

connection between Dr. Hommert’s remarks and the Council’s previous work with Deloitte on emerging technologies and the nations with the strategic assets to emerge as leaders in these fields. He also listed areas where the United States still leads, including aerospace, materials, communications, and healthcare. Participants also discussed the importance of intellectual property policy. Ms. Sara Lawrence of RTI International discussed China’s emergence in shaping the World Intellectual Property Organization, and lamented the lack of thinking on the implications of long-term changes in power structures. Dr. Roland Stephen of SRI International noted that increasing concerns about physical and intellectual property rights in China might encourage greater investment in productization in the United States by companies.

Participants also discussed the importance of “Competing for the Next Economy,” a phrase that emerged from the Council’s Executive Committee and Board meeting on Monday. Ms. Lawrence seconded this formulation, and Dr. Robie Samanta Roy of Lockheed Martin emphasized the United States’ continued advantage in quality of innovation, which Dr. Stephen seconded. Dr. Samanta Roy argued China has too much capacity for the United States to out-quantify them, but could continue to innovate more effectively and disruptively.

Encouraging Collaboration Without “Picking Winners and Losers”

Many participants experienced in interacting with Congress and the Federal government discussed strong concerns by policy makers over the risks of “picking winners and losers” when the government becomes directly involved in supporting investment and research. Dr. Candy Culhane of Los Alamos National Laboratory noted that federal involvement with projects runs the risk of over-specification, with the end result of disappointing products, something she experienced first-hand while involved with the intelligence community. She urged either a more flexible approach to collaboration or a shift to incentivizing private companies to invest, which she

framed as “winning the race” versus “how to run the course.” Dr. Hommert also discussed encountering these concerns during his time at Sandia National Laboratory, and emphasized the Commission must acknowledge the validity of these concerns, and the challenges inherent in public-private partnerships. He pointed to consortia with transparent decision-making processes as examples of collaboration that assuages these fears.

Participants noted numerous examples of successful collaboration that avoided the “winners and losers” concern. Dr. Culhane discussed DARPA’s use of prizes to encourage research on autonomous vehicles, and how this initiative inspired universities to partner with corporations. After the initial round of investments was unsuccessful, participants learned from the experience and eventually the prize was claimed. Dr. Samanta Roy mentioned the X Prizes, which helped spur the creation of the sub-orbital launch and commercial space flight industries, and of Sematech as a successful industry-government consortium. He characterized prizes and consortia as successful when they establish a clear mission among participants and reach a consensus on maximizing benefits for all stakeholders. He hoped that the country would retain its sense of national purpose after the COVID-19 pandemic passes. Dr. Stephen strongly agreed with the use of prizes, noting that they do not pick winners and losers, but “shoot at” a disruptive technology. They also motivate people who were not previously part of the innovation space to become involved. He expressed support for consortia but encouraged the Council to develop a blueprint for avoiding the challenges of industry collaboration. Ms. Yasmin Hilpert described the Global Federation of Competitiveness Councils’ work on prizes as drivers of extreme innovation, and Ms. Wince-Smith added that the report included a global scan of the structure, process, and impact of such activities around the world, as well as future opportunities.

Focusing on Specific Technologies

The group also discussed which technologies to encourage American investment in, including AI, 5G, healthcare, climate change, and manufacturing. Dr. Samanta Roy noted the Administration’s aggressive actions on artificial intelligence, including an AI Task Force that recently released its first set of quarterly recommendations. He identified several areas for public-private partnerships in the AI space, including ethics, data availability, hardware development for large-scale data analytics and machine learning, and AI application spaces. He cited the example of Oak Ridge National Laboratory’s use of its supercomputer to comb through drug research data to identify candidates for human trials. Dr. Samanta Roy also warned that China is investing heavily in these areas, and does not share America’s ethical or privacy norms. However, he also argued that China’s strategy comes with vulnerabilities, and urged the United States to move from investment in “second wave” AI, like machine learning and big data, to “third wave” AI, including artificial cognition and sense-making and human-machine interfaces. Dr. Stephen discussed the importance of AI and machine learning in genetic research, and Dr. Campbell concurred on funding AI sense-making research. He added that venture capital does not have the time horizon or risk tolerance to engage in crucial basic research in this area. Dr. Stephen said that because of venture capital’s risk- and time-aversion, only Fortune 500 companies currently possessed the resources to conduct their own research in disruptive technologies. Ms. Trimble noted that China is not the only competitor with the United States in AI, and Dr. Campbell added that fifty other countries either already have a national AI strategy or are developing one, and that South Korea and Singapore are particularly invested in AI research. Dr. Campbell also argued that no single government should “own” AI advances, as this would exacerbate global inequality between the technological “haves” and “have-nots.”

Ms. Trimble asked the group where the United States was falling behind in investment. Ms. Wince-Smith also asked the group to find three major issues to zero in on and form task forces around. Dr. Ravi Prasher of Lawrence Berkeley National Laboratory suggested climate change, as firms and venture capital have so far not shown interest in the scale and risk of investments in climate change-mitigating technology. Ms. Wince-Smith suggested climate change as an opportunity for collaboration between Working Groups 1 and 3, and discussed her past work on consortia, including Sematech. She noted that even during a Republican administration, the threat of semiconductor competition from Japan led to consensus about the need for an organized U.S. response because of the national security ramifications. Dr. Campbell stressed the increased global interest in telecommunications during the COVID-19 pandemic, and warned that China was already leading in 5G through Huawei. He suggested telecom AI as an opportunity for the Council to encourage government investment, especially since many people may be working from home for the next year or more. Ms. Wince-Smith agreed with this, and mentioned that during the Executive Committee and Board meeting, she learned that Verizon is managing 800 million mobile calls each day in the United States. She added that 5G is an enabling platform for numerous other technologies, along with

advanced microelectronics. She also cited healthcare as an enabling factor, and stressed the importance of being able to respond with less loss of function when the next pandemic hits. Ms. Trimble also suggested manufacturing and supply chain issues as a topic for a task force, and Ms. Wince-Smith said that would be an opportunity for a Working Group 2-led collaboration effort.

Closing

Mr. Evans encouraged participants to reread the issue primers from the January Launch Conference, especially since they serve as the basis for guiding questions for the weekly calls. Ms. Trimble reminded the group that the next discussion will take place on Thursday afternoon.

Working Group 1 Calls

April 9

Setting the Stage

Ms. Kathy Trimble and The Honorable Deborah L. Wince-Smith welcomed the group and introduced the kickoff speaker, Mr. Mark Minevich of Going Global Ventures, on the topic of the U.S. competitive position in emerging technologies relative to China.

Kick-off Remarks

Mr. Minevich kicked off the discussion by contrasting the American response to COVID-19 to that of countries such as South Korea and Singapore, which use contact tracing rather than social distancing, as an example of America being caught unawares and losing its leading edge. He then focused on four major elements of the U.S.-China competition: Chi-

na's rise, its strategic plans, its current comparison to the United States, and its strategic advantages.

Mr. Minevich noted that China's economy has grown tenfold since 2000 and threefold since 2008, and that its firms have become increasingly large and sophisticated. Although the first large Chinese firms to emerge did so in finance and energy, China is increasingly shifting to technology with the rise of companies like Baidu, Tencent, and Alibaba. China now has firms competing in nearly every industry, from online shopping to mobile payment, with U.S. firms, and they are already approaching those firms in size. China's large financial sector is an important part of its rise as a scientific power through funding of research, and the four largest banks in the world by total assets are Chinese.

WORKING GROUP PARTICIPANTS

Dr. Ramprasad Balasubramanian
University of Massachusetts-Dartmouth

Mr. Eric Cylwik
Sundt Construction

Mr. Robert Dixon
PepsiCo (Emeritus)

Dr. Gloria González-Rivera
University of California, Riverside

Mr. Ryan Haines
Sundt Construction

Dr. Alan Hevner
University of South Florida

Dr. Nathan Hillson
Lawrence Berkeley National Laboratory

Dr. Laurie Locascio
University of Maryland

Dr. Carolyn Meltzer
Emory University

Mr. Mark Minevich
Going Global Ventures

Dr. Albert Pisano
University of California, San Diego

Dr. Gary Pratt
Kansas State University

Dr. Arun Rai
Georgia State University

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Dr. Neil Thompson
MIT

Mr. David Vasko
Rockwell Automation

Dr. Bogdan Vernescu
Worcester Polytechnic Institute

Dr. James Weyhenmeyer
Auburn University

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Josh Oswald

Mr. Tim Planert

Worryingly, China has a strategic plan to dominate the next wave of emerging technologies, and to leverage this dominance for geopolitical power. The Made in China 2025 initiative details China's attempt to be the leader in all of the top ten manufacturing industries by 2025, as well as to lead in artificial intelligence. On the latter front, China has made clear its plans to dominate the AI marketplace by 2030, starting with a \$150 billion investment in its domestic industry before jumping internationally. China's "Belt and Road" initiative has allowed it to control the technological infrastructure- particularly wireless networks- in numerous countries, including Italy. Further, Chinese companies are investing heavily in surveillance technology and the use of AI for facial recognition.

Mr. Minevich described the U.S.-China battle for technological supremacy as a "Global Technology Cold War." He noted that China has more robots, supercomputers, and internet users than the United States, and that in China, companies must operate with national goals in mind. China has also either equaled or surpassed American expenditures on research and development, and is leading in the number of patent applications and scientific publications. While they are still behind the United States in semiconductor manufacturing, they are rapidly gaining, and have already caught the United States in supercomputing ability. China is also turning to Singaporean and South Korean manufacturers to develop the next round of semiconductor chips, and is engaged with the United States in a struggle to take the lead in quantum technology. Mr. Minevich warned that losing this battle would leave the United States at a severe disadvantage in a variety of domains, including encryption.

However, Mr. Minevich noted the United States retains some advantages. The United States has a free society that enforces the rule of law, protects intellectual property, and encourages independent thinking. It also possesses an independent judiciary and robust startup culture. The United States possesses major firms like IBM and Google, which recently achieved quantum supremacy, and has

spent \$92 billion on basic research since 2017. Agencies like the Defense Advanced Research Projects Agency (DARPA), which has a \$3.6 billion budget, provide valuable research funding, and most of the current leading-edge AI firms are American. The current administration has backed the \$1.2 billion National Quantum Innovation Act, and the Department of Energy has also invested \$80 million in quantum research. Mr. Minevich warned that this was insufficient, and that China was already developing quantum technology for use in stealth military craft that could pose a serious threat to America's national defense.

American Strategies for Competing with China

Participants questioned whether the United States should adopt a holistic, strategic approach to investing in priority technologies to regain the lead from China. Dr. Laurie Locascio of the University of Maryland asked whether the United States needed to rethink its science and technology portfolio, and Ms. Trimble echoed this concern, while noting that the United States has historically placed great value on the separation of private and public sector research. Ms. Trimble also asked how the United States should address the talent pipeline and ensure a supply of skilled workers in these fields. Mr. Minevich emphasized that the United States should not copy China's authoritarian model, as evidence in its Draconian response to the COVID-19 crisis, but should seek to match it in expertise. He also urged the United States to pay attention to China's willingness to "capture" expertise it cannot produce at home via copying of research and recruitment of talent. He praised the White House for issuing a strategic plan on AI, but urged the incorporation of multilateral efforts, ethics, compliance, and regulatory concerns into strategic plans, as well as plans for resilience in the face of future disruptive events like pandemics.

Ms. Trimble noted that there is reluctance in the United States to direct private firms to conduct research in particular fields, and Dr. Locascio sug-

gested a “bifurcated” approach, with a test case of one or two industries to see if such efforts were effective in spurring innovation, while waiting for “winning” technologies to emerge in other sectors. Other participants were focused on questions of framing. Dr. Robert Dixon, formerly of PepsiCo, asked what the stakes were if China obtained a commanding lead in these key technologies.

Unique Aspects of the American Innovation Landscape

Dr. Neil Thompson of MIT broke China’s rise down into two categories. The first, which involves increases in scale due to China’s large population becoming wealthier, he categorized as not threatening the United States’ competitiveness. However, he urged intense focus on areas relevant to American innovation vis-à-vis China, including the ability to attract foreign talent to universities and science and technology funding by the government. Dr. Arun Rai of Georgia State University agreed with this demarcation, and also pointed out that the United States’ culture of open-source innovation in software, owing in part due to narrow patent laws, means the extent of U.S. innovation is not fully captured by patent applications, and pointed to benefits of such collaboration. Mr. Minevich agreed, but reiterated that his concern was with the emerging pattern of systematic approaches by China to lead across major technologies. Dr. Rai asked how the United States could leverage its strengths, including an open and collaborative environment, to compete with China, and urged developing strategies to do this for apex technologies like AI. He noted that companies such as Microsoft and Google are invested in helping startups scale up their research, and cited the American startup environment as a significant asset. Participants also noted differences in the research environments of the two countries. Dr. Gary Pratt of Kansas State University questioned how much China relies on original research versus appropriation of other countries’ work. Dr. Ramprasad Balasubramanian of the University of Massachusetts-Dartmouth echoed Mr. Minevich in urging the United States

not to copy China in a reactive fashion, but to independently develop a strategy for achieving technological supremacy.

The Role of Necessity in Determining Priorities

Dr. Tony Tether, formerly of DARPA, stated that invention is spurred by needs, and encouraged the group to focus on what problems the United States needs to solve, and where it is falling behind. He described how Chinese companies are focused on AI for surveillance and facial recognition because of the Chinese government’s preoccupation with identifying individuals planning disruptive or rebellious acts against the state, as well as how DARPA helped kickstart the GPS and geolocation industries under his tenure. Concerned that American forces were not able to locate each other during operations, he offered funding to anyone who could develop a small, fast device for determining global positioning, and how this work led to the development of portable, accurate GPS devices that used gallium arsenide rather than silicon as semiconductors.

Mr. Chad Evans asked the participants which technologies they classified as “needs”, and noted Ms. Wince-Smith’s example of next-generation microelectronics. Mr. Minevich cited AI as a priority and need for the United States, noting its applications to computing, surveillance, and decision making, and urged the United States to align commercial research with this goal, even to the point of picking “champion” firms. Dr. Locascio added quantum computing, synthetic biology, and biotechnology.

Finding the Next Innovation

Dr. Gloria González-Rivera of the University of California, Riverside urged the group to think about finding the next disruptive technology, noting that the current generation of emerging technologies evolved from basic research, including that done by universities, in the past 5 to 10 years. She warned that universities had insufficient funding for basic research,

and characterized academia, as well as federal agencies like the National Science Foundation and National Institutes of Health, as the key to generating the research that will inspire the next wave of transformative technology, especially because of the risk aversion of the private sector. Dr. Tether agreed, but noted that the private sector was generally much better at identifying groundbreaking applications of that research than universities. He noted that the idea to use gallium arsenide in a GPS device was made possible by basic research on transistors, but that the U.S. military was the body to identify a problem that could make use of this research.

Re-framing the Discussion

In concluding the discussion, Ms. Wince-Smith urged fresh language and a fresh perspective on bolstering U.S. competitiveness. Rather than thinking about “winners and losers”, she urged a re-characterization of key technologies as platforms for enabling continued prosperity. She warned about the dangers of losing leadership in quantum, AI, and microelec-

tronics to an authoritarian regime with incompatible values, and that shoring up these platforms, as well as the infrastructure needed to support them, was a necessity. She identified the intersection of the physical and virtual worlds, AI and cognitive technology, and telecommunications infrastructure (especially during the COVID-19 pandemic), as crucial platforms. Dr. Tether encouraged using stories like the development of GPS as test cases to encourage greater appreciation of the importance of research for disruptive innovations.

Working Group 1 Calls

April 14

Introduction and Setting the Stage

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the kickoff speaker, Mr. Andre Doumitt of the Aerospace Corporation, who discussed his experiences in the startup environment and the internal and external factors that contribute to the success of scale-up efforts for innovations. She stressed the importance of increasing basic research funding at the federal level to its mid-20th century share of GDP, and urged the group to identify priorities for research, public-private partnerships, and commercialization.

Kickoff Remarks

Mr. Doumitt discussed his experiences working at an aerospace startup that spun off from intellectual property developed from university research on satellite imaging. After struggling to illustrate the

uses of his company's innovation to clients, who didn't understand the applications of the technology, the firm began rebooting its product line based on feedback and input from end users. He said that a disconnect between the designers of products and their end users is a major contributor to the "Valley of Death." Mr. Doumitt praised the Council's work on problems of technology transition and touted the idea of a national prototyping initiative, discussed during the January Launch Conference at Arizona State University, as a potential solution. He noted that both universities and industry frequently face a lack of expertise in converting early-stage research into adoptable technology, and he expressed frustration at the lack of interest many engineers and designers had in "business problems."

Mr. Doumitt also discussed the importance of incorporating feedback from end users throughout the design process, rather than after the prototype had

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Mr. Dave Copps
Worlds Enterprises

Mr. Eric Cylwik
Sundt Construction

Mr. Andre Doumitt
Aerospace Corporation

Ms. Leah Guzowski
Idaho National Laboratory

Mr. Ryan Haines
Sundt Construction

Dr. Alan Hevner
University of South Florida

Dr. Paul Hommert
Sandia National Laboratory (Emeritus)

Mr. Gerardo Interiano
Aurora Innovation

Dr. Kelvin Lee
University of Delaware

Mr. Guy Snodgrass
Defense Analytics

Dr. Roland Stephen
SRI International

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Dr. Neal Woodbury
Arizona State University

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Josh Oswald

Mr. Tim Planert

Ms. Carol Ann Meares

been developed. As an illustration, he described the successful development of a new model of Medevac helicopter whose success was due to continual input from hospitals about important design features and capabilities, and which later became the most popular model for medical evacuation craft. He encouraged more researchers to cultivate the understanding of “market traction” that startups have by necessity, and also advocated for increased funding of research. He noted that the federal government formerly funded 70 percent of the nation’s basic research, but that the share had declined to 40 percent. In what he described as a “post-Marshall Plan world” and with rising competition from China, he urged greater activity from both government and industry to maintain U.S. competitiveness.

Cultural Dimensions of Scale-Up

Mr. Ryan Haines of Sundt Construction shared a similar “success story” to Mr. Doumitt in the culture of his company. He described how Sundt seeks to “mine its inefficiencies” to innovate internally by examining weaknesses. A key aspect of this process involved cultivating diverse talent. He described how his firm sought out people without specific construction experience to leverage their mathematical or technological expertise, and how this enabled the company to reconceive construction challenges as math or technology challenges. This reframing of problems led to new insights and helped the company successfully innovate to solve problems. Mr. Doumitt concurred with this assessment, and described how his current company, the Aerospace Corporation, discovered that employees were afraid to ask “stupid questions” and as a result frequently didn’t understand the problems they were trying to solve. By creating a more open, “playful” space and actively encouraging these “stupid” questions, the company was able to actually generate new headspaces for its employees that enabled them to approach problems differently and generate more and better ideas. Many of these ideas turned into prototypes or even products because people felt free to ask questions without fear of embarrassment. Ms. Kathy Trimble discussed the argument that fre-

quent job turnover among software engineers spurs innovation because workers become exposed to many different corporate environments and ways of thinking, and bring those mindsets with them to new companies.

Structural Dimensions of Scale-Up

Dr. Paul Himmert, formerly of Sandia National Laboratory, discussed the problem of “gaps” between government needs and approaches to problems and those in the private sector. As an example, he cited the failure of his lab to successfully develop solutions to homeland security problems after the September 11 attacks, because the government was focused on acquiring technologies that had already been developed rather than looking for ongoing or new research projects to support. He expressed concern that similar gaps could develop in extremely pressing areas, such as climate change and public health. Ms. Trimble then asked the group how the government could address these gaps. Dr. Kelvin Lee of the University of Delaware discussed the Manufacturing USA initiatives, which were designed to pool resources among academia, labs, industry, small businesses, and the government. He characterized the strength of these institutes as their ability to bring in creativity and innovation from the academic and research worlds while de-risking technologies for investors. He described how the government was able to support entire sectors without either “picking winners” for specific technologies or firms or investing so heavily in technologies that there was no meaningful co-investment from the private sector. He described this approach as a “leverage” approach that enables the government to convene and deploy resources while letting industry lead the way and providing a nurturing environment for small firms and startups.

Dr. Lee also discussed the current state of the Manufacturing USA program. Originally, there were plans for 40 institutes, but there are currently 14, with two more set to commence during 2020. While existing institutes have focused on advanced technologies and the manufacturing techniques needed

to produce them, new concerns about supply chain security and workforce upskilling have catalyzed a new wave of discussions on expanding the program. Currently, the Departments of Commerce, Energy, and Defense are the primary governmental sponsors, but Dr. Lee expressed the importance of continuing to expand the program to meet new challenges, and said that “all the pieces need to come together” in the innovation ecosystem to solve technology challenges in manufacturing. Dr. Hommert questioned whether the government should wait to see if investments in areas like commercial space flight, renewable energy, and vehicle electrification will achieve sufficient market penetration and cost efficiency that they become viable on their own, or whether the government should intervene with support to maximize the potential economic and employment benefits of the technologies.

The Effects of COVID-19 and Gaps in the Innovation Ecosystem

Mr. Doumitt described how the ongoing COVID-19 pandemic has revealed underlying weaknesses in both firms within the aerospace industry as well as the government's approach to facilitating innovation there. He described how two prominent firms have filed for bankruptcy recently, one of which was in talks with the government for a collaborative venture. Now, that entire initiative will be scrapped and any ideas or uses the government had for the new technology the firm was developing will not be realized. He predicted that the COVID-19 crisis will lead to a shift in the government's approach in which they provide underlying support for all aspects of advanced technology development, rather than merely “filling in the gaps” on the commercial side, because of the need to ensure a viable commercial sector for developing advanced technologies during periods of crisis. Dr. Neal Woodbury of Arizona State University described similar problems in academia to those Mr. Doumitt mentioned in his kickoff remarks. He said that finding people with the expertise needed to “pitch” innovations to clients was expensive and time consuming, and that innovators often missed their

window of opportunity to attract investment because of it. He said it was incumbent on innovators to make their case for their inventions, but that he did not have a complete answer for how to address this issue.

Connections With Previous Council Efforts

Mr. Bill Bates described the Council's previous work on advanced manufacturing and scaling of technological innovations, including the Energy and Manufacturing Competitiveness Partnership (EMCP), which produced several sector-specific studies as well as the summary publication *Accelerate* (2018). He noted two major takeaways. First, across sectors as diverse as aerospace, agriculture, manufacturing, and biotechnology, key commonalities emerged, including talent and workforce development and getting ideas into the marketplace. He noted that many solutions were difficult to scale, and that processes and structures that worked in one sector or location didn't work in others. Second, he discussed the Manufacturing USA initiative, and the ongoing debate about whether its mandate should be made permanent, as the funding stream is subject to sunset and the program was intended to be temporary. He asked if it might be better to establish it as a permanent program given the new competition the U.S. economy is facing in advanced technology deployment.

Case Studies and Illustrations

There was general consensus on the value of case studies to illustrate the dynamics of successful scale-up and make the case for investment. Mr. Haines discussed how Sundt Construction was able to identify a challenge in concrete production. By leveraging 3D modeling, the firm was able to automate a significant part of its production process, and generated returns on this innovation that far exceeded the costs of acquiring 3D modeling capability. He described how Sundt uses a combination of legacy knowledge and experience and judicious investment in innovations to generate

higher productivity that allows the firm to self-fund many upgrades and technological innovations. He also stressed the need to partner with other industry actors and not “reinvent the wheel”, citing Sundt’s use of drone technologies developed by other firms. Ms. Wince-Smith suggested publishing a case study looking at a critical strategic technology with both governmental and commercial applications where the United States faced competition from China, like hypersonics. Dr. Tony Tether, formerly of the Defense Advanced Research Projects Agency (DARPA) agreed. He described how the United States has long been hampered by a lack of tunnels in which to test hypersonic engines, which has slowed the pace of innovation. Meanwhile, China has spent significant resources on building test tunnels, and the United States government continues to be unwilling to spend the money to do the same. He also described a positive story in hypersonics in the form of additive manufacturing. The adoption of additive manufacturing allowed DARPA to cheaply develop a fuel nozzle that would prevent fuel from leaving the center of the engine and lose energy. He concluded by noting that companies where people spend their entire career in one place develop stale cultures, and people with new ideas brought in from elsewhere struggle to win acceptance for them, slowing innovation. Dr. Hommert agreed that hypersonics provided a good case study, but he cautioned that there would be some challenges around classified information. Ms. Wince-Smith concluded the discussion by suggesting the Commission pursue this idea, and to involve Lockheed Martin personnel in the initiative as well.

Working Group 1 Calls

April 16

Introduction and Setting the Stage

The Honorable Deborah L. Wince-Smith welcomed the group, and Mr. Chad Evans stressed the importance of the National Commission's work in light of the recent news that unemployment claims have increased by 22 million over the past four weeks. He stressed the importance of creating new industry and job creation engines for the country.

Opening Remarks: The Problem of Geography

Dr. Roland Stephen of SRI International kicked off the discussion by stressing the importance of geography to the scale up problem. He argued that without addressing the concentrated nature of venture capital investment by industry and geographic

region, most of the country will not have the capacity to scale up innovation in a meaningful way. He described the decline in the United States capacity to produce across a variety of sectors, especially since the 2008 recession, and added that investors who do choose to invest in a startup are perfectly willing to offshore the scale-up process as a result. Dr. Stephen emphasized the topical relevance of such offshoring: the supply chains for vaccines and tests for COVID-19 stretch all around the world but almost entirely bypass the United States. He closed by identifying the reasons venture capital does not invest outside of a handful of areas of the country. First, there is a lack of knowledge of opportunities for venture capital in much of the country due to information deficits. Second, the infrastructure, or lack thereof, makes investment difficult, including the lack of broadband access and other critical IT

WORKING GROUP PARTICIPANTS

Dr. Thomas Campbell
Future Grasp LLC

Mr. Dave Copps
Worlds Enterprises

Ms. Candace Culhane
Los Alamos National
Laboratory

Dr. Nathan Hillson
Lawrence Berkeley National
Laboratory

Ms. Sara Lawrence
RTI International

Dr. Fred Mannering
University of South Florida

Mr. Mark Minevich
Going Global Ventures

Mr. Greg Morin
Argonne National Laboratory

Dr. Al Pisano
University of California, San
Diego

Dr. Gary Pratt
Kansas State University

Dr. Arun Rai
Georgia State University

Dr. Robie Samanta Roy
Lockheed Martin

Dr. Roland Stephen
SRI International

Dr. Neil Thompson
MIT

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Josh Oswalt

Mr. Tim Planert

Mr. Gourang Wakade

Ms. Carol Ann Meares

infrastructure in rural areas. Finally, there is an issue of talent pipelines- many regions are not producing the kinds of human capital needed to scale up ideas, and some of the regions that are, like the Pittsburgh metropolitan area, are still seeing an exodus of talent to traditional venture capital hotbeds. He stressed the need to not only replicate the success of regions like Pittsburgh in producing talent, but also reach a “tipping point” where talent is abundant enough to bring venture capital to it rather than the other way around.

Opening Remarks: Case Study in Rapid Scale Up

Mr. Dave Copps of Worlds Enterprises used his recent success in securing venture funding for an innovation to provide a case study in how scale-up can occur rapidly and efficiently. His company was connected with an investor for a non-invasive test for COVID-19 that was repurposed from an earlier technology thanks to the facilitation of the venture capital arm of the U.S. Air Force. He then received matching funds from both the U.S. Air Force and the Small Business Innovation Research (SBIR) program. He noted that co-investment lowers the risk for any individual venture capital investor, encouraging them to make larger investments as a result. Dr. Robie Samanta Roy of Lockheed Martin noted that in this case, the Air Force choosing to match investment funds, and to help facilitate securing an initial funder, was due to necessity. Most personnel in the defense and intelligence communities cannot work from home, and need a way to safely return to work. As a result, the Undersecretary for Acquisition Technology and Logistics put COVID-19 mitigation at the top of the agenda, at the expense of other initiatives. This included doing market research and making connections within the startup community, like Mr. Copps. This occurred within a ten day span, and illustrated how the combination of deeply engaged senior leadership that prioritizes innovation and a platform to connect funders to ideas can make the scale up process very fast and efficient.

Current and Future Venture Behavior

Mr. Mark Minevich of Going Global Ventures reported that his discussions with the VC community indicated that venture firms were focused on shoring up their existing portfolio of investments, rather than looking for new opportunities. He also expressed uncertainty about how venture capital firms would invest once the crisis had passed, including whether there would be activist VC firms, and whether they would rethink their emphasis on quick profitability over long-term growth potential. He also said it was an open question what kinds of products and services they will invest in. Mr. Copps echoed this assessment, noting precipitous drops in value for many startups due to the recession. He also said that the recent WeWork scandal had caused investors to rethink the valuation of startups when those startups’ perceived value draws so heavily on a single investor. He further predicted that after the crisis, venture firms will increasingly seek outside validation to guide their decisions, including greater participation in public-private partnerships. Mr. Copps also expected the concentration on software to continue, and for investment interest in services to decline, since service-based startups are valued at roughly their current revenue, while tech startups, especially in “enabling” fields like AI, can be value at 10 to 15 times their current cashflow. Conversely, Dr. Samanta Roy referenced a Bloomberg report that 62 venture capital firms had collectively raised \$21 Billion in new financing last quarter despite the recession. Dr. Stephen asked what the medium-term picture was for investment when venture began looking to invest again and there was public money going to tech startups, and Mr. Copps said the picture looked bleak unless venture firms felt a startup had immediate relevance to the COVID-19 crisis or was somehow positively impacted by the current economic environment.

Potential Funders of Innovation

Participants discussed various potential sources of capital outside the traditional venture capital world. Ms. Sara Lawrence of RTI International agreed with Dr. Stephen's analysis of the geographic problems in venture capital, and highlighted state-supported efforts to boost startups in Ohio and Utah as potential models. She further added that these initiatives were increasingly starting to encourage greater diversity in recipients of venture capital funding and in venture capital networks generally. Mr. Copps reported that venture firms were sitting on large amounts of cash, and that many startups, including some on the verge of positive cashflow, were not going to survive the economic downturn due to lack of funding. He said companies needed to discover ways to pivot in response to the crisis and improve their pitch for more funding. Mr. Evans said that there was \$1.5 trillion in idle capital that could be deployed in hedge funds and private equity firms, but Mr. Minevich warned that pension funds, family offices, sovereign wealth funds, and university endowments were all pulling back from venture capital investments. He asked where investment capital would come from after these retreats.

The Role of Crowdfunding Platforms

Dr. Arun Rai of Georgia State University spoke about the promise of crowdfunding platforms, both as a source of capital for innovators who could not attract venture capital funding, and as a mean of signaling to venture capital firms about potential profitable investments. He described a Ph.D. student he advised whose dissertation found that VC firms follow developments on platforms like Kickstarter, and that this reduces venture capital concentration by both location and industry. He urged the group to think about the use of platforms in the different phases of the venture capital process. Mr. Copps agreed with this assessment, and spoke of a desire to create National Innovation Network platform that would both allow investors and innovators to locate

each other by searching industries or key words, and enable different innovators to collaborate and investors to co-invest in products, accelerating the development of ideas and expediting funding for scale up. He added that the technology for such a platform already existed. He predicted this rapid matching of ideas to resources could result in "Direct to Phase 2" experiences like his COVID-19 test startup, and said that "innovation accelerates" when more people come together to work on ideas. Dr. Stephen added that crowdfunding platforms could be an excellent signaling mechanism for venture capital.

Necessity as a Driver of Innovation

Ms. Trimble discussed her experiences working at the Joint Chiefs of Staff, and how senior acquisition personnel were frustrated by the time-consuming nature of the evaluation process. She said that understanding trade-offs, and then scaling up technology and persisting in that scale up over time, was the biggest challenge in technology transfer. Dr. Samanta Roy added that no significant innovation in military technology came about from a stated written requirement. Instead, innovations came from tech-savvy senior personnel who understood the operational utility of basic research discoveries and worked to advance them to scale-up. He discussed the Department of Defense's efforts to increase the frequency of this process through programs like Air Force Ventures and the Defense Innovation Unit, but noted that large programs eventually require innovations be entered into programs of record with their extensive standards and requirements. Dr. Samanta Roy added that wars, pandemics, and other "stress cases" that forced personnel to take shortcuts end up spurring innovation, as the time pressure helps them identify which processes can be expedited and which hurdles eliminated. If senior staff can institutionalize knowledge of these shortcuts once the crisis has passed, the organization becomes more innovative. Ms. Wince-Smith asked if there was a systemic way to facilitate this process, and Dr. Samanta Roy said that changing the focus of military

acquisition standards from perfection to near-perfection in a shorter timeframe was needed. He said that startups are innovative precisely because they work on a short timeline that necessitates creativity.

Non-Deployment of Capital

Dr. Tom Campbell of Future Grasp, LLC noted that many potential investors were not deploying their capital, and asked if there was any comprehensive reporting on the past, present, and future status of investment, or a systematic analysis of why capital was not being deployed. He suggested that such a project from the Council would be very influential. Mr. Minevich said that while there was not yet any granular data, initial attempts to gather such information by Goldman Sachs, as well as his own conversations with people in the venture world, suggest a bleak picture for investment by venture capital, family offices, private equity, sovereign wealth funds, and pensions funds. He further identified human capital and product market fit as key ingredients to successful scale up, and said startups will also need assistance in finding these things, not just funding. Dr. Neil Thompson of MIT referenced a Duke University study showing a retreat by businesses from investing in basic research, leaving the federal government as the only basic research funder. He worried about the impact this would have on the future commercialization of innovation, because most innovations build on basic research and applying knowledge gained in novel ways. Mr. Evans agreed that the drying up of funding would have a significant impact in 15 to 20 years.

Supply Side Considerations

Dr. Thompson questioned whether the problem of capital availability was truly one of demand. He said that while entrepreneurs complain about the unwillingness of venture capital to invest in their ideas, venture capitalists he talked to explain that they are seeing fewer promising ideas with sufficient potential returns to justify their investment. He pointed out

that prior to the recession, capital was already far cheaper than its historical average, and asked how to help entrepreneurs generate more good ideas. Ms. Lawrence added that she had heard the same things from venture capitalists, and reiterated that there was increasing concern in the venture world about broadening and diversifying venture capital networks and recipients of investment.

Tax and Regulatory Incentives and Conclusion

Ms. Wince-Smith asked what sorts of tax and regulatory incentives might increase venture capital's willingness to invest, especially in longer-term projects with more risk involved. Mr. Copps said that many firms use warrants to limit their tax liability, but that the benefit of existing tax preferences is skewed toward investors with the most money, and that the incentive system overall was messy and complicated. Ms. Wince-Smith emphasized the importance of catalyzing investment in key technologies that are relevant to U.S. competitiveness, including AI, microelectronics, and bio-resiliency. She said that if a company like Intel were trying to launch today, they would fail to receive funding because of the risk aversion of venture capitalists, and wondered if government intervention was necessary to encourage investment in these areas. Ms. Trimble noted that next week's discussions would be kicked off by former Sandia National Laboratory Director Paul Hommert, and would focus on developing strategic priorities and roadmaps for critical technologies.

Working Group 1 Calls April 21

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group, and Mr. Chad Evans shared that the Council would make its previous works on the subject of scaling technology available via the online portal. Ms. Kathy Trimble introduced the day's topic, developing priorities for technology scaling, and the opening speaker, Dr. Paul Himmert, formerly of Sandia National Laboratory.

Opening Remarks

Dr. Himmert drew on the concept of the “value chain” developed by Dr. Michael Porter, a former affiliate of the Council. He spoke of how Dr. Porter distinguished between “primary” components, including logistics, manufacturing, sales, marketing, and customer service, and “supporting” components, includ-

ing human resources, firm infrastructure, technology development, and procurement. Dr. Himmert identified pressing issues in the U.S. value chain space as ensuring maximum societal benefit from investments in the value chain and the appropriate distribution of foundational research efforts.

Dr. Himmert noted that different industries had dramatically different supply chains. Apple, despite employing over 90,000 Americans, has significant components of its value chain in China and South Korea, while the defense and oil and gas industries have primarily domestic supply chains for national security or resource endowment and infrastructural reasons. He discussed how new companies, like Tesla, have some of their value chain in China- like battery manufacture- but the majority is located in the United States. He stressed the need for the United States to not lose out on the fruits of its

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Dr. Ramprasad Balasubramanian
University of Massachusetts-Dartmouth

Mr. Bill Briggs
Deloitte

Dr. Thomas Campbell
Future Grasp LLC

Mr. Robert Dixon
PepsiCo (Emeritus)

Mr. Andre Doumitt
Aerospace Corporation

Dr. Paul Himmert
Sandia National Laboratory (Emeritus)

Dr. Laurie Locascio
University of Maryland

Dr. Fred Mannering
University of South Florida

Dr. Robie Samanta Roy
Lockheed Martin

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Dr. Neal Woodbury
Arizona State University

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

efforts, giving the example of Extreme Ultraviolet Lithography (EUVL), which Sandia helped develop in conjunction with American microelectronics firms in the 1990s. Although there was no commercial use at the time, leading firms, like Taiwan's TSMC, are making use of it to develop better processors. He discussed the loss to the U.S. economy from not being the "first to market" with an American innovation, and asked how the United States could strengthen its control of the value chain.

Dr. Hommert also discussed the different levels of research in innovative technology. He noted that government, nonprofits, and academia account for the majority of basic research and business for the majority of experimental development research. However, there is a roughly even split when it comes to applied research, which he characterized as the middle of the research value chain. He said this space offers the greatest opportunities for public-private partnerships, giving examples of previous successful collaboration. Fracking, and its expansion of the domestic natural gas industry, is possible because of a combination of three innovations. Diamond drill bits were developed by General Electric and perfected by Sandia, seismic mapping developed from Department of Energy experiments, and directional drilling was developed by the private sector. Dr. Hommert said that by focusing on the middle of the research process, government and industry can identify the key components of the value chain for a given technology.

Finally, Dr. Hommert discussed other issues that will require the collaborative development and scaling of innovation. These include establishing climate-resilient infrastructure, long-term storage options for renewable energy, carbon capture, nuclear power expansion, and healthcare. In particular, he discussed the potential value of pan-viral drugs that could be prepared and stockpiled in advance of future pandemics. He suggested reallocating existing funds to help pay for such research, and said that federal support for key technologies could de-risk their introduction and scaling.

Capturing the Value Chain in Advanced Technologies

Ms. Wince-Smith asked about the importance of maintaining leadership in next-generation microelectronics with the looming end of Moore's Law and diminishing productivity from CMOS processor technology. Dr. Hommert said that microelectronics must be carefully evaluated against the value chain, and that it will be difficult to get "ahead of the curve" because the industry is so large and has so much capital investment. He reiterated his disappointment in seeing Taiwan develop the first instantiation of American-designed EUVL technology, and warned that without pressure, the microelectronics value chain would continue to move offshore. He then pivoted to the development of pan-viral therapy as an example of how to avoid this pitfall. Because pharmaceutical manufacturers are profit-driven, they will not invest in developing a therapy that may not need to be used, making advance development of drugs for future pandemics an opportunity for public investment. He also suggested the involvement of nonprofits, like the Bill and Melinda Gates Foundation, in such an endeavor, since they play a role in connecting academia and government with industry and tend to be forward-looking in their research agendas.

Prioritization Strategies and Opportunities for Collaboration

Dr. Laurie Locascio of the University of Maryland asked whether the United States should prioritize continued leadership in technologies where it already leads, or if it should invest more in catching up in areas where it lags behind. Dr. Hommert argued that the country needed to balance both objectives, and mentioned that the United States lagged China and the EU in multiple critical arenas. He further warned that the United States formerly led in many technologies before "losing sight" of the value chain and ceding leadership to foreign countries. He urged for the United States to take a hard look at those areas, and ask on a case-by-case basis if it is crucial for

those technologies to be manufactured domestically. Mr. Ted Agne of Communications Strategy Group discussed biotechnology as an opportunity for collaboration between the United States and its allies that makes use of each side's respective leadership. He described how Swiss companies and British research universities were doing innovative work on incorporating AI into biotechnology, but they lacked the expertise in scaling and implementing their discoveries. Mr. Agne said there was great potential for American partnership with Switzerland and the UK, where both sides could benefit from faster development and scaling of innovation. Dr. Hommert concurred, and he praised the strength of the UK university system in developing innovation, but emphasized its profound difficulties in the engineering and application of innovations. He stated that recognizing the strengths and weaknesses of different parties was the basis for successful collaboration. Dr. Tony Tether, formerly of the Defense Advanced Research Projects Agency (DARPA) described how Britain has struggled to set up an equivalent agency to DARPA because of the unwillingness of their government to reorient from basic research to problem-driven research.

Healthcare and Technology “Streams”

Mr. Evans spoke of shifting focus from single technologies to “streams” of key technologies that would combine to drive productivity growth and disruptive innovation across sectors. He mentioned the Council's collaboration with Gallup to produce *No Recovery* (2016), which discussed the slowing of the U.S. economy due to lagging productivity in education, healthcare, and the built environment. He suggested determining priorities and “pillars” via this integrated framework that focuses on unlocking productivity and solving problems. Ms. Carol Ann Meares of TechVision 21 identified technology streams as key to scaling, and scaling as the key to job growth and productivity growth. However, she noted policy

makers focused more on funding of basic R&D and the Valley of Death than on expediting deployment. Dr. Robert Dixon, formerly of PepsiCo, echoed the importance of healthcare as productivity-slowing industry. He predicted that unless innovations stemmed the increase in healthcare costs as a share of GDP, the healthcare system would collapse under its own weight in the coming decades because of affordability issues. He said streamlining the healthcare value chain will require disruptive innovation and novel thinking, and encouraged the group to think about critical opportunities in the healthcare value chain.

Challenge-Driven Research

Dr. Tether argued that problems and challenges spur successful innovation, and urged a reorientation of national science and technology priorities around solving major problems. Mr. Evans agreed, but noted there were areas where the problem was clearly defined, such as healthcare, but unlocking greater productivity remained an obstacle. Ms. Meares asked if academia's and government's research portfolios should be more problem-driven. Dr. Neal Woodbury of Arizona State University replied that universities and government institutions like NSF and NIH will always have some focus on basic research, especially because of unforeseen discoveries that emerge from this research, like CRISPR technology for gene editing. However, he also said that these groups are increasingly focusing on making connections between their academic research and concrete problems in government or industry. He said finding a way to facilitate these connections is crucial, as is developing greater resiliency. Dr. Woodbury said that it will take 18 months to develop a COVID-19 vaccine, but this is because of the lengthy safety demonstration process. To be more responsive to crises in the future, researchers will have to develop a way to gather relevant data faster, possibly using advanced technology.

The Importance of Resiliency

Dr. Tom Campbell of FutureGrasp, LLC also advocated focus on resiliency. He argued that technology does not exist in vacuum, and must be relevant to emerging geopolitics and current events. He stressed the importance of near-term resiliency solutions because of the massive disruption to supply chains caused by the COVID-19 pandemic, and warned that the expert consensus was that they would not return to their pre-pandemic states. Mr. Evans noted reports that firms experienced fewer losses in the Chinese market than they had predicted, and wondered if they would alter their supply chains as dramatically as believed. He also discussed the Council's ongoing work on a report addressing resiliency in the American economy, which will be released shortly, along with recommendations for investment priorities.

Intellectual Property

Dr. Robie Samanta Roy of Lockheed Martin identified intellectual property, especially negotiation of tech transfer agreements between academia and industry, as a major obstacle to quicker scaling of innovation. He said the current pandemic has motivated the parties involved to develop a solution because of the critical importance of timely response to mitigating its effects. He discussed Harvard, Stanford, and MIT's joint decision to change their IP policies to enable the private sector to make use of their research in developing COVID-19 responses. Dr. Locascio added that the University of Maryland had joined this agreement, and Dr. Dixon discussed his experiences negotiating IP agreements through his work with Georgia Tech. He added that any work the Commission could do in streamlining and expediting tech transfer agreements would have significant benefits for the pace of innovation.

Concluding Thoughts

Ms. Wince-Smith thanked the group for their discussion, and emphasized that the Council must balance short-, medium-, and long-term issues to maintain its impact and credibility. She particularly stressed the need to identify solutions for problems generated or exacerbated by the COVID-19 crisis, like mass testing and deployment of treatments and vaccines. She also discussed the applications of AI and High Performance Computing in accelerating research on treatments and vaccines. Dr. Hommert discussed other areas where broad infrastructural resiliency will be key in the coming years, including climate change and intellectual property. He spoke of the importance of balancing the "whats" and "hows" of innovation, and said it was unlikely the country would run out of problems to solve. Dr. Samanta Roy suggested exploring the DOD framework for intervention in research projects, which delineates roles including "lead", "follow/partner", and "watch." He said this framework would help policy makers balance long-term strategic goals with short-term dynamic reallocations to deal with emergent crises.

Working Group 1 Calls

April 23

Introduction

Ms. Kathy Trimble and The Honorable Deborah L. Wince-Smith welcomed the group. Ms. Trimble introduced the opening speaker, Dr. Paul Hommert, formerly of Sandia National Laboratory.

Opening Remarks

Dr. Hommert opened his remarks with a discussion of former Council affiliate Dr. Michael Porter, of Harvard Business School, and his conception of the “value chain.” The value chain consists of primary components, such as supply chains, manufacturing, delivery, marketing, and sales, and of

supporting components, including human resources, procurement, and technology development. He said that technology development and inbound logistics (like supply chains) were particularly relevant to the group’s discussion. Dr. Hommert surveyed the varied nature of American companies’ supply chains. Apple has a significant supply chain presence in China, but still employs over 90,000 Americans and has domestic suppliers. The oil and gas industry has an almost entirely domestic supply chain for historical and resource reasons. Tesla has factories abroad but has its value chain located mostly in the United States. Dr. Hommert said identifying why Tesla chose a domestic value chain, whether from founder pref-

WORKING GROUP PARTICIPANTS

Mr. Mike Cassidy
Emory Biomedical Catalyst

Ms. Candace Culhane
Los Alamos National Laboratory

Dr. Jennifer Curtis
University of California, Davis

Dr. Gloria González-Rivera
University of California, Riverside

Mr. Ryan Haines
Sundt Construction

Ms. Maggie Hallbach
Verizon

Dr. Alan Hevner
University of South Florida

Dr. Nathan Hillson
Lawrence Berkeley National Laboratory

Mr. Gerardo Interiano
Aurora Innovation

Ms. Sara Lawrence
RTI International

Mr. Mark Minevich
Going Global Ventures

Lt. Col. Stewart Parker
Center for a New American Security

Dr. Albert Pisano
University of California, San Diego

Dr. Gary Pratt
Kansas State University

Dr. Arun Rai
Georgia State University

Dr. Roland Stephen
SRI International

Dr. Neil Thompson
MIT

Mr. David Vasko
Rockwell Automation

Dr. James Weyhenmeyer
Auburn University

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

Mr. Gourang Wakade

Ms. Carol Ann Meares

erence, government incentives, or other reasons, was important to understanding how to capture more of the value chain from American innovations.

Dr. Hommert identified societal benefit as a valuable construct for organizing thinking about how to prioritize policies, segments of the value chain, and technologies. He defined societal benefit as comprising national security; economic security, including manufacturing capacity and technological connectivity with production; and health and well-being, including healthcare and the environment. He cited the Council's 2018 report *Accelerate*, particularly its list of "Exponential Technologies" on page 44, as examples of valuable cross-cutting, enabling technology. These include AI, 3D printing, cybersecurity, high-performance computing, biotechnology, and advanced materials. He described these fields as areas where the United States was a leader in innovation, but was not controlling or capturing the full value of these innovations. Mr. Chad Evans added that the Council had partnered with Deloitte in 2018 for a deep dive on exponential technologies and their applications called *Exponential Technologies in Manufacturing*.

Dr. Hommert characterized applied research as an ideal focus for public-private partnership in disruptive technology. He noted that the public sector conducted most basic research and the private sector most experimental development, but that there was near parity in public and private expenditure on applied research that bridged the two. He advocated collaboration in this area to de-risk investment in exponential technologies, citing the example of Sandia's collaboration with microelectronics manufacturers to develop Extreme Ultraviolet Lithography. However, this technology, which enabled the development of 13.5 nanometer laser lithography, was first brought to market by a Taiwanese semiconductor manufacturer, and illustrates the costs of failing to capture the value chain in technology development. For future areas of partnership, Dr. Hommert suggested low carbon energy, post-lithium ion energy storage, high-density energy generators like modular nuclear reactors, and nuclear fusion, which has been made more feasible by advances in magnet and containment technology. He also identified resilient

infrastructure in light of climate change and rising sea levels, and healthcare, especially pandemic deterrence via pan-viral drug therapies, as valuable endeavors.

Facilitating Serendipitous Discoveries

Dr. Al Pisano of the University of California, San Diego asked how to increase the frequency of serendipitous discoveries of applications for technologies, such as improvements in magnet technology that have expedited research on nuclear fusion. He said generating more of these connections could move latent innovation through the ecosystem faster, and Dr. Hommert agreed on the benefits of such connectivity. He suggested creating policies, forums, platforms, and partnerships between entities that would force more intersection between exponential base technologies and unmet needs, including healthcare and low-carbon energy. Dr. Hommert said the United States does well in basic research, but not in realizing its applications and turning them into products. He also warned that too much focus on a particular end-use for an innovation, which is what motivates private sector investment, can lead to stakeholders overlooking potential alternative applications. Dr. Pisano asked if the country needed more "ecosystem" thinking with respect to innovation, and Mr. Evans discussed the Council's 2018 *Clarion Call*, which includes a graphic illustrating the role ancillary technologies play in disruptive innovation.

Improving the Value Chain

Mr. Mark Minevich of Going Global Ventures asked what concrete, specific steps the country could implement to improve the national value chain, in both the short and long-term. He said that experts believed the economy would never return to its pre-COVID-19 state, and that the United States needed disruptive innovations to improve its manufacturing and logistical systems in light of this new reality. The pandemic has altered supply chains, human capital, and the future of work, and Mr. Minevich spoke of the need to move manufacturing out of China and help Americans adjust to the new economic reality,

which will include the transformation or elimination of many businesses and new deployments of information and communications technology and artificial intelligence. Dr. Hommert said he wasn't sure exactly what the solutions to these problems were yet, but noted there would be pressure both to forge ahead in the new economic landscape and to resurrect parts of the old one. He spoke of the opportunity to clarify what constitutes value in the "new normal," and of the continued need for traditional sectors like energy and transportation, even if in modified form. Dr. Roland Stephen of SRI International said the general inclination for policy makers was to look through the "wrong end of the telescope", and that the focus was always on market applications of technologies and industry needs. He predicted the crisis would accelerate existing trends, like the development of shorter, more agile supply chains and the deployment of new technologies in the service sector. Dr. Pisano asked if the "new normal" would provide as many job opportunities as the old landscape, and how innovation could be leveraged to create them if not.

Mr. Dave Vasko of Rockwell Automation said the crisis offered an opportunity for companies to radically rethink and improve their processes and business model. He noted that the "old normal" often included many techniques and models that were "good enough" but not optimally designed. He noted that familiarity and a lack of flexibility previously prevented firms from making changes that would yield efficiency improvements, and that this crisis could provide them with a springboard toward a robust, flexible supply chain. Dr. Gary Pratt of Kansas State University added that the crisis was accelerating changes in the higher education arena, including the closing of institutions, the changing relevance of traditional pedagogy, and new challenges in supporting research and compliance.

Changes in Trends

Ms. Margaret Hallbach of Verizon predicted that the COVID-19 pandemic would reverse the trend toward rapid urbanization in the United States, as people became desirous of more open spaces and feared the public health implications of population density. She also forecasted an increased emphasis on supply chain diversity, which she characterized as a microcosm of the government's competitiveness challenges. She added that the country needed to think about competitiveness in challenging times and crises as well as normal times, and of reframing competitiveness as protection and security, including access to food, medication, and crucial raw materials. Ms. Wince-Smith agreed, and added that movement away from urbanization made the development of robust 5G communications infrastructure in rural areas even more urgent, and noted that a healthy, economically secure populace was crucial to competitiveness as well. She added that reliability was an important component of competitiveness along with security.

The Need for Security

Dr. Gloria González-Rivera of the University of California, Riverside identified food production as an area where the United States needs to invest in supply chain security. Mr. Evans agreed and noted that disruption to the food supply would stifle efforts at enhancing security, productivity, or prosperity. Mr. Minevich added healthcare and biotechnology as key sectors for ensuring supply chain security, and Ms. Sara Lawrence of RTI International echoed the emphasis food security, adding agricultural technology as a key component. Dr. Stephen noted that new needs prompt transformation in applied technology, and that problem-driven approaches would expedite the development of technology to address these issues.

Priorities, Problems, and Platforms

Ms. Trimble asked the group if the United States should adopt a list of strategic technology priorities. Dr. Stephen suggested the development of priority challenges that will require advanced technology to solve, as it gave the country the opportunity to “pull on threads” and uncover new applications for innovations. He discussed the need for the casino industry in Nevada to placate customers regarding the spread of disease by developing ways to remotely identify the sick, and Ms. Lawrence said that Disney World was researching the same issue. Mr. Evans predicted this would become important for all industries that deal with crowded spaces, including cruise ships, airlines, and even office buildings. Dr. Stephen discussed Apple and Google’s joint venture to create a platform for COVID-19 testing and contact tracing, and of the need to adequately handle privacy concerns from the gathering of people’s personal data. Dr. Pratt urged the continue recognition of the importance of privacy. Ms. Lawrence asked if the focus should be on individual technologies or on cross-cutting platforms to prioritize, and Mr. Evans suggested thinking about problems and the platforms to collaborate on solving them on the one hand, and the technologies and investments needed to do so on the other. Ms. Carol Ann Meares of TechVision 21 asked if a problem-focused approach would change the way the government makes R&D funding decisions, and Ms. Lawrence said that at the regional level innovation blueprints have already shifted from single technologies to cross-cutting clusters that have more applications and opportunities and greater impacts.

Dr. Arun Rai of Georgia State University discussed the potential value of platform technologies for collaboration at scale and through uncertainties. He discussed Bill Gates’ recent article on the future of vaccine development, and how creating a common platform for innovation enables the stakeholders who are most important during different stages of the

innovative process to easily enter into the process, resulting in a fundamental transformation of the nature of experimentation. This new paradigm would be built for navigating uncertainty, constant innovation, and collaboration at scale. Ms. Meares asked if such a platform would generate problem-specific technologies that could be fed back into improving or informing basic research, and Dr. Stephen said that upstream signaling was critical, with platform technology providing a bridge solution. Ms. Lawrence suggested the group develop criteria for choosing platforms, technologies, and industries to help the prioritization process and focus national and regional conversations in investment in disruptive technology.

Dr. Neil Thompson of MIT suggested delineating three categories of output, especially in light of a “grand challenge” framework. First, there are market-driven research projects, intended to solve pressing issues in key industries like healthcare or energy. Second, there are research projects fundamental to basic research, such as deeper understanding of the brain, or of the nature of matter. Finally, there is research into the technologies needed for the other two kinds of research, such as advanced computing. Ms. Trimble noted that any focus of government research would face political, social, and resource constraints, and that there would always ultimately be trade-offs between different approaches.

Public Desires and Human Capital Questions

Mr. Minevich stressed the importance of considering the societal implications of economic change. He discussed how organizations like the G20 and the International Chamber of Commerce were shifting their focus away from questions of productivity growth and disruptive technology and toward a sustainable, comprehensive, robust, and inclusive economy of the future. Dr. Stephen added that technology was not sufficient to solve societal challenges. Dr. Rai said the emphasis on inclusion was very power-

ful, and too many people were not participating in the innovation ecosystem through expressing their needs and participating in developing solutions. He said in a diverse, democratic country like the United States, an emphasis on expanding participation in the innovation ecosystem was both powerful and imperative.

Ms. Hallbach discussed the importance of the current pandemic on the future of work. She noted that while even some low-wage workers such as call center employees were able to work remotely, “non-critical” service employees who do not have the luxury of working from home were unable to participate in the economy. She said this has the potential to create new groups of “haves” and “have-nots,” and will shift the manner in which economic models are contemplated. Dr. Stephen agreed and said it was worrying that a large share of the workforce could be “sidelined” for such a long time. He also expressed hope that “essential” workers, including sanitation workers, food service workers, and first responders, would see an increase in their perceived value, bargaining power, and subsequently pay and conditions. Ms. Trimble noted a similarity in this conversation to issues being discussed in the second Working Group.

Dr. Hommert said he was also concerned about the needed transitions when the COVID-19 pandemic ends after the development of a vaccine and treatments, including how to reassure people about returning to crowded events. He stressed the need to develop the technology to enable people to feel safe from the spread of contagious disease in public. He also suggested developing a priority list for technologies with widespread societal benefit, including healthcare, infrastructure, and climate resiliency. He further emphasized the importance of prioritizing cross-cutting platforms that will enable these innovations.

Concluding Thoughts

Ms. Wince-Smith thanked the group for participating, and noted the common themes that were emerging across all three working groups, particularly those focusing on quality of life and human capital concerns. She compared the current landscape to that of the late 1980s and early 1990s, when U.S. manufacturing capabilities were off-shored and the production infrastructure deteriorated, and the U.S. economy faced significant competition from Japan. She said movement toward advanced production and manufacturing gave the United States an opportunity to develop a more balanced economy, and spoke of the national security and health implications of America relying on foreign manufacture of pharmaceuticals and medical devices. Ms. Wince-Smith added that the Commissioners had charged the working groups with developing short-, medium-, and long-term policy recommendations, and that it was crucial to develop responses to the COVID-19 pandemic to offer short-term solutions.

Working Group 1 Calls April 28

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the opening speaker, Mr. Greg Morin of Argonne National Laboratory. Ms. Kathy Trimble said the day's discussion would be focused on the issue of national leadership and strategies for competitiveness. She cited the Commissioners' charge to increase innovation "tenfold", and encouraged the group to think about the structures the country needs to implement to bolster innovation, along with ways to strengthen industry investment in universities and national laboratories.

Opening Remarks

Mr. Morin opened with a discussion of the innovation ecosystem in Chicago, where Argonne is based. He noted that innovation ecosystems vary throughout

the country, but felt that Chicago's successes and challenges offered lessons. He described the ecosystem in Chicago as "stovepiped", with insufficient local, state, and federal leadership, a lack of coordination and collaboration, and insufficient incentives for innovators and entrepreneurs to remain in Illinois. He cited the lack of necessary infrastructure and equipment, including lab facilities, as a major obstacle to keeping innovators in the Chicago area.

Mr. Morin also emphasized the importance of tax incentives for investment and construction of manufacturing facilities, and called for a clear plan with defined leadership roles and the involvement of private equity firms in a joint venture to increase innovation tenfold. He warned that venture capital and startups did not possess sufficient resources to shoulder the burden of exponential innovation growth alone. Mr. Morin also called for the creation of incu-

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Dr. Thomas Campbell
Future Grasp LLC

Mr. Dave Copps
Worlds Enterprises

Ms. Candace Culhane
Los Alamos National Laboratory

Dr. Alan Hevner
University of South Florida

Dr. Paul Hommert
Sandia National Laboratory (Emeritus)

Mr. Gerardo Interiano
Aurora Innovation

Dr. Kelvin Lee
University of Delaware

Dr. Laurie Locascio
University of Maryland

Dr. Fred Mannering
University of South Florida

Mr. Greg Morin
Argonne National Laboratory

Dr. Gene Robinson
University of Illinois

Dr. Robie Samanta Roy
Lockheed Martin

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

bation spaces for entrepreneurs that would provide access to labs and other scarce facilities and equipment, to be co-located with research universities and national laboratories. In the wake of the COVID-19 pandemic, Mr. Morin urged the country to seize the opportunity to reexamine its supply chains, and to make use of tax and trade incentives that would encourage on-shoring of key production facilities, especially since the United States' competitors use these policy tools.

Another theme of Mr. Morin's remarks was talent development. He praised the decision by President Michael Crow of Arizona State, a Commission Co-Chair, to overhaul the school's engineering program, and encouraged other schools to follow suit with disruptive innovations. He said that because engineers design and make things, without developing the capacity to put knowledge into practice domestically, U.S. engineering schools would become training grounds for the world's workforce but not our own. He also encouraged incentives for students to attend technical schools, and predicted the promise of a job at the end of training would be more enticing going forward as the pandemic and ensuing economic crisis disrupt the traditional four-year college system.

Mr. Morin also addressed the issue of national leadership on innovation. He noted that while the executive branch's ad hoc approach to innovation policy had worked well in the past, the national research enterprise currently suffers from a lack of coordination and collaboration, and is failing to seize opportu-

nities to maintain U.S. leadership in critical technologies. He suggested that the Office of Science and Technology Policy (OSTP) could provide organization and leadership, but worried its support would fluctuate heavily with election cycles. He described AI and quantum technology as opportunities to catalyze a new era of collaboration, and while praising the coordination of efforts by stakeholders in response to the COVID-19 crisis, argued that those systems should have been in place already. Mr. Morin suggested the development of analogs to the Department of Energy's Office of Technology Transition in other agencies, and underscored the importance of coordination from the executive branch given the efforts of America's competitors. While supportive of a national body to integrate research efforts, he expressed concerns that such an initiative could become heavily bureaucratized, like the Department of National Intelligence created in the wake of the September 11th attacks, and identified the need for an organization like the Office of Technology Assistance, which provided in-house education to members of Congress from 1972-1995. At the state level, Mr. Morin discussed Illinois' creation of the Discovery Partners Institute, designed to coordinate research, bring together government, industry, labs, and academia, and encourage entrepreneurs to remain in the state.

Finally, Mr. Morin discussed the role of industry in investing in academic research. He said that companies were willing to invest in universities if they could find a value proposition, but added it was crucial for universities and labs to have appropriate funding to help companies with their needs. He said that most

companies that approach Argonne have specific technological challenges in product development, creating an obvious value proposition with clearly defined roles for the participants. He said that issues around intellectual property and tech transfer were being solved, but warned that continuing declines in R&D funding were decimating America's research capabilities. He also warned that the United States was falling behind not only China, but countries like Japan and Germany, in making the coordination of stakeholders in research a standard operating procedure.

Examples to Replicate

Mr. Chad Evans asked if there were examples states or the federal government could learn from, including endeavors like the BRAIN Initiative, clean energy projects, the National Strategic Computing Initiative, or the Manufacturing USA institutes created by the National Manufacturing Innovation Initiative (NMII). Dr. Robie Samanta Roy of Lockheed Martin said that while the jury was still out on the long-term benefits of Manufacturing USA, there were still key takeaways. First, the NMII showed that government and industry had identified key technologies such as composite manufacturing and advanced computing that were important for the nation to prioritize. He added that the Department of Defense was the key sponsor for many early Manufacturing USA institutes, with corporate sponsors including Lockheed Martin also joining. He described the importance of creating win-win propositions where all stakeholders

believe they are getting value, and cited scalability as the biggest issue. He warned that companies were beginning to get "institute fatigue" and were afraid of diluting their efforts by sponsoring more and more institutes. Dr. Samanta Roy further stressed the need to identify a "burning platform" that would focus the energies of participants. In the recent past, national security questions filled this role, but in recent years, innovations themselves were creating challenges. In particular, the deployment of 5G wireless networks has required both government and companies like Lockheed to redesign many communications systems to be compatible.

Dr. Samanta Roy said that the biggest problem facing U.S. technology leadership was advanced microelectronics. He warned that America relied on processors manufactured in South Korea and Taiwan, both of which are in striking distance of strategic adversaries like China and North Korea. To develop protections against supply chain disruption, the United States needs to prioritize the development of microelectronics manufacturing capacity, as well as find a way to fund the tens of billions of dollars in investments this will require.

Mr. Evans asked what the value proposition was from the Discovery Partners Institute (DPI) in Illinois, and asked how the German Fraunhofer Institutes managed to escape the challenge of "institution fatigue." Mr. Morin said that the value proposition for the DPI involved clear leadership of its various components, and noted that prior to the crisis, the state had allocated \$1.2 billion in funding, but bud-

getary uncertainties might alter this. He added that one purpose of the DPI was to keep entrepreneurs in Illinois by providing them with access to resources. He discussed how a colleague had relocated multiple startups from Chicago to Boston due to insufficient access to wet labs in Illinois. Mr. Morin said the Fraunhofer Institutes are funded indirectly by the government through funding to industry that is then invested in the institutes, which provides an incentive for engagement with laboratories and causes the institutes to function as a shared service. He also cautioned that it was better to concentrate on finding incentives for all firms to benefit from investment in facilities rather than create long-term projects like the NMII with uncertain value propositions.

State Level Efforts

Dr. Laurie Locascio of the University of Maryland asked if states should engage more with federal science and technology strategy, noting their leadership in response to the COVID-19 pandemic. Mr. Morin said that state engagement was inevitable because funding for national laboratories and for basic research was disbursed at the federal level. He added that states have significant control over innovation ecosystems through tax policy and the environment they create for entrepreneurs, and in their ability to respond to the unique challenges and conditions of regional innovation ecosystems. He said that Argonne struggles to attract and retain startups because of a challenging environment for entrepreneurs at the state level. Mr. Morin also called

for improved coordination frameworks across agencies, noting that none of the national laboratories conduct medical research because there is no way for them to collaborate with NIH. Finally, he praised the current administration's funding of AI and quantum research, saying that picking targets for labs, universities, and industry to focus on is the right policy, provided those targets are relevant to America's national interests.

The BUILD Initiative

Mr. Evans discussed the Council's Building University-Industry-Laboratory Dialogue (BUILD) Initiative, the final report for which will be posted on April 30. Funded by a grant from the National Science Foundation, the final report contains ideas for public-private partnerships to create the next generation of microelectronics, as well as "bridge" technologies to allow for continued progress before a new technology with its own "S-Curve" innovation path is found. He discussed America's need for semiconductor leadership, and the rapid consolidation of the processor market, as cutting-edge 7nm fabs are only being manufactured by Intel, Samsung (South Korea), and TSMC (Taiwan), in contrast to 8 leading-edge firms just 10 years ago. He said the United States needs to think about resiliency and innovation in this space, and noted that the recommendations are geared toward the Joint Program Office of the National Strategic Computing Initiative.

Continuity Across Administrations

There was significant discussion by participants about ensuring continued support for scientific research in national priority areas across presidential administrations. Dr. Paul Hommert, formerly of Sandia National Laboratory, said any coordinating office needed the capacity to span administrations, and had to develop a “burning platform” to encourage ongoing focus, such as national security. He said that securing Presidential support was the most important element of robust investment in research. Ms. Candace Culhane of Los Alamos National Laboratory noted that current initiatives in quantum computing and artificial intelligence are the result of policy groundwork laid by the National Strategic Computing Initiative of the previous administration. Ms. Trimble highlighted a graphic produced by NSF showing how its investments in basic research in past decades contributed to the development of current commercial technologies, which is available on the online portal. Dr. Tom Campbell of Future Grasp Ventures noted that because administrations change frequently and bring their own priorities with them, some sort of legislative or legal structure was necessary to ensure long-term research enterprises were not disrupted. He said it was frustrating to watch great projects “die on the vine” due to a change in administration or a new session of Congress.

Next Generation Microelectronics and the Importance of Administrative Support

Ms. Wince-Smith identified microelectronics as the “holy grail” of U.S. competitiveness, and spoke of the need to encourage collaboration and shared investment across departments and agencies. She noted that the Department of Defense, with its large budget and clear mandate, was in a strong position to help guide such efforts, especially with renewed focus on national security in the wake of the COVID-19 pandemic. She also identified several challenges in the governmental and legal structures surround the research ecosystem that required addressing.

First, agencies face arbitrary rules restricting their funding activities- the National Science Foundation cannot invest in the national laboratories or universities, but the Department of Energy’s Office of Science faces no such restrictions. Second, funding for research is appropriated by Congressional Committees whose purview does not match with the mandate of the agencies they oversee. A case in point is the National Institute of Standards and Technology (NIST), which, along with the rest of the Department of Commerce, is funded largely by committees with other focuses, including housing. Third, administrations and Congresses led by both major parties have defunded important efforts due to changing political goals. In the 1990s, the administration gutted funding for nuclear energy through the Department of

Energy, which continues to hamper deployment of nuclear technology in the United States today. She also noted that many times new administrations shut down their predecessors' programs before belatedly realizing their value and trying to restart them. She urged cultivation of bipartisan support for scientific research to mitigate these problems.

Ms. Culhane noted that American innovations in High Performance Computing stemmed from the HPCC Act of 1992, which was a response to Japanese challenges to American leadership through the Fifth Generation Project. She said that the United States often seems to respond better when it is reacting to leadership challenges from competitors rather than thinking proactively. Ms. Wince-Smith also praised the current Under Secretary of Energy for Science, Dr. Paul Dabbar, who has expressed a desire to continue initiatives in advanced microelectronics and quantum computing from the previous administration.

A Tipping Point?

Dr. Hommert suggested engaging with Congressional committees responsible for science and technology, encouraging them to take a bigger role in fostering understanding among government officials of the importance of scientific research, and in enhancing connectivity between the parts of government responsible for funding scientific endeavors. He said that while full-scale change of governmental structures would be difficult, the committees could highlight and push for implementation of valuable

adjustments to the existing structure. Mr. Evans noted renewed interest in microelectronics from policy makers, and asked if the government was reaching a "tipping point" of interest in research in next generation semiconductors.

Industry Investment in Universities

Ms. Trimble asked the group for thoughts on bolstering industry investment in academia. Dr. Samanta Roy identified intellectual property as one area for improvement, although he said the issues were not insurmountable, and praised Dr. Locascio's work on collaborative research with the University of Maryland. He said that universities and industry collaboration could enhance the talent pipeline of students and workers, and could generate more ideas and help turn them into products and processes. He added that the relationship works best when universities produce students who can fill unmet needs for industry, industry invests in university infrastructure, and they co-create ideas and work to bring them to market.

Dr. Samanta Roy also identified a tension between the openness of the U.S. university research system, which is a strength, and the risk of having intellectual property stolen or used for asymmetric benefit by strategic competitors like China. He praised OSTP for recognizing the importance of the issue and soliciting university and industry input in addressing the problem, but warned that the nation needed to strike a balance. He said an overreaction in one direction could damage the university enterprise, and

that his own company often faced challenges when working on projects with a national security dimension. Mr. Dave Copps of Worlds Enterprises characterized the problem as one of urgency. He noted that universities accept funding from China because the Chinese government is willing to provide prompt funding and assistance. He also characterized the university technology transfer system as archaic and highly uneven in quality. He advocated for a national system that tracks research projects, funding levels, and resource and equipment needs at universities around the country, warning that money was wasted when it was not spent with a strategy in mind. Mr. Evans noted a recent presentation by an academic at a leading research institution arguing that American and Chinese research efforts were complementary, and said this view prompted questions about how to ensure that America's investments in research redound to our own benefit.

Concluding Thoughts

Mr. Morin reiterated his call for greater entrepreneurial access to research facilities owned by the government, warning that Argonne and other national laboratories turned away hundreds of great startup opportunities every year over resource and authorization concerns. He added that the Department of Defense and other federal agencies possessed labs facilities that could benefit entrepreneurs as well. Mr. Evans praised the idea of entrepreneurs-in-residence at research facilities and institutes, and added that the Council's AEMC initiative with the Department

of Energy included a report with a public-private partnership proposal to encourage these arrangements. Ms. Wince-Smith thanked the group for their discussion, and praised the work Argonne National Laboratory has done to make Chicago an innovation hub. She discussed the region's importance to economic progress throughout American history, as well as present initiatives like financial institutions that provide liquidity to small businesses and startups and the Climate Exchange to encourage low-carbon innovation. She also praised the work of Argonne and the University of Chicago on the Advanced Battery Consortium. Finally, she warned that it was crucial for universities to reopen for the new academic year, as it would be catastrophic to America's higher education ecosystem if universities suffered another fiscal blow following the COVID-19 pandemic.

Working Group 1 Calls April 30

Introduction

Ms. Kathy Trimble welcomed the group and discussed the focus of the day's conversation: leadership in national strategies for innovation and competitiveness. She then introduced the two featured speakers, Mr. Greg Morin of Argonne National Laboratory, and Dr. Arun Rai of Georgia State University.

Opening Remarks: Creating a Hospitable Ecosystem for U.S. Technology Leadership

Mr. Morin framed his remarks around the guiding questions for the day's discussion: increasing innovation capacity, improving the national leadership structure for innovation, and fostering greater

industry investment in research and development at universities and national laboratories. He opened by listing federal support for basic research, the education system, and infrastructure as the backbone for America's innovation ecosystem. He praised the development of a national innovation strategy by the Obama White House, and hoped it would become a best practice for future administrations. In Chicago, where Argonne is located, Mr. Morin praised the investments the city and state have made in the innovation ecosystem, but said it was hampered by a lack of leadership at the federal, state, and local levels. He urged the creation of policy incentives for building innovation capacity, and stressed the importance of having engaged and committed policy makers in addition to adequate funding. Mr. Morin

WORKING GROUP PARTICIPANTS

Mr. Eric Cylwik
Sundt Construction

Mr. Andre Doumitt
Aerospace Corporation

Ms. Leah Guzowski
Idaho National Laboratory

Mr. Ryan Haines
Sundt Construction

Dr. Nathan Hillson
Lawrence Berkeley National Laboratory

Ms. Sara Lawrence
RTI International

Mr. Greg Morin
Argonne National Laboratory

Lt. Col. Stewart Parker
Center for a New American Security

Dr. Albert Pisano
University of California, San Diego

Dr. Arun Rai
Georgia State University

Dr. Roland Stephen
SRI International

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Dr. Neil Thompson
MIT

Mr. David Vasko
Rockwell Automation

Dr. Bogdan Vernescu
Worcester Polytechnic Institute

Mr. Phil Weilerstein
Venturewell

Dr. James Weyhenmeyer
Auburn University

COUNCIL STAFF

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

Mr. Gourang Wakade

warned that Chicago was still losing innovators to the coasts in spite of its investments because of a lack of infrastructure and facilities.

For his first category of recommendations, Mr. Morin called for a coordinating body that would establish clear targets and hold policy makers accountable for implementing them. He said increasing innovation “tenfold” per the Commissioner’s charge, was a real goal, but that it needed an explicit framework to be achievable. He called for tax incentives to spur investment in innovation, trade policies that put American manufacturers on even footing with competitors, and the leveraging of private equity and large firms in fostering innovation. He reiterated his call for more local infrastructure for innovators to use, including co-location programs that would allow entrepreneurs to access federally-owned research labs. He warned that America’s competitors were using trade and tax levers against U.S. firms and urged a response, and strongly urged an overhaul of the talent development pipeline. Mr. Morin praised Arizona State University’s revamping of its engineering school to significantly increase its output of graduates, calling for other universities to follow its lead. He said that engineers want to make things, and without manufacturing capacity, America’s engineering schools would become international training grounds for overseas jobs. However, improving the talent pipeline is essential to increasing American manufacturing capacity. To that end, he called for greater leveraging of technical schools, with manufacturing jobs available to students upon graduation. He predicted the appeal of such programs would increase as the COVID-19 pandemic disrupted the conventional four-year college model.

Mr. Morin also made several recommendations regarding governmental leadership in innovation. He observed that the executive branch lacked a central coordinating entity for overseeing innovation policy. He said that while the White House Office of Science and Technology Policy (OSTP) could fill such a role, its funding and emphasis vary significantly across administrations. Mr. Morin also criticized the “stovepiping” of research by different federal agen-

cies, with minimal opportunities for coordination or collaboration among the Departments of Defense and Energy, the National Institutes of Health, the National Science Foundation, and other science-focused agencies. However, with the last two administrations providing ample funding for quantum computing and artificial intelligence research, he expressed hope that this, along with the efforts of America’s competitors, would spur action on better coordination, especially with the rise in collaboration during the COVID-19 pandemic. Mr. Morin suggested that other agencies create analogues to the Department of Energy’s Office of Technology Transition, and creating an integrating body for the national research enterprise. However, he urged the government to learn from the example of the Office of the Director of National Intelligence, which he said was too bureaucratic and inefficient. His final recommendation for the executive branch was a well-funded program allowing entrepreneurs to access federal research facilities. He noted that Argonne was forced to turn away hundreds of entrepreneurs every year due to lack of funding for partnership opportunities, and praised the Department of Energy’s advanced manufacturing program as a model for scaling.

Mr. Morin offered further suggestions for Congress and for sub-national governments. He advocated the creation of an office analogous to the Office of Technology Assistance (OTA), which provided in-house, bipartisan information to Congress on emerging technologies from 1972-1995. Between the demise of the OTA and the dearth of scientists in Congress, Mr. Morin expressed concern at policy makers’ lack of scientific understanding and appreciation of the value of scientific research. At the state and local level, Mr. Morin called for all states to develop offices similar to the Illinois Science & Technology Coalition. He said that businesses found this office so valuable that they financially supported it after it was privatized by the state.

Finally, Mr. Morin offered his thoughts on increasing industry investment in universities and national laboratories. He said that industry is willing to invest in these organizations when it can see a value prop-

osition, citing the examples of companies turning to national labs to research solutions to technical challenges during their design process. He said that intellectual property challenges were navigable provided companies have effective legal counsel, and warned that America's competitors, especially China, were far ahead in making industry-academia partnerships standard. Mr. Morin cited the German Fraunhofer Institutes as a model for collaboration, and called for greater internal R&D efforts by corporations, which would provide more opportunities for partnership. He encouraged the use of tax incentives to increase corporate research, and urged companies and labs to pay attention to China's infiltration of American academia and its security implications.

Opening Remarks: Ramping Up “Solutions” Innovation

Dr. Rai distinguished between innovations that occur serendipitously as the result of basic scientific research and experimentation, and “solutions” innovation in response to a market need or societal problem. He said the latter were most directly connected to competitiveness, and identified four aspects to increasing America's capacity for solutions innovation.

First, he called for broadening and deepening entrepreneurship initiatives at universities. While many universities have expanded these programs in recent years, particularly at his institution, Dr. Rai urged scaling of the many grassroots efforts in this space, which include incubators and accelerators, faculty externships at companies, and executives-in-residence. Second, Dr. Rai argued that innovation requires atypical combinations of talent and resources. He noted the development of novel, agile organizational designs at universities to improve innovation. One example is Hong Kong University of Science & Technology's sister campus in Guangzhou, focused on cross-cutting themes and technologies like AI and entrepreneurship. Another example is MIT's College of AI, which is focused on translating academic knowledge into practice, developing a pipeline of students and workers, and bringing

together expertise in disciplines ranging from computer science to ethics to cognitive psychology. He added that these initiatives incentivize industry investment by providing a value proposition up front, and called for continued improvement on IP and tech transfer frameworks, noting the lagging U.S. position relative to countries like China and Germany

Dr. Rai called for investment in improving digital platforms and infrastructure, which he said would “democratize” innovation. He criticized the heavy geographic, demographic, and industry concentration of venture capital and human capital, and argued for greater engagement from professional schools outside the STEM field and demographically diverse universities in the innovation space. He said this democratization would require much greater interconnectivity and sharing of data and digital assets. He noted that China just announced a national initiative for a new wave of digital innovation, and said widespread data sharing will require 5G, cloud technology, and blockchain to preserve privacy. However, with over 100 universities classified by the Carnegie foundation as “highest research activity,” Dr. Rai said the United States possessed the capacity to prototype new structures between academia, industry, and government.

Finally, Dr. Rai called for the architecting of regional innovation ecosystems to shorten the flow from innovation to commercialization. He described NSF's efforts to build regional innovation ecosystems around the country, including one in the southeast focused on healthcare technology with participation from Georgia State University, Georgia Tech, and the University of North Carolina-Chapel Hill, among others. He praised the initiative's partnering with Amazon to provide access to cloud capacity and platform infrastructure, and its focus on developing prototypes for experimentation. Another key component of regional innovation is community outreach, especially to high schools. By encouraging students to think about becoming innovators at an earlier age, the United States can develop a larger cohort of future entrepreneurs with an innovation mindset.

Measuring Innovation Capacity

Participants debated and discussed the definition of “innovation capacity” and how best to develop metrics that were relevant, comprehensive, and understandable. Dr. Al Pisano of the University of California, San Diego noted that a tenfold increase in innovation capacity was a very lofty target, and that he doubted the United States was currently equipped to even double its innovation output. Lt. Col. Stewart Parker of the Center for a New American Security stressed the importance of clarity in metrics, lest we end up chasing meaningless statistics and ascribing value to things because they are measured, rather than vice-versa. Ms. Sara Lawrence of RTI International embraced the “tenfold” goal, asking who would drive exponential innovation if not for the United States. She also voiced support for a national coordinating body, which she said could ignite a renewed regional development push and foster innovation mindsets around the country.

Dr. Tony Tether, formerly director of the Defense Advanced Research Projects Agency (DARPA) asked what a tenfold increase in innovation capacity would look like. He warned that without a clear picture of what to aim for, stakeholders would not know where or how to spend money. Dr. Neil Thompson of MIT responded that there were many proxies, including patents issued and citations in academic journals. He also expressed alarm at two other proxies for innovation that he said were trending in the wrong direction- the number of new FDA-approved drugs and the cost of bringing them to market, and the

decreasing contribution of scientists and engineers to U.S. GDP. Of particular note is that the latter value is decreasing even as the share of scientists and engineers relative to the total population increases, meaning the productivity of America’s scientific research is declining. He suggested greater use of automation and other innovations to make scientific research more productive. Dr. Tether expressed a desire to define innovation capacity for the entire country, rather than a single sector like universities.

Dr. Pisano suggested the creation of platforms allowing collaborative innovation. He cited the MOSIS Project, which allowed large numbers of innovators access to experimental resources and used crowd-sourcing of experimentation to develop advances in microelectronics. He suggested tracking the number of innovators participating in these initiatives as a metric, arguing that more “shots on goal” would lead to more breakthroughs. Dr. Tether asked how to develop a metric for overall capacity, and Dr. Pisano suggested that platforms could be one component of a composite measurement that spans different sectors. Mr. Bill Bates clarified that the tenfold increase in innovation was aspirational, and that the Commissioners wanted the Working Groups to think more boldly than just increasing funding for different agencies. He also described the attempt of the Council to define innovative capacity in the National Innovation Initiative in 2005, summarized in *Innovate America*. Mr. Bates described innovative capacity as a combination of talent, investment, infrastructure,

and technology, and provided a succinct definition of innovation as “value from ideas.” Dr. Tether said that using gross national product per capita was a possible metric for innovation, even if a tenfold increase was a high bar to clear.

Another idea for a metric came from Dr. Tether, who suggested setting a goal of increasing the number of newly licensed technology companies by a factor of ten. He said this metric would reveal America’s capacity of innovation, and added that to achieve it the country would have to vastly improve its ability to connect people with ideas to funding. Dr. Rai said that while metrics are important, they must also specify whether they are measuring novelty or value. He discussed attempts to leverage the USPTO’s database of patents to identify which inventions are breakthroughs using citations, and noted that many papers and patents are never cited after publication. He added that an output-focused metric should also distinguish between improvements from greater inputs and improvements from better connectivity between existing inputs, and overall favored a “scorecard” approach that measured innovation along multiple dimensions.

Dr. Tether suggested that striving for a tenfold increase in innovation, however defined, would necessarily generate better government leadership in innovation and increase industry investment in universities and labs. Dr. Rai said that digital infrastructure improvements would provide us with far more data and enables researchers to measure things they previously couldn’t, which would enhance the abil-

ity to develop effective metrics. He described data as the biggest constraint facing researchers, and warned that U.S. scholars were doing and publishing empirical work in China, including on COVID-19, because that was where they could get real data. He emphasized that use of blockchain could protect privacy while giving researchers far greater resources.

Mr. Andre Doumitt of the Aerospace Corporation suggested creating a national innovation metrics dashboard. It would track the number of new technology companies, new laboratory licenses of technology to industry, the number of SBIR awards to startups, STTR awards to universities, technology internships filled by high school and college students, and other metrics. Ms. Lawrence echoed this idea, saying it would also provide away to develop a common innovation agenda for stakeholders. Mr. Doumitt emphasized its simplicity and marketability, while Ms. Lawrence discussed and shared examples of similar dashboards that RTI International had developed in Southeast Asia and in North Carolina. Mr. Morin shared a link to Illinois’ Innovation Index as another potential model.

Institutional Design

A common theme in discussions was the need to better support innovators with systems that facilitate, rather than obstruct, innovation. Dr. Roland Stephen of SRI International stressed the need for end-user inspired research and greater collaboration, arguing these would facilitate transition of innovations out of

the lab. Ms. Lawrence called for cultivation of entrepreneurship outside the university system. Mr. Phil Weilerstein of VentureWell said that while the economic impact of an innovation is hard to predict, there were too many cases of ideas failing to leave the laboratory, or of startups failing to take off, due to a lack of basic support. He said the market is sometimes too clogged with competitors relative to the opportunities in a given space, and he encouraged the group to think about what the pipeline should look like. Mr. Weilerstein said that with thoughtful support, policy makers could also begin to identify the yield ratio of ideas needed to advance a given number to the next stage of development. He also stressed that gathering this information would not require significant time or capital, and could rely on existing mechanisms, but that there would be a need for new forms of capital once promising ideas had been identified. Without this support structure in place, there will be no value proposition at the stage of development where de-risking investment is most needed.

Existing Mechanisms for Fostering Innovation

Participants discussed the challenges and opportunities present in existing mechanisms for fostering innovation, including the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program. Mr. Doumitt noted that STTR now allows a faculty member to start a small business and obtain Phase 1 and Phase 2 funding while working full time, and that

this de-risks innovative spinoff companies at universities. He suggested that this model be followed for national labs and federally-funded research and development centers (FFRDCs) as well. Mr. Weilerstein said that the pathway from idea to impact needed to be made more efficient to keep good ideas from dying. He advocated better early funding, easier access to talent, and more flexible early stage capital. He also criticized many of the program rules in SBIR, arguing that they disincentivized doing the right thing. He noted there were mechanisms in other agencies that would provide value to SBIR participants in terms of talent and infrastructure, but that there was no coordination across agencies to weave these resources together in a more coherent way. Dr. Tether pointed out that getting venture capital funding could be even more challenging than obtaining SBIR funding, and Mr. Doumitt praised SBIR's recent revamp that cut down on bureaucratic. He described how the Phase 1 funding process had condensed from 9 months to 3 months, and that the funding amounts for Phase 2 had increased to between \$750 thousand and \$3 million. Mr. Doumitt also praised the Air Force Venture track, which enables recipients to receive up to \$60 million over four years.

Problems and Platforms

Dr. Stephen Roland encouraged a focus on platform technologies to facilitate innovation, and on a problem-centric national mindset to sharpen innovators' focus on major societal challenges. He characterized

stove-piping and lack of communication as a major obstacle, and suggested redesigning institutional environments to focus on problems as a starting point. Dr. Stephen also suggested academia work with business and other external partners on identified problems. Ms. Lawrence said developing a platform for collaboration was a key first step, and would then allow stakeholders to develop criteria for problems to select. Dr. Stephen added that a platform approach would help with the developing and monitoring of innovation metrics, but urged the group to focus those metrics on being more efficient in generating innovation outputs from existing resources, not just increasing inputs. He also reiterated the need to instill a problem-focused mindset in universities. Ms. Lawrence said that in a time of crisis, it made sense to connect problems to ongoing societal needs, including healthcare and economic challenges.

Efficiency and Total Factor Productivity

Dr. Thompson discussed the link between innovation capacity and Total Factor Productivity (TFP), the residual economists use to measure productivity improvements that translate into a higher standard of living. TFP is calculated by measuring the observed increases in capital and labor (both size and skill of the labor force) and their impact on economic growth, with remaining growth explained as productivity increases. TFP growth has been declining in the United States in recent years. Dr. Tether asked if TFP was a proxy for innovation capacity, and Dr. Thompson said that while they were not identical,

TFP represented innovation manifested as prosperity, and was thus an extremely important metric. Dr. Stephen asked what the causes of the TFP slowdown were, noting some commentators had identified the lack of technological adoption in fields like healthcare and education as a cause. He asked if it was possible to look at what the U.S. economy was doing differently when TFP was higher. Ms. Lawrence noted that the dashboard her company made for southeast Asian clients included a TFP tracker, and echoed the importance of measuring and trying to increase it.

Other participants were cautious about too much emphasis on resource efficiency as a proxy for innovation. Lt. Col. Parker said that while it is important to be good stewards of resources, the innovation ecosystem is full of unforeseen dead ends, and that too much emphasis on efficiency will result in restrictive control mechanisms by innovators and leave them without alternatives if a line of inquiry hits a dead end. Mr. Weilerstein agreed that efficiency in research and experimentation was not everything, but reiterated that the country could not afford to lose ideas or companies because of insufficient advice and support or excessive bureaucracy.

Concluding Thoughts

Ms. Trimble asked the opening speakers how the conversation had shaped their thoughts. Mr. Morin said he was glad to see robust discussion on definitions and metrics for innovation capacity, and

Dr. Rai said the group should continue to explore different aspects of its discussion. Dr. Rai said that if the group develops a solid metric for innovation, it could become a valuable reference for stakeholders. He also called for greater understanding of how different components of the innovation system connect with each other, and said that while the patent system is important, the United States must do a better job connecting different fragments of the innovation pipeline. He concluded by urging a coordinated initiative to increase data and data access, which he said would enable more robust measurement of innovation capacity.

Ms. Trimble connected the innovation capacity dashboard discussed by the group with the idea in Working Group 3 of a dashboard containing information on ongoing innovation projects and their funding levels and needs. She noted they shared the ideas of transparency and creating a “one-stop shop” for important information, making it easier to leverage resources and connect the dots between different components of the system. Dr. Tether noted that the patent system was the United States’ first attempt to encourage innovation through intellectual property, and Ms. Trimble mentioned Working Group 3’s exploration of the challenges of the patent system in an increasingly digital economy.

Working Group 1 Calls May 5

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the featured speaker, Ms. Sara Lawrence of Research Triangle Institute International (RTI). She noted that the Council studied the innovation ecosystem in the North Carolina Research Triangle, anchored by the cities of Raleigh, Durham, and Chapel Hill and their associated institutions of North Carolina State University, Duke University, and the University of North Carolina-Chapel Hill, in the late 1990s. This initiative was the first Council publication focused on regional innovation ecosystems.

Mr. Chad Evans announced that following the June 16 virtual meeting of the National Commissioners, the Working Groups will undergo two substantive changes for phase II of the Commission. First, a fourth working group will be spun out of the second working group, with Working Group 2 focusing on

the future of sustainable production and consumption, and the new Working Group 4 focusing on unleashing capabilities for work and entrepreneurship. Additionally, starting the week of June 22, calls for each group occur once per week, and will be led by co-chairs nominated by the Council, with Council support. Each call will be preceded by a primer with background information and policy recommendations to debate and consider, and the focus of the next phase of calls will be the development of actionable policy recommendations stemming from the conversations the working groups have had.

Opening Speaker

Ms. Lawrence began her discussion with a background overview on RTI. Started by the three Research Triangle universities in 1959, it is a non-profit venture with offices across the United States

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Ms. Candace Culhane
Los Alamos National Laboratory

Mr. Eric Cylwik
Sundt Construction

Ms. Leah Guzowski
Idaho National Laboratory

Mr. Ryan Haines
Sundt Construction

Dr. Paul Hommert
Sandia National Laboratory (Emeritus)

Dr. Fred Mannering
University of South Florida

Mr. Marcus Owenby
AT&T

Dr. Robie Samanta Roy
Lockheed Martin

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Dr. Gilroy Vandentop
Intel

Mr. Mike Cassidy
Emory Biomedical Catalyst

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Josh Oswald

Mr. Tim Planert

Mr. Gourang Wakade

Ms. Carol Ann Meares

and around the world, featuring staff trained in over 230 disciplines. She characterized the institute as a “university without students” due to its research and thought leadership activity. She discussed her background in helping states, regions, and other countries diversify their industrial base, foster innovation, and create jobs as head of the institute’s economic development practice. Ms. Lawrence said the take-aways from her work internationally had significant relevance to the challenges of developing regional innovation ecosystems in the United States.

Ms. Lawrence identified seven major lessons in developing successful innovation hubs. First, it is necessary to establish a coordinating organization to prevent different agencies and stakeholders from fighting for control of the initiative and to align all the different parties’ activities. Second, policy makers must make innovation plans and stick to them over time. Ms. Lawrence said that over 50 countries have launched a national innovation initiative of some kind in the past decade, but the United States has not. Third, it is crucial to invest in education, both to prevent “brain drain” as talent leaves for other opportunities and to help create the talent needed to take advantage of facilities and other assets. Ms. Lawrence warned that building research parks and laboratories will not result in innovation without a skilled workforce and a means of connecting workers to opportunities to innovate. Fourth, countries and regions need to invest in R&D. While many countries have set targets for R&D as a percentage of GDP, often around 2 percent, most countries are not spending at that level. Ms. Lawrence added that ideally R&D funding should come from both public and private sources. Fifth, policy makers must strengthen university-industry partnerships through intern and externship programs, curriculum co-development, joint R&D grants and projects, faculty sabbaticals in companies, and shared facilities and working spaces. Sixth, innovation plans must have a sector focus. Ms. Lawrence noted the success of nations like Taiwan, Singapore, and South Korea in fostering dynamic economies through focusing on key industries and building infrastructure to benefit entire sectors. Finally, there must be places to

innovate. These include science and technology parks, innovation hubs and districts, incubators and accelerators, and shared working spaces. The keys to place-based innovation are dense, multi-purpose, mixed-use infrastructure and facilities to ensure people from different sectors with different ideas and skill sets interact.

Ms. Lawrence also stressed the importance of assessing the innovation policy climate. While she emphasized that assessing political institutions and political economy were more of a focus for emerging economies, she encouraged evaluating the existing policy landscape. Policy makers should identify policies that reinforce innovation, policies that create bottlenecks, useful policies that are missing, and policies that should be modified or eliminated. To the extent that political economy becomes important, policy makers should identify potential leaders who will champion innovation initiatives, and identify potential bottlenecks and mitigation strategies in advance. Ms. Lawrence also stressed institutional capacity, which she said develops when stakeholders feel a sense of urgency. She expressed her belief that the United States was finally shaking off complacency about the importance of innovation for competitiveness, and characterized the current moment as an opportunity for the Council and the Commission to help chart a bolder course for the future.

Framing Questions

Ms. Wince-Smith praised the presentation and said that the focus on urgency was especially important. She emphasized that the Commissioners gave the working groups a mandate to “knit together” different regions and establish innovation centers throughout the country, not just on the coasts. Mr. Mike Cassidy of Emory Biomedical Catalyst praised RTI’s work in the tech sector around the country, and Ms. Kathy Trimble drew attention to the framework Ms. Lawrence presented for assessing the policy climate. This includes identifying actors and organizations (capital, government and public agencies, the private sector, support services and contractors, and uni-

versities and research institutes) and foundational components (human capital, digital infrastructure, and culture, values, and norms).

Successes and Challenges in Setting Up Collaboration

Dr. Paul Himmert, formerly of Sandia National Laboratory, asked Ms. Lawrence if RTI had seen success in fostering innovation ecosystems at the state level. Ms. Lawrence said that RTI had seen progress in developing industry clusters of innovation, but that the institute had struggled to cultivate regional innovation centers. She described the successes of the IT and biotechnology hubs in the Research Triangle region, which stem from investments made up to 40 years ago by the state government in microelectronics and biotechnology. In particular, grants and collaborative projects for microelectronics research helped draw IT companies to the region, and the North Carolina Biotechnology Center seeded and cultivated initiatives to attract researchers, funding, and industry investment. However, expanding this innovation beyond metropolitan centers, both in North Carolina and across the United States, has proved challenging, due to funding constraints, the difficulty of identifying potential growth clusters outside of urban areas, and the need for a more comprehensive focus.

Mr. Cassidy described Georgia's efforts to build an innovation cluster centered around Atlanta after the state saw the creation of the Research Triangle initiative as a wake-up call. He said that while Atlanta had succeeded in developing robust financial and security technology industries, more comprehensive innovation would require a more comprehensive approach. He warned that simply creating industry clusters or trying to attract venture capital is not sufficient to develop innovation centers, and praised the Commission's attempts to develop a comprehensive framework for addressing the issue. Ms. Lawrence described RTI's "blueprint" for extending innovation in a 125-mile radius around the Research Triangle, and encouraged the group to think of the geography of policies and opportunities.

The Importance of Leadership

Mr. Evans, drawing on the Council's previous work in this space, said that "clusters" follow economic activity, not political boundaries. He stressed the importance of leaders who think beyond their electoral jurisdictions and work to connect experts and innovators throughout the broader region. He added that because of changing personnel, it was important to continually push this focus as new leaders emerge, and characterized the present as a good time to re-emphasize the Council's existing thought leadership on the issue. Dr. Tony Tether, former director of the Defense Advanced Research Projects Agency (DARPA), encouraged the development of a problem-focused mentality. He said that when stakeholders realize what they need, they make significant progress on innovation. Mr. Evans added that even though many Council reports on regional innovation and leadership are dated, they are foundational and contain many takeaways worth restating or updating. He added that there are more Council efforts underway on the regional dimensions of specific advanced technologies, like high performance computing, and said that the group's conversation had illustrated clear advances in how to think about regional innovation. Nevertheless, he cautioned that many problems will never go away and require constant vigilance from thought leaders and stakeholders.

Flows of Funding, Ideas, and People

Dr. Robie Samanta Roy of Lockheed Martin characterized the key components of successful innovation systems in terms of flow. First, he discussed the flow of people and talent. While acknowledging their good intentions, he characterized policies that restrict the movement of people between government and industry as an impediment to innovation. He said that the United States has become too risk averse in this regard, and that our competitors do not have these restrictions. He suggested that it was possible to develop inter-personnel agreements between government and industry to facilitate the flow of expertise and human capital while maintaining robust conflict of interest protections.

Second, Dr. Samanta Roy discussed the flow of ideas. He stressed the importance of expediting the creation, regulation, and preservation of intellectual property in order to streamline the flow of ideas. He praised ongoing efforts by universities including Harvard, MIT, Stanford, and the University of Maryland to cut through IP red tape and make public their research and ideas to address the COVID-19 pandemic.

Third, Dr. Samanta Roy emphasized the flow of money. He criticized provisions surrounding federal research grants to industry, which must be used within two years or else returned, and suggested allowing recipients to “bank” unused research funds for future opportunities, since there are not always chances to deploy funding immediately. He also suggested addressing tax incentives and other policies that influence the flow of money among government, industry, and academia.

Mr. Evans framed Working Group 2's discussions of test beds and demonstration platforms as an example of flow, from sharing ideas across groups and individuals to ensuring a flow of funding to startups and inventors. He added that national labs and universities are natural hubs for regional innovation clusters, and that many projects can be done in a regional context. He also discussed the flow of topics across working groups, and suggested an opportunity for cross-pollination between this group and Working Group 2 on the issue of test beds. He emphasized that technology must ultimately be deployed and scaled in a way that drives manufacturing and value creation.

Another example of flows and connections arose in the discussion of university-industry collaboration. Ms. Carol Ann Meares of TechVision 21 asked how universities in the Research Triangle incentivize industry collaboration. Ms. Lawrence said the major draws were a pool of students who were already partially trained for jobs in industry and provided firms with a fertile recruiting ground, and shared access to research facilities and working spaces. She cited the Georgia Research Alliance in the Atlanta area as another example of such collaboration.

Cultural Dimensions of Regional Collaboration

Ms. Lawrence agreed with Dr. Samanta Roy's comments on risk aversion. She noted that one challenge in building regional innovation ecosystems in North Carolina was a sharp divergence on how stakeholders viewed risk. While academic and industry leaders in urban centers were enthusiastic about dynamic transformation and risk-taking, and smaller urban centers also expressed a desire to transform their economies, in more rural areas a scarcity mindset predominates. Some stakeholders are focused on trying to regain assets and industries they have lost, and view collaboration as inviting further unwanted transformation in the form of deindustrialization. Ms. Lawrence noted that even high school sports rivalries have served as barriers to different jurisdictions cooperating on projects. She said this lack of underlying vision is the cause of many breakdowns at the state level. To combat this, Ms. Lawrence stressed the importance of highlighting examples of successful collaboration, even at levels as granular as specific university departments or subsets of industries. By describing these ventures and showing how they work, policy makers can encourage broader adoption of best practices. She observed that universities, companies, can capital can only generate innovation if they have frequent, high quality interactions.

Political Splintering

Ms. Wince-Smith observed that there was little collaboration between North Carolina and South Carolina, even though both states had invested heavily in innovation. She characterized this as an example of lack of coordination across jurisdictions hindering regional innovation efforts. She added that while some organizations, like the Western Governors Association, are designed to foster this collaboration, the Council needs to engage more with the National Governors Association and encourage the formation

of more alliances. As an example of the pitfalls of the status quo, Ms. Wince-Smith described the failure of an alliance centered around Rochester and incorporating former executives from major companies like Xerox and Kodak that failed because county governments could not come to an agreement on funding shared infrastructure. She also discussed the problems regional splintering is presenting for state responses to the COVID-19 crisis. She said it was imperative for the Commission to look at the innovation capacity of the whole country, and not just certain parts.

Mr. Cassidy agreed with Dr. Tether's assessment that innovation stems from perceived needs, but added that national innovation strategies require the engagement of national leadership. He lamented the lack of national action on innovation in the years since the America COMPETES Act, stemming from Council research, was passed, and asked what lessons could be drawn about securing national engagement. He added that organizations like the National Governors Association have emphasized this issue, but have been unable to make any policy headway. Ms. Wince-Smith said the Council's National Innovation Initiative succeeded by carefully cultivating industry leaders who were deeply engaged with the areas where they worked, and through engaging leaders in Congress and among state governors from both parties alongside university leaders. She noted the Council is active in engaging with current governors regarding the National Commission, but that the COVID-19 pandemic presents challenges in this regard. However, she praised the actions of governors in northeastern states, and of universities around the country, as they come together to coordinate a response to the pandemic.

Concluding Thoughts: Keys to National Engagement

Ms. Wince-Smith encouraged the group to think about cutting across regions in developing innovation, and to take the best elements of the federal system and marry it to state and regional innovation initiatives. She stressed the importance of leaders in industry, government, academia, and the national laboratories, who she said care deeply about the good of the country but need to be identified and engaged with. While the Council can serve as a powerful systems integrator, it is ultimately these leaders who develop ideas and solutions and put them into practice. She also stressed the need to carve out a regional focus for the Commission's work going forward.

Working Group 1 Calls May 7

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the featured speaker, Ms. Candace Culhane of Los Alamos National Laboratory. Mr. Chad Evans discussed two important changes to the structure of the Working Groups following the June 16 virtual meeting of the National Commissioners. First, a fourth working group will be spun off from the second working group. This new group will focus on unleashing capabilities for work and entrepreneurship, while the second group will concentrate on the future of sustainable production, manufacturing, and consumption. Second, beginning the week of June 22, Working Group calls will

move to once per week, and will be led by co-chairs nominated by the Council. Calls will be preceded by a primer containing background information as well as concrete policy recommendations for the group to discuss. The second phase of the Working Groups will be focused on generating actionable policy recommendations ahead of the National Competitiveness Forum in December.

Featured Remarks

Ms. Culhane discussed her background in the federal government as both a scientist and a member of the intelligence community, and Los Alamos National

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Dr. Ramprasad Balasubramanian
University of Massachusetts–Dartmouth

Mr. Bill Briggs
Deloitte

Dr. Thomas Campbell
FutureGrasp

Mr. Mike Cassidy
Emory Biomedical Catalyst

Dr. Candace Culhane
Los Alamos National Laboratory

Mr. Robert Dixon
PepsiCo (Emeritus)

Mr. Andre Doumitt
Aerospace Corporation

Dr. Alan Hevner
University of South Florida

Dr. Nathan Hillson
Lawrence Berkeley National Laboratory

Dr. Paul Hommert
Sandia National Laboratory (Emeritus)

Mr. Gerardo Interiano
Aurora Innovations

Dr. Laurie Locascio
University of Maryland

Mr. Mark Minevich
Going Global Ventures

Dr. Albert Pisano
University of California, San Diego

Dr. Gary Pratt
Kansas State University

Dr. Arun Rai
Georgia State University

Dr. Neil Thompson
MIT

Mr. David Vasko
Rockwell Automation

COUNCIL STAFF

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Ms. Kathy Trimble

Mr. Gourang Wakade

Ms. Yasmin Hilpert

Mr. Tim Planert

Laboratory's focus on the safety and security of the country's nuclear weapons. She focused her remarks on various challenges to U.S. leadership in advanced computing, and the numerous national initiatives and their impacts on the development of advanced computing technology.

The first major challenge to American computing dominance came in 1982, when Japan introduced its "Fifth Generation" project, which aimed to make Japan the leader in parallel circuits and logic programming within ten years, leapfrogging third generation (integrated circuits) and fourth generation (microprocessors) technology. This alarmed the United States sufficiently to establish the Microelectronics and Computing Consortium (MCC), which was actually illegal until the 1984 passage of the National Cooperative Research Act. This initiative was driven by industry and did not receive government funding for many years, but contributed to the AI boom of the 1980s and 1990s before being dissolved in 2000.

Similarly, Japanese dominance in semiconductors led to the establishment of the nonprofit Sematech consortium in 1987 as a joint venture between the federal government and fourteen American semiconductor manufacturers. Although initially funded with matching contributions, the consortium eventually eliminated public funding, and gradually pivoted toward the much larger international semiconductor market. Sematech was crucial to the United States regaining competitiveness in semiconductor manufacturing, and Ms. Culhane attributed this to its having a required outcome to reach, which sharpened participants' focus and fostered engagement with stakeholders across the R&D space.

In 1991, the High Performance Computing Act (HPCA) established a requirement of continued U.S. leadership in high performance computing. The federal research conducted in response to this act built on earlier network infrastructures like ARPANet and NSFNet, funded the development of the Mosaic web browser, and helped create the information superhighway and high-speed fiber optic computer network that were crucial to the development of the

internet. Also as part of this initiative, NASA created the Beowulf cluster of supercomputers, which took over the supercomputer market due to their cost, accessibility, and scalability.

The next milestone came in 1995, with the Department of Energy's Advanced Strategic Computing Initiative (ASCI). The ASCI came with the requirement that DOE develop modeling and simulation capabilities to enable them to ensure the functioning of the country's nuclear weapons in the absence of the ability to conduct nuclear tests, as well as to maintain the security of the nuclear stockpile. While it failed to achieve all of its goals, ASCI helped accelerate the development of high performance computing (HPC), and inspired the Department of Defense to authorize five major studies in HPC through the Defense Advanced Research Projects Agency (DARPA). This project was one of the first initiatives with a ten-year horizon that stretched beyond single administrations.

In 2002, Japan released the Whole Earth Simulator, sparking a new wave of concerns about U.S. dominance in computing, especially because U.S. scientists were increasingly traveling to Japan to run their experiments. This led to increased funding for DARPA and the Department of Energy, and in 2004, ASCI had developed the Blue Gene supercomputer in conjunction with IBM, reestablishing U.S. computing dominance. Japan's advances also spurred the 2002 Integrated High-End Computing Study and the 2003 High-End Computing Revitalization Task Force, as well as the Department of Energy's Roadrunner supercomputer in 2008, the first computer in the world to break the petaflop barrier. Roadrunner also represented a breakthrough in using non-native languages to program computers.

By 2010, the federal government increasingly began to view supercomputing as a "meaningless arms race", and the President's Technical Advisory Committee suggested that further investments were not important given the rise of cloud technology and the diversity of computer architectures. However, in 2012 China announced plans to become a leader in high performance computing, and openly boasted of being capable of beating any American benchmark.

In 2013, they developed the faster supercomputer in the world, displacing the United States from the TOP 500 list of fastest computing systems, while using American technology to build it.

In 2018, the United States regained the title of fastest computing system with the launch of the IBM Summit System in June of that year. While the United States has retained this title since, there are concerns that China is currently sitting on even more advanced computers. Other notable developments in recent years include China's winning the Gordon Bell Prize for supercomputing in 2016-2017. This was the first indication of China producing innovative research and algorithms, as well as a clear vision of computing problems to solve.

Ms. Culhane also described other developments in U.S. computing over the past decade. In 2013, based on concerns about the end of Moore's Law, the Department of Energy launched the Exascale Computing Project, as it felt that the current rate of progress required unacceptable energy expenditures. The National Strategic Computing Initiative (NSCI), launched in 2015, established five key priorities for U.S. computing: accelerated delivery of advanced computers, increased coherence between modeling and simulation and data analytics, a viable path to quantum computing, a stronger HPC ecosystem, and more public-private partnerships. The NSCI faced criticism for not providing new funding or including requirements, as well as moving the Cancer Breakthrough 2020 program under its umbrella. However, this whole-of-government focus enabled the Department of Energy to collaborate with the National Cancer Institute, using its supercomputers to run major pilot efforts without legal red tape.

In 2016, the Department of Energy also launched the Exascale Computing Program, with a goal of fielding exascale machines by 2022. During 2016, the White House also released a National Strategic AI Plan, although it did not include any hard targets or requirements. However, it incorporated eight sub-strategies and represented a comprehensive framework for AI research, and was renewed in 2018. In 2017, DARPA launched the Electronics

Resurgence Initiative, aimed at ensuring far reaching improvements in electronics beyond conventional scaling and increasing the complexity of component integration. This initiative included \$216 million in dedicated funding, including \$75 million in new funding. Finally, in 2018, Congress passed the National Quantum Initiative with near unanimous support, focused on advancing quantum technology in general and quantum computing in particular. This initiative did not provide new funding or requirements, but has spurred action by the National Science Foundation and Department of Energy to establish quantum computing centers.

Ms. Culhane concluded her remarks with an illustration of the importance of hard targets and requirements in securing funding and spurring action. She discussed the Space Race and the U.S. project to put a man on the moon following the USSR's 1957 launch of Sputnik, which provided a clear threat to the United States. She stressed the necessity of illustrating the importance of advanced technologies like AI and quantum computing through the threats they protect us against. She noted that the COVID-19 pandemic will provide an example of such a threat to policymakers in the form of mass mortality, spurring research on viruses and vaccine development. However, she warned that it is much harder to create urgency for investment in computing because of the prevailing belief that government research cannot keep up with industry giants and should just wait to buy their technology. She made the case the public and private sector must collaborate for major technological advancements using their respective strengths. The government can establish targets and requirements and provide a vision, while industry excels in productization and scaling of innovation.

Catalyzing Action on Advanced Computing

Ms. Wince-Smith thanked Ms. Culhane for her remarks, and discussed the Council's history of developing the business case for advanced computing dating back to 2003, including partnerships with DARPA, the Department of Energy, and the National

Science Foundation. She asked how the Council could take the next steps in carrying forward leadership in advanced computing. Ms. Culhane said the Council has been very helpful in “telling the story” in the past, and said that perceptions of threats to U.S. leadership have historically been the most effective means of securing U.S. investment in advanced technologies, citing the examples of Sputnik and of China surpassing the United States in supercomputing capacity in 2013. She expressed regret that the United States is not more proactive in making these investments, and noted that it is challenging to elicit investment in mature industries because technologies advance much more slowly. She said this was a particular problem for the semiconductor industry, and expressed the need to find an event to “react to” to encourage investment.

Dr. Paul Himmert, former director of Sandia National Laboratory, discussed his time working on ASCI, and said that ASCI's clear focus and imperative made it easy to explain to public officials and funders. He said that depending on political developments over the next year, the United States could soon have clear national imperatives in the fields of pan-viral deterrence, low-carbon energy, and national security, all of which have enormous embedded computing challenges. He said capturing the challenges in each that are independent of underlying technological enablers and connecting them to the competitiveness aspects of high performance computing will be key. Ms. Culhane agreed and framed this as emphasizing the “what” of the problem at hand and the “how” of technology. Dr. Neil Thompson of MIT said he wanted to stress the importance of this problem to the group, because computing is essential to productivity improvements everywhere. He discussed economic research attributing 1/3 of all U.S. productivity gains since the 1970s to information technology improvements, even at the level of individual firms. He said making future leaps in science and technology, especially critical fields like AI and machine learning, will require major improvements in computing power.

Dr. Laurie Locascio of the University of Maryland echoed the importance of perceived threats in catalyzing action, describing her experiences at the National Institute of Standards and Technology (NIST), in which discussing potential threats increased the budgetary authority available to the agency. She asked the group if there were examples of major research initiatives not prompted by threats. Ms. Culhane said that even things like public health and climate change were responses to immediate or long-term threats, even if not prompted by a specific national security concern. She also mentioned the HPCA as an example of an initiative that was not particularly reactive, but which helped rapidly scale up network access. She said that the impetus for networks was the National Science Foundation searching for more cost-effective ways to have widespread access to supercomputing than building supercomputers at every university.

COVID-19 as a Call to Action

Dr. Albert Pisano of the University of California, San Diego suggested the current COVID-19 crisis might serve as a wake-up call along key dimensions of scientific research. He said the current approach to virology is ripe for innovation in the midst of the emergence of coronaviruses, which attack humans in a unique way. He also recalled fellow Working Group member and former DARPA Director Dr. Tony Tether's exhortation to measure problems to organize an effective response. He discussed President Kennedy's goal of putting a man on the moon within nine years and suggested a similar time-bound initiative for developing a pandemic preparedness plan that will enable the United States to handle future outbreaks without completely shutting down. Ms. Wince-Smith agreed, noting that Commission Co-Chair Mr. Brian Moynihan of Bank of America expressed similar sentiments. She said we are seeing the consequences of under-preparation in real time, and advocated developing major end goals to work backwards from in formulating a plan to achieve them. Dr. Thomas Campbell of Future Grasp LLC agreed that COVID-19 represented the mostly likely threat to resonate with policy makers, noting that addressing

pandemics requires new capabilities in AI and high performance computing, among other technologies due to the need to model vaccines and disease progression through populations. Dr. Roland Stephen of SRI International suggested presenting the threat as a series of inter-linked existential challenges across sectors, including clean energy, public health, advanced manufacturing, and national security. He classified the solutions as inter-linked technology platforms, including 5G, advanced computing, and zero-carbon energy.

Creating a New Normal

Mr. Mark Minevich of Going Global Ventures said that the COVID-19 pandemic has permanently changed society, and that the focus of the Commission should be on creating a “new normal” in which advanced technologies provide a sense of security and stability for Americans, respond to a rapidly changing and increasingly volatile world, and enable the United States to remain prosperous and ultra-competitive. He said the United States came into the current pandemic empty-handed, and that in the future we must develop the AI and modeling capabilities to predict short- and long-term consequences of future disruptions to markets, supply chains, and other structures as they occur. He further stressed the need to adjust large systems, including production and consumption, consumer preferences, and business models for industries and universities, to this new normal, and the need to adopt advanced manufacturing technologies immediately.

The Positive Externalities of “Space Races”

Dr. Pisano said that the Commission should emphasize the positive externalities that come from all-of-society efforts to address challenges. He pointed out that both the Space Race of the 1960s and the Computer Races of the 1980s and 1990s led to numerous serendipitous inventions and led to the establishment of many companies and industries. He said the Council should emphasize the new jobs and boost to competitiveness that will follow from concerted efforts to address challenges in advanced computing and other disruptive technologies, and that these efforts will lift many boats, not just those directly connected to the research. Mr. Andre Doumitt of the Aerospace Corporation discussed a recent television series on the Space Force, and said that the Commission should seize on opportunities presented by popular culture to capture the public’s imagination and awaken the workforce and educational system to the potential of disruptive technologies across the economy.

Using Chinese Competition to Frame Threats

Dr. Thompson discussed his work with the Council on the Building University-Industry-Laboratory Dialogue (BUILD) initiative, in particular his survey of advanced computing researchers in the United States. He said that there was a consensus that China was about even with the United States in

terms of advanced computing, and was improving at a much faster rate. He wondered why this was not seen as sufficient threat to induce greater funding. Ms. Culhane added that in 2012, the Office of the Director of National Intelligence assessed foreign computing capacity and identified China as a “fast follower.” By 2016, they were starting to innovate rather than merely copying American research. She said the ultimate test of whether they will become leaders is if they advance science in a way that forces the United States to play catch-up to them, and that this is not easy to measure by simply looking at publication metrics. However, she warned that China has far more manpower than the United States.

The Importance of Biotechnology

Dr. Nathan Hillson of Lawrence Berkeley National Laboratory said it was surprising given the discussion of COVID-19 that the bioeconomy, biomanufacturing, and biotechnology had not been discussed. Dr. Locascio agreed, and noted the dire consequences if China developed a vaccine but withheld it from the United States or other nations. Dr. Campbell said the United States must be much more proactive in using modeling to accelerate vaccine development, and that high performance computing was crucial to such efforts. Mr. Evans agreed that this was a major concern and illustrated the linkages between competitiveness, prosperity, and national security. He also noted that Working Group 2 was having a discussion on the bioeconomy next week, and suggested there

might be opportunities for cross-participation from this group’s members. Mr. David Vasko of Rockwell Automation said his company is involved in biotechnology research initiatives, especially those aimed at scaling new innovations and bringing them from the lab to the factory floor.

Concluding Remarks

Ms. Wince-Smith shared with the group the discussions she had with the Global Federation of Competitiveness Councils on the impact the COVID-19 crisis is having on competitiveness in general, and in participants’ own economies. She stressed the need to identify the structural innovations that will take humanity into a new era that is prosperous, sustainable, and inclusive. She further emphasized the importance of modeling, simulation, and other advanced technologies in producing that future, and the role the Commission can play in understanding these advancements and articulating grand visions for the future of the country, including how to marshal the investments and capabilities to bring those visions to fruition. Mr. Evans added that in light of the group’s discussion he would share the presentation of Dr. Steven Koonin of New York University on the path forward from COVID-19 that he shared as part of the Council’s Technology Leadership and Strategy Initiative Competitiveness Watch Seminar in April.

Working Group 1 Calls May 12

Introduction

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group, and Ms. Wince-Smith introduced the featured speaker, Dr. Kelvin Lee of the University of Delaware. She discussed Dr. Lee's role as the head of the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL), one of the Manufacturing USA institutes. Mr. Chad Evans said he looked forward to hearing about the key lessons learned from Dr. Lee's experiences as head of NIIMBL.

Featured Remarks

Dr. Lee opened his remarks by contextualizing the importance of advanced manufacturing to American prosperity. He said it provides an economic multiplier of between four and twelve and is a major source of innovation. He also discussed the concerning trend since 2000, when U.S. manufacturing employment began to drop precipitously and the United States went from having a surplus in trade of advanced manufactured materials, including semiconductors and biopharmaceuticals, to a deficit. He said the

WORKING GROUP PARTICIPANTS

Mr. Ted Agne
Communications Strategy Group

Dr. Thomas Campbell
FutureGrasp LLC

Mr. Mike Cassidy
Emory Biomedical Catalyst

Ms. Candace Culhane
Los Alamos National Laboratory

Mr. Eric Cylwik
Sundt Construction

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PepsiCo (Emeritus)

Mr. Andre Doumitt
Aerospace Corporation

Ms. Stacy Esposito
Arizona State University

Ms. Leah Guzowski
Idaho National Laboratory

Mr. Ryan Haines
Sundt Construction

Dr. Nathan Hillson
Lawrence Berkeley National Laboratory

Dr. Paul Hommert
Sandia National Laboratory (Emeritus)

Dr. Anne Marie Knott
Washington University in St. Louis

Dr. Kelvin Lee
University of Delaware

Dr. Fred Mannering
University of South Florida

Mr. Mark Minevich
Going Global Ventures

Mr. Marcus Owenby
AT&T

Dr. Albert Pisano
University of California, San Diego

Dr. Gene Robinson
University of Illinois

Dr. Robie Samanta Roy
Lockheed Martin

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Mr. Phil Weilerstein
VentureWell

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

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Mr. Tim Planert

Manufacturing USA institutes, which began under the previous administration but have continued to expand in recent years, are designed to bridge the gap between basic research and commercialization, and are focused on high-value added sectors that have been transformed by digitization and automation.

A major problem in American manufacturing is the gap in funding for the middle section what the government defines as “readiness levels” in the manufacturing process. Readiness levels 4 through 7 comprise the space between the development of a proof of concept and the point where a technology has been de-risked enough to secure private sector investment. Dr. Lee said that the United States, while exemplary in attracting government and academic support for research in levels 1 to 3, and industry investment in levels 8 to 10, lags behind other countries over the middle of the curve. He added that the Manufacturing USA institutes, which combine public and private resources, are unique among such efforts because they are primarily “pulled” by industry rather than “pushed” by the public sector or academia.

Dr. Lee then discussed the defining features of the fourteen Manufacturing USA institutes. They are public-private partnerships and member consortia with clear missions. Each institute is focused on a technology with critical industry applications, and there is no overlap in the institutes respective mandates. Some institutes, like NIIMBL, focus on vertically integrating an entire industry, while others have a more cross-cutting focus. The institutes provide space to collaborate on pre-competitive R&D that solves major challenges facing all participants in an industry, and create value by providing an avenue for public-private co-investment. Federal funding must catalyze at least a 1-to-1 match in non-federal funding, and each institute includes workforce training and development programs to address the skills gap. Dr. Lee emphasized the importance of this last feature, noting that our technical capabilities will not produce any jobs if we do not have the workforce needed to fill them.

The Manufacturing USA institutes have already had an impact on the U.S. innovation ecosystem. Nearly 2000 organizations across academia, industry, and the nonprofit sector are members of at least one institute, with some participating in several, and many state governments have also co-invested in initiatives in their state. The ratio of “federally compliant” non-federal funds sits at approximately 1.7-to-1 vis-à-vis federal funding, but Dr. Lee estimated the true ratio to be in the neighborhood of 4- or 5-to-1. Overall, nearly \$500 million has been invested, and the institutes have already provided workforce development and education to over 205,000 workers and students. There are currently fourteen institutes, with two more poised to launch by the end of 2020. Currently, eight are funded by the Department of Defense and five by the Department of Energy, with NIIMBL being funded by the National Institute of Standards and Technology (NIST) within the Department of Commerce. While the heads of the different institutes are in regular communication, this has been somewhat obstructed by the COVID-19 crisis, and their conversations in recent weeks have turned toward brainstorming policy responses to prepare our economy and supply chains for the next crisis.

Dr. Lee concluded his opening remarks by discussing NIIMBL in more detail. He described pharmaceutical products as falling into two major categories. The first, medicines made by chemistry, are relatively easy for manufacturers to develop because the process of creating stable molecules is well understood. As a result, as long as the manufacturer can accurately produce the molecule, the FDA will grant approval, and it is easy for competitors to enter the market with generic molecules once the exclusivity period ends. By contrast, NIIMBL focuses on biologic medicines, which are created through biology and are much more difficult to make, because it is harder to control the process of molecule development when there are living components involved. Examples of biologics include insulin, recombinant proteins and antibodies like Humira, vaccines, and cell and gene therapies, the last two of which can have life or death impact for critically ill patients. The FDA regulates both the product and the process for

making biologics, and because of the cost and risk involved in pioneering a new drug in this space, no firm wants to be the first mover toward a new manufacturing process, but instead a close second. The goal of NIIMBL is to encourage all the participants to be “first movers” together.

Bridging the Mindset Gap Between Academia and Industry

Dr. Tony Tether, former director of the Defense Advanced Research Projects Agency (DARPA), discussed the success he had in encouraging the development of commercialization-ready innovations. He instituted a policy in which researchers had to find at least one end user for their innovation by the end of the project’s third year in order to continue receiving funding. He said this acted as a powerful motivator for researchers to adopt a problem-oriented approach to innovation and think about ways to make their ideas easy to bring to the market. Dr. Lee said that one of the biggest surprises he experienced heading NIIMBL was the clash of mindsets and approaches to research between academia and industry, especially in a field like biopharmaceuticals where there has historically been substantial collaboration. He described the academic mindset in which researchers attempt to keep a project going indefinitely and secure new funding for further exploration, and the industry mindset in which a project either succeeds or fails to generate a product in a clearly defined timeframe. He characterized much of his work as director as helping bring both sectors to a middle ground where each understands the other’s needs and incentives. Dr. Tether agreed with this approach, and noted that as director at DARPA he had the power to compel different stakeholders to talk to each other through his control of funding for projects.

Mr. Phil Weilerstein of VentureWell connected this theme to his organization’s work with the I-Corps program, which he said was designed to address cultural gaps between academia and industry. He described how the program provides postdoctoral students and graduate students to lead efforts and

identify valuable applications of basic research and potential customers. He asked if there was a way to incorporate this process into the Manufacturing USA institutes, especially because the crucial element in actually bridging these divides in the I-Corps program is securing the resources to do so. Dr. Lee said that while he had not heard of any specific programs with a similar mission within the Manufacturing USA umbrella, that did not mean they didn’t exist, but he stressed the need to identify a reliable funding source. As an example, he discussed the commitment by the Biomedical Advanced Research Development Agency to provide grants and agree to purchase from vaccine developers like Moderna and Johnson & Johnson in the wake of the COVID-19 crisis, noting that the hundreds of millions of dollars involved was still only a small portion of their total costs. He said that other nations have historically been more willing to pick priority sectors for investment, and suggested there might be value in the United States taking the same approach.

Addressing the Gap in Technology Development

Mr. Robert Dixon, formerly of PepsiCo, asked about the requirement for a minimum of 1-to-1 matching funds from non-federal sources, and also suggested a “policy reversal” in which the government shifted its resources from funding basic research to funding the missing middle of the manufacturing readiness curve. He also suggested officially clarifying that innovation would be measured by the successful commercialization of technology, and encouraged stakeholders to think about the entire value chain, including which areas were most lacking in needed investment, as well as critical priority areas to invest in.

Dr. Lee said that the government requires matching funds to avoid criticisms that it is engaging in “industrial welfare” and giving firms handouts, so co-investing allows them to de-risk ventures for firms while still requiring them to contribute. He said that each of the fourteen institutes has its own culture and priorities, and that the government views the institutes as fourteen different experiments, which will be allowed

to grow in ways that make sense for their business sector. He added that the early returns have been promising, but that it is impossible to change an economy after five to six years with a modest investment. Dr. Lee also noted that high-level thinkers in the federal government had identified priority areas that have influenced investment decisions, but that there was no formal national strategy for prioritizing investments.

Dr. Anne Marie Knott of Washington University in St. Louis attributed the emergence of the funding gap to a general decline in government support of R&D. She noted that from 1980 to 2000, this figure went from 0.8 percent to 0.3 percent of GDP, a 63 percent reduction. She pointed out that this corresponds to the drop in manufacturing employment and the advanced manufacturing trade deficit that emerged after 2000.

Challenges in Biopharmaceutical Manufacturing

Ms. Wince-Smith asked how to accelerate the development of vaccines, and whether the FDA was primarily a facilitator or a barrier to new drug development. Dr. Lee said the FDA was largely a facilitator, and that many of the obstacles to drug development come from the risk aversion of manufacturers. Because of the high costs of testing a drug and further high costs in building a facility to manufacture it, drug makers tend to go for safe, low-cost-common-denominator products. With vaccines in particular, the margins are low, and the numerous approval processes required mean there is a long time lag before vaccines are ready to hit the market. Dr. Lee said NIIMBL operates test beds where manufacturers can run new safety tests and other processes alongside existing ones for established third party products to demonstrate the efficacy of the new techniques, in an effort to encourage their adoption. However, overall the costs of obtaining the data companies need to prove that a faster development and safety testing process works as well as the status quo are usually prohibitive. Because of this,

most companies have not invested in new vaccine development processes that can telescope steps that take weeks or months into a few days.

Dr. Robie Samanta Roy of Lockheed Martin said that the success DARPA has had in bringing new products to market illustrates the importance of having open lines of communication between developers and the end user, as well as between developers and regulatory bodies. With better communication, developers can ensure they are testing the right functions and developing products with value for end users, and can catch mistakes earlier. Dr. Tether clarified that DARPA only sought FDA approval for products that would be marketed to the general public as well as the military. He emphasized that the rules requiring customers for continued funding were the biggest driver of DARPA's success in scaling technology.

The Value of Platform Technologies and Facilities Access

There was significant discussion in the group about the value of platforms that give innovators access to facilities and technology. Dr. Albert Pisano of the University of California, San Diego cited the example of the MOSIS program to accelerate innovation in Complementary Metal-Oxide-Semiconductor (CMOS) technology for computer chips. MOSIS allowed remotely located innovators and educators to access manufacturing technology and learn its constraints and capabilities, and allowing lots of different people to work on innovating led to an accelerated development of innovations. He gave the example of modems, crucial to cell phone technology, and how the whole industry was pushed forward by the number of competing designs. He predicted similar value could be derived from competition in circuit technology, and he asked if there were similar programs providing access to facilities and technology within the Manufacturing USA umbrella. Dr. Lee said that several institutes did lease space and provide training to innovators testing out products, and noted that technologies like additive manufacturing had spread across the different institutes.

Dr. Pisano asked if there would be value in incorporating specific platform programs to encourage widespread sharing of facilities across the Manufacturing USA institutes, and Mr. Weilerstein added that providing these resources in high-tech sectors could drastically reduce the cost and complexity of moving from proof of concept to proof of demonstration. He gave an example of a problem in the chemical industry, where access to small-batch manufacturing is so expensive that innovators are in a chicken-and-egg situation in which they don't want to risk a large investment at an early stage but can't afford a smaller one either. Mr. Evans said that the Digital Design/Manufacturing Innovation Institute in Chicago likely had these capabilities, but that he wanted to hear from members of the group with experience in this space.

Ms. Wince-Smith said the group needed strong recommendations for U.S. leadership in advanced manufacturing and public-private partnership models that incorporate co-investment and dual-use platform technology. Dr. Pisano agreed and wondered if it would be valuable to invest in a program that provided the entire innovator community with broad access platform technology. Mr. Evans said that this is an example of what the Council refers to as "shared national innovation infrastructure." Mr. Weilerstein discussed an early stage advanced composites company that VentureWell is working with, and their difficulties in getting investment interest from manufacturers until they can provide data. He suggested developing a voucher approach that allows innovators to demonstrate their technologies in the relevant environment.

Questions for Consideration

Several participants posed questions to the group for future discussion and contemplation. Dr. Paul Hommert, former director of Sandia National Laboratory, discussed his experience working on the development of Extreme Ultraviolet Lithography, which did not see a market application until nearly two decades later because it was ahead of the technology curve. He asked if the Manufacturing USA institutes were

considering the timeframe and technology curve dimensions of product commercialization when working on innovations to try to scale. Dr. Thomas Campbell of FutureGrasp LLC discussed the significant draw-down and disruption in supply chains caused by the COVID-19 crisis, and asked whether this would cause the scope of the gap between the lab and the market to increase, decrease, or remain unchanged.

Mr. Mark Minevich of Going Global Ventures emphasized the importance of advanced transportation to the economy of the future, including advanced manufacturing. He said that the U.S. transportation industry supports 10 million jobs and accounts for 3.5 percent of Gross Domestic Product, and urged the group to focus on the innovation needed in the transportation sector for it to remain capable of supporting and incorporating disruptive technologies. He added that younger generations want more sustainable products and substitutes for petroleum-derived plastic, and called for the promotion of advanced biofuels and bio-materials through touting their scientifically-backed sustainability and efficiency.

Concluding Thoughts

Ms. Wince-Smith thanked the group for its contributions to the discussion, and encouraged the participants to make bold recommendations. She said that thinking big was essential for delivering the transformative solutions the country needed. Dr. Lee agreed, and said that it was important to develop lots of ideas to experiment with because not all of them will end up coming to fruition.

Working Group 1 Calls May 14

Introduction

The Honorable Deborah Wince-Smith and Mr. Bill Bates welcomed the group, and Ms. Wince-Smith introduced the featured speaker, Mr. David Vasko of Rockwell Automation. She described the Council's previous collaborations with Rockwell, and said the firm was at the forefront of smart manufacturing, the subject of the day's discussion. Mr. Bates detailed Rockwell's involvement in the Council's Energy Manufacturing and Competitiveness Partnership (EMCP), and said it would be exciting to catch up with recent developments in the smart manufacturing space.

Featured Remarks

Mr. Vasko focused his discussion on the way re-purposing existing technologies is as important to scaling disruptive innovation as the new products and processes themselves are. He detailed the efforts at the BioFab USA institute in New Hampshire, part of the Manufacturing USA institutes, in developing human tissue to be used in medical procedures and transplants. He said that while the focus on novel ideas was appropriate for breakthrough technologies like quantum computing, many of the techniques the BioFab institute have long existed, but are being used for novel purposes. He also stated that the idea of "pre-competitive" collaboration is a myth, and

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Ms. Margaret Brooks
Verizon

Mr. Mike Cassidy
Emory Biomedical Catalyst

Dr. Jennifer Curtis
University of California, Davis

Ms. Leah Guzowski
Idaho National Laboratory

Dr. Alan Hevner
University of South Florida

Dr. Nathan Hillson
LBNL

Mr. Gerardo Interiano
Aurora Innovation

Dr. Anne Marie Knott
Washington University in St. Louis

Ms. Sara Lawrence
RTI International

Mr. Greg Morin
Argonne National Laboratory

Lt. Col. Stewart Parker
Center for a New American Security

Dr. William Pike
Pacific Northwest National Laboratory

Dr. Gary Pratt
Kansas State University

Dr. Arun Rai
Georgia State University

Dr. Roland Stephen
SRI International

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Dr. Gilroy Vandentop
Intel

Mr. David Vasko
Rockwell Automation

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Tim Planert

that consortia like the Manufacturing USA institutes work best when the participants have complementary intellectual property interests and bring unique capabilities to the effort.

A major problem with tissue fabrication is the intensity of labor needed to produce a single tissue, which involves a Ph.D. scientist manually building it. The costs of hiring the number of Ph.D.s needed to mass produce these tissues would be prohibitive, and Ph.D. researchers do not have the inclination or expertise for assembly-line work. To address this, BioFab looked at the kinds of actions performed by researchers making different kinds of tissues and modularized them, allowing the repetition of basic operations. The institute also worked on modularizing the transportation and logistics to ensure the tissues could get to people who needed them. Mr. Vasko emphasized that modularizing is a standard manufacturing technique, and allows the 160+ participants in the initiative to specialize in different aspects of the process without conflict. He noted that manufacturers do not need the IP for tissue design, and the researchers do not need the IP for the manufacturing process. He also underscored the potential benefits from one day being able to manufacture organs within hospitals for rapid transplantation.

Mr. Vasko described the process for generating fabricated tissues using a new “closed-loop” modular technology that only required human interaction for the first step. Cells are put into the machine, from which point the machine develops a culture, harvests and washes the cells, and then assembles the tissue and lets it mature. All of the components of this process are used in other manufacturing operations, although the institute is working on improving the sensors used. As one example, the load balancing mechanism in the machine is the same mechanism used by soft drink manufacturers to maximize beverage production capacity in their factories. He likened the automation of the tissue process to mass producing cookies from a recipe made by one person—rather than trying to reproduce people with the exact same skills as the original creator, it leverages much more common capabilities in a new way to scale up production.

Mr. Vasko described a similar process for expediting documentation for FDA review, in the form of a software program that automatically collates relevant data generated during production and packages it in a format that makes it easy for reviewers to digest. These efficiencies combine to allow these closed loop systems to produce simple tissues like ACLs in 45 days, and in a converted textile mill rather than a high-tech clean room in a laboratory. Mr. Vasko predicted that facilities would be able to hold hundreds of these machines under one roof, and the process could be replicated for other kinds of tissues. He said that bringing more vendors into the production process with usable skills will accelerate this scaling and further innovations. Finally, Mr. Vasko attributed much of the success of the project to having a clear objective that allowed BioFab members to identify existing resources that could be deployed in service of that goal.

Scaling from Tissues to Organs

Dr. Anthony Tether, former director of the Defense Advanced Research Projects Agency (DARPA), pointed out that recipes often need to be tweaked to fit particular circumstances, which makes them challenging to scale. Mr. Vasko said that sensing technology addressed these issues. Ms. Trimble asked what the next steps were for scaling, and Mr. Vasko said the institute had five pilot programs for different types of tissue, with clear roadmaps for scaling them up. He said developing noninvasive sensing technology was the next major step, and that tissues like ACLs and knee cartilage will be the easiest to scale. He added that as more people adopt and implement fabrication technology, they will discover improvements and efficiencies faster, accelerating the development of ways to fabricate entire organs at scale.

Ms. Trimble asked how the institute was planning to handle the transition up to more complex fabrication projects, like organs. Mr. Vasko said scaling was the main problem, but that the basic work of creating tissues has opened up many different pathways. While initially researchers believed 3D printing would

be essential for building organs, during their research they realized that de-cellularization was also a viable means of constructing organs. While most research was focused on developing hearts, the same process could be extended to other organs, including kidneys, pancreases, and livers. He said the ability to develop replacement organs with the recipient's own DNA would eliminate the concern of rejection and massive reduce medical costs while providing lasting cures.

Addressing the Skills Gap

Ms. Trimble asked what role the skills gap had played in the institute's work. Mr. Vasko said much of the institute's work consisted in training medical researchers in automation, and translating technical processes into familiar terms and concepts. He said that the more automation is de-mystified and the more people see connections between existing technologies and the problems they are trying to solve, the more buy-in there is for adopting these technologies. He noted that many people expressed surprise at how the group was able to produce so many tissues with so few people while relying on existing processes.

The Need for Diverse Talents and Clear Roles

Dr. Roland Stephen of SRI International discussed the perception that some Manufacturing USA institutes were more successful than others, and asked what role complementary versus competing IP interests played in this. Mr. Vasko said having clear swim lanes not only reduced IP challenges, it meant that every stakeholder brought a unique capability, and that bringing in experts from different fields can help people in one field think about their problems in new ways and see solutions that they previously couldn't. He discussed a conference where he suggested using parameterized software for data analytics to solve a problem medical researchers were having. Because they lacked expertise in data analytics,

they were unaware that they didn't need a separate software program for each function they were performing. Mr. Vasko also attributed the rapid six-week turnaround of the closed loop system to this synergy.

Balancing Scaling Against Regulatory Pressures

Ms. Trimble discussed the problems biopharmaceutical manufacturers have in production and scaling due to regulatory pressures and the long time horizon for various aspects of testing and safety review. She asked how to balance the need for scaling with regulatory pressures. Mr. Vasko said it was crucial to team researchers with experts in the regulatory process who could shepherd them through the different obstacles, and that coming up with a consistent process that was easily measurable was also essential. He said it was difficult to gain approval for an intuition-based process, and that getting tools into manufacturers' hands quickly enabled them to scale technologies much faster. He said that it was important to design products with long-run scalability in mind.

Preventing Rejection

Dr. Tether asked how fabricated organs would avoid the problem of rejection, and the associated issues of immunosuppression in organ transplant recipients. Mr. Vasko said that the sample tissue for generating the fabricated organs would come from the patients themselves, and with their own genetic material being the basis for the organ there would be no worry of rejection. Dr. Tether also asked how the institute planned to get from tissues to organs, because whole-organ regeneration was the real breakthrough technology. Mr. Vasko noted that even tissue manufacturing allows for the discovery of optimal cell-building techniques that will expedite the development of organs, and said the closed-loop system helps address the biggest challenge in developing manufactured hearts. Because the growth of

cardiac cells needs to be measured, conventional construction techniques involve invasive measurements that often contaminate the samples, something that is not a concern in a closed-loop system. He added that the other issue for organs was the structure, and that the current approach was to use the collagen structure, without cells, from a human or pig heart as a scaffold onto which the fabricated cells were grafted to construct a functioning organ.

Supply Chain Issues and Top-Down vs. Bottom-Up Approaches

Ms. Trimble asked if there were raw material or supply chain challenges facing attempts to scale up production of fabricated tissues. Mr. Vasko said that the major challenge was the timeframe. He said that even an ACL takes 45 days to grow in the closed-loop system, and that organs would take even longer. However, growing organs too fast also presents challenges. Dr. William Pike of Pacific Northwest National Laboratory asked if there was a difference in the success rate of Manufacturing USA institutes that developed from a top-down mandate from a government department as opposed to those that developed from a bottom-up decision by the various stakeholders to collaborate prior to securing government support. Mr. Vasko said that while many of the institutes predated his involvement, the success of the BioFab institute was the clear problem to be solved and the ability of stakeholders to determine the size of the gap they needed to scale, which made it easier to figure out how to deploy existing resources to address it. He said that while institutes come together in different fashions, those that try and bridge specific gaps tend to be the most successful, and added that the military has a great need for biofabrication for treating combat injuries. Especially important was the fact that this need was not likely to disappear any time soon. Ms. Wince-Smith suggested that it might be possible to one day print organs on the battlefield.

Making Manufacturing USA Programs Permanent

Mr. Bates described the Council's work on the U.S. Manufacturing Competitiveness Initiative from 2010 to 2011, and how the Council had called for manufacturing hubs that resemble the Manufacturing USA institutes. He said that the current institutes are far more extensive than the Council had imagined, and wondered if they should be converted from limited-support public-private partnerships to permanent public investments, since they concern technologies and industries where U.S. leadership is essential for our competitiveness and national security. Mr. Vasko said the institutes should be thought of as accelerators that expedite the development of robust private industry, and that it was important to provide incentives for manufacturers to invest in innovation, even as they struggle to stay afloat during the current crisis. Dr. Stephen suggested doubling down on funding the successful institutes that were meeting needs and integrating diverse groups of stakeholders with a variety of capabilities.

Anticipating Future Applications of Innovations

Dr. Tether stressed the importance of identifying the national security and competitiveness dimensions of innovations like tissue fabrication, as this was the key to securing investment. He described how the semiconductor industry developed as the Air Force sought to develop integrated circuits that could withstand shock and vibration in missile systems during the Cold War, and how additive manufacturing was spurred by the need to design engines with built-in coils that spun fuel and kept it from spreading to the walls of the engine and dissipating energy. While both of these technologies would have likely been developed at some point, Dr. Tether credited their immediate application to pressing problems with accelerating the development of both industries significantly. He said that while the humanitarian benefits of biofabrication were obvious, the institute needed to find a security or competitiveness angle as well.

Mr. Vasko said that one of the advantages of the Manufacturing USA institutes was the potential for serendipitous discoveries, as occurred in semiconductors, and Dr. Tether clarified that it was essential to think of secondary applications during the design phase rather than after. He said the best way to do this was to team researchers with “connectors” who were skilled in seeing implications of technology, because researchers are primarily interested in and skilled at design rather than application or marketing. He said universities often lack these experts, and that companies only deploy them when faced with competitive pressure. Dr. Stephen suggested embedding go-to-market teams at all of the Manufacturing USA institutes, modeled after those at the Advanced Research Projects Agency-Energy (ARPA-E). Mr. Vasko suggested that it wouldn't be necessary to do so provided different stakeholders could adequately communicate their needs, but Dr. Tether said in-person interactions between people from different fields was essential to generating ideas. Mr. Vasko said that he had seen the benefits of these connections while working at the BioFab institute.

The Competitive Position of the United States in Biofabrication and Gaps

Ms. Trimble asked where there were technological gaps that the country should invest in addressing, and Mr. Vasko identified explainable AI as the most important one. He said that AI will not be implemented on a broad scale unless people can understand it and its value, citing the example of suspicion around autonomous vehicles. He said that making AI that could be understood and operated by non-scientists was essential because it would be impossible to increase the number of data scientists by the orders of magnitude needed to operate much existing AI. Ms. Wince-Smith asked where the United States stood in tissue fabrication relative to competitors, and Mr. Vasko said the United States was currently the leader, with no other country possessing closed-loop technology. However, he said that the United States

needs to follow through on its strong foundation, and that the biofabrication industry needs to become as large as the semiconductor industry to ensure continued U.S. leadership and reach its full potential. Ms. Wince-Smith said she would love to share this presentation with Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO), because of the shared strengths between the United States and Australia and their close relationship.

Concluding Thoughts

Ms. Wince-Smith thanked the group for their participation, and said that she was excited to hear Mr. Vasko share his presentation with the second Working Group. Ms. Trimble said that themes and narratives were starting to emerge across the different working groups, and asked Mr. Vasko how BioFab measured success and value generated by its efforts. Mr. Vasko said that quickly transitioning these ideas out of the laboratory and getting more people involved in production and scaling was the most important metric, and that if something works, it is crucial to scale it because it is only the starting point.

Working Group 1 Calls May 19

Introduction

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group, and introduced the featured speaker, Dr. Robie Samanta Roy of Lockheed Martin. Mr. Chad Evans discussed the upcoming hiatus in Working Group calls as the Council prepares to commence the second phase of the Working Groups' work. He added that he was looking forward to hearing from Dr. Samanta Roy about the challenges of scaling technology in a national security context given his experiences working with both the private and public sectors at Lockheed Martin.

Featured Remarks: Overview and Framing

Dr. Samanta Roy began his remarks with a discussion of the role science and technology played in the Allied war effort during World War II, including developments like radar and nuclear weapons. He discussed how the war established the position that science and technology would provide the United States with a critical edge on the battlefield, and how after the war Vannevar Bush, the president of MIT and a science advisor to President Roosevelt, formally stated this position in his publication *Science: The Endless Frontier*, which advocated basic research as a building block for the nation's continued scientific and technological advancement. He

WORKING GROUP PARTICIPANTS

Mr. Edward Agne
Communications Strategy Group

Dr. Thomas Campbell
FutureGrasp

Mr. Mike Cassidy
Emergy Biomedical Catalyst

Mr. Dave Copps
Worlds, Inc.

Ms. Stacy Esposito
Arizona State University

Dr. Paul Hommert
Sandia National Laboratory (Emeritus)

Ms. Sara Lawrence
RTI International

Dr. Fred Mannering
University of South Florida

Dr. Robie Samanta Roy
Lockheed Martin

The Honorable Reuben Sarkar
American Center for Mobility

Mr. Guy Snodgrass
Defense Analytics

Dr. Anthony Tether
Defense Advanced Research Projects Agency (Emeritus)

Mr. Phil Weilerstein
VentureWell

Dr. James Weyhenmeyer
Auburn University

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Mr. Tim Planert

also emphasized the need for partnerships among industry, academia, and government laboratories to transition inventions stemming from basic research and turn them into commercial technologies on both the civil and military side. During the post-War period and for much of the Cold War, the United States and Soviet Union continually countered each other with newer, more sophisticated technology, but on a decadal scale. Dr. Samanta Roy argued that this paradigm no longer holds, as the United States is no longer the sole center of gravity for technology development, and because the commercial sector is now leading, rather than following, the defense and national security sectors in the scaling and deployment of disruptive innovations.

Invention vs. Innovation

Dr. Samanta Roy said that while the Department of Defense, the National Laboratories, and the National Science Foundation were often the first inventors of various technologies, they, along with the defense industrial base, were among the last to adopt them, due to timing and other considerations. He used this discrepancy to highlight the difference between invention and innovation, which is the adaptation of an invention into something useful. Examples of technology that the Department of Defense and other government bodies pioneered that were then first adopted by the private sector include microelectronics and artificial intelligence. The Department of Defense, through its creation of the Defense Advanced Research Projects Agency (DARPA) and its role in supporting the Sematech consortium, helped create and sustain the microelectronics industry in the United States through its investments in space technology and missile systems that drove the development of transistors and integrated circuits. However, the leading edge in microelectronics is now the private sector, with chipmaker Nvidia recently releasing a state-of-the-art Graphics Processing Unit chip and the Taiwanese firm TSMC announcing plans to invest \$12 billion in chip manufacturing facilities in Arizona. Similarly, DARPA and

the Department of Defense invented many of the seminal AI algorithms, but big technology companies like Google, Amazon, Microsoft, and Facebook have combined these with big data and sophisticated computational infrastructure to become leaders in machine learning. The Department of Defense is now in a position of scrambling to keep up, always one iteration behind the private sector.

Linear vs. Non-Linear Pipelines

Traditionally, technologies developed in a linear fashion, from the drawing board to testing to entry into the market. Now, the process is iterative and non-linear, with repeated rounds of prototyping and development and many non-traditional actors. Dr. Samanta Roy described a recent Air Force solicitation of technology solutions via the web platform Zoom, which over 5,000 people, 90 percent of them from outside of the defense contracting industry, attended. Now, startups, large technology companies, universities, and many other stakeholders are proffering ideas for national security technology, but they often lack the expertise needed to scale these technologies and develop them to withstand harsh environmental conditions. Many defense contractors are now partnering with these actors to co-develop useful innovations.

Platforms vs. Architectures

Dr. Samanta Roy said that previous generations of national security and defense innovations were developed on large, monolithic platforms, but that newer platforms are emerging that are more adaptable to new technology, enabling a much faster rate of technological refreshment. He described how many aircraft are still in use from generations ago, but rely on newer, more adaptable platforms to continually upgrade their technology. He also discussed the challenges of large bureaucracies, on both the industry and government sides, in trying to centrally plan the adoption of technologies while relying on decentralized execution by various actors or branches of the armed services.

The “Innovation Sandbox”

In attempts to harness the rising numbers of non-traditional actors in the national security space, the Department of Defense and its various constituent agencies have developed a large, complex web of organizations to identify promising technologies for investment or adaptation and more rapidly deploy and scale innovations. Many of these ventures, including the National Security Innovation Network and the Defense Innovation Board, have provided incentives for investment in AI and software and thought leadership on venture capital investment. However, there is also little coordination, as each branch of the military has stood up its own separate organizations, and there are many programs with overlapping goals and mandates.

Political Considerations and Supply Chains

Dr. Samanta Roy discussed the challenges of supply chain management for national security products, given that political imperatives require defense programs to be scattered across the country in different states. These dispersed programs have more complex and more international supply chains than they otherwise would, with the F-35 aircraft having thousands of different suppliers alone. These sprawling supply chains create significant vulnerabilities that require extra planning to account for, as well as opportunities for improving security.

Materiel vs. Non-Materiel Innovations

An important distinction Dr. Samanta Roy made in discussing innovation was that between product (materiel) and process (non-materiel) innovations. He stressed that new ways of doing business and platforms were as important to new technology, and the immense value that process innovations can bring through developing faster and more efficient ways to operate.

The Role of Necessity in National Security Innovation

Dr. Samanta Roy gave several examples of urgent needs being the primary driver of a major innovation in the national security space. During the wars in Iraq and Afghanistan, improvised explosive devices (IEDs) were a disruptive innovation from the perspective of enemy combatants, as they exploited vulnerabilities in United States forces and equipment. The Department of Defense not only had to develop IED-resistant armored vehicles, but also ensure the supply chain for these new vehicles was secure and robust. The government and industry collectively spent billions of dollars to develop IED-resistant vehicles through the Joint Improvised Explosive Device Organization (JIEDO), which successfully developed and scaled these new vehicles. Another example of such collaboration was the Intelligence Services Reconnaissance Task Force (ISR-TF), which helped develop reconnaissance and intelligence gathering technology that could operate in rugged conditions and brought it to scale. Finally, collaboration between the medical and pharmaceutical industries and the Department of Defense resulted in major improvements in treating combat trauma. Dr. Samanta Roy summed up these developments with the takeaway that urgent needs are more important than stated written requirements for spurring innovation.

Time Pressures and Cutting Corners

Dr. Paul Himmert, former director of Sandia National Laboratory, cautioned that during his time working on JIEDO, many ideas were rushed into testing or deployment due to time pressures and ended up not working or backfiring. He said that careful applied development is challenging during times of urgency, and also mentioned the early struggles and challenges involved in rapidly establishing the Department of Homeland Security after the September 11 attacks. Dr. Samanta Roy said that these examples illustrated the role of the Department of Defense and the Department of Energy as “honest brokers” for testing and evaluation, and that cutting corners can lead to negative consequences.

National Security Supply Chains and COVID-19

Dr. Thomas Campbell of FutureGrasp, LLC asked how innovation in the defense and national security sectors was changing in the wake of the COVID-19 pandemic, and suggested that there might be a move toward decentralization in the industry. Dr. Samanta Roy said that one change flowing from the pandemic was an increased willingness by the Department of Defense to approve investments in synthetic biology and other pandemic-relevant areas, where previously those initiatives had struggled to secure funding. He said that government agencies and traditional actors in the defense industry were increasingly turning to crowd-sourcing and providing apertures for non-traditional players to become involved in innovation. However, he noted that it remains to be seen how these new actors will interface with the federal bureaucracy. Ms. Trimble said that there was an ongoing contraction in the domestic defense market that preceded COVID-19, and that the Department of Defense and the defense industry base had boosted exports of military technology, like military engines for aircraft, to keep those sectors going. She said it is too early to tell what the long-term implications of the pandemic will be for these initiatives, and for the defense industry generally. Dr. Samanta Roy noted that contractors often use proceeds from their sales to fund investment in innovation, and that these funds are being devastated by the economic downturn.

Mission and Necessity Driven Invention

Dr. Anthony Tether, former director of DARPA, discussed the importance of necessity in motivating innovation. He said that the Soviet launch of Sputnik took the United States by surprise and obviated a massive investment into a national air defense system. As a result, President Eisenhower investigated the state of U.S. national security research and found that the military's various branches were not heavily prioritizing space. He ordered the creation of DARPA and gave it the goal of researching every

idea that could impact national security to ensure the Soviets never took the United States by surprise again. Dr. Tether said that the relative freedom afforded DARPA, combined with a clear mission, were the keys to its success. He noted that attempts to replicate DARPA invariably become bogged down with extremely long, detailed charters- in contrast to DARPA's one-and-a-half page charter- and that these operational documents can combine with a mindset of short-term returns on investment to stifle innovation. As an example of the long-range impact of DARPA's investments, Dr. Tether noted that Apple's Siri comes from DARPA's cognitive processing program. Dr. Hommert added that TSMC's new venture in Arizona will make use of Extreme Ultraviolet Lithography (EUVL), a technique pioneered by Sandia in the 1990s through a public-private partnership. He added that China is not the location of the new factory because the original Department of Energy partnership included the requirement for partial U.S. manufacture of the EUVL technology, which the Dutch tool company ASML is honoring.

Unlocking and Transitioning Technology from Labs and Universities

Mr. Dave Copps of Worlds, Inc. asked what Lockheed Martin was doing to make use of many of the technological inventions "locked" in national laboratories and university research facilities without avenues for deployment and scaling in the market. Dr. Samanta Roy said that national laboratories have technology transition offices with a mission to go through their portfolio of research projects looking for ideas with commercial potential, and that outside of the lab, there are lots of organizations and companies looking to partner with venture capital, including Lockheed Martin. He said that Lockheed, like many other companies, has a venture capital arm that goes to universities, national laboratories, and federally funded research and development centers to scout ideas that are suitable for licensing and investment, and then offer to work with their developers. He said that Lockheed also has a large program dedicated

to connecting with SBIR grant recipients and other small businesses for joint ventures, and that the company also works directly with the government, especially the Department of Defense, on joint projects to commercialize technology. He said that IP concerns can be a challenge, but that working together produces more than enough benefits to compensate.

Dr. Tether said that Lockheed Martin's skunkworks program, which used to not have a mandate to be profitable, was able to find lots of great ideas for joint venture because it was not constrained by a need for fast returns on investment. However, in the past decade it has become more profit-driven, which Dr. Tether characterized as a loss for innovation. Mr. Marcus Owenby of A&T said Bell Labs had a similarly effective skunkworks program, and Dr. Tether lamented that the company sold off much of the Bell Labs enterprise. Mr. Owenby said that AT&T is interested in expanding its investment in this space again, and has already established FirstNet, which is a foundry designed to fund investments in innovations benefiting first responders, FEMA, the Department of Defense, and other crisis and national security organizations. Dr. Samanta Roy said that in addition to its long-term research, which included innovations like the invention of the transistor, Bell Labs also worked on practical, applied problems, like secure harnesses for telephone pole repairmen, and that the proceeds from these applied efforts helped to fund their long-term, basic research.

Risk Aversion, Consolidation, and the Pace of Innovation

Dr. Samanta Roy said that the defense industrial base is not viewed as a high-tech sector, but as value stock, by investors. He said the sector has become very risk averse, and suffers from a lack of mutual understanding among industry, finance, and government. He noted that engineers no longer run the defense contractors that they founded, and that there were two opposing trends affecting the industry. On the one hand, there is considerable ongoing consolidation among traditional defense contractors, but on the other, many new players, including big

technology companies, are entering the field. He noted that a handful of these companies and contractors are responsible for a disproportionate share of startup spinoffs in AI, and warned that big companies and big government needed to adapt to the new imperative for speed. Dr. Samanta Roy highlighted the speed gap between the defense industry and other sectors through the example of the F-22 aircraft, which took as long to get from initial mandate to market entry as it took the electronics industry to go from early personal computers to the iPhone. He also noted the rapid political and economic changes that occurred during this span, and noted that long gaps between ideas and productization can render the idea irrelevant.

Platform Technologies Vital to National Security

Ms. Wince-Smith asked which enabling platform technologies were key to U.S. national security and competitiveness, and warned that China was focused on controlling "civil-military fusion" technologies. Dr. Samanta Roy noted that this use of "platform" differed from the conventional defense industry term that refers specific technologies, but that there were three operational spaces that it is crucial for the United States to lead in. The first is microelectronics, which is the basis for all other advanced technology. Dr. Samanta Roy said the United States should be encouraging more developments like TSMC's investments in Arizona and Nvidia's new cutting edge graphics processing unit. He emphasized the importance of taking the lead on the "next big thing" as Moore's Law nears its end, and said that having the capabilities to on-shore the supply chain for these products provided additional security.

The second platform Dr. Samanta Roy mentioned was AI, where he stressed the importance of ensuring the proliferation of U.S. ethics and values governing the use of this technology. He discussed the DARPA classification of three "waves" of AI. The first wave consisted of "expert" programs like TurboTax, and the second (current) wave includes machine learning, neural networks, and text, image, and

speech recognition. The third wave involves bringing sense-making and cognition to artificial intelligence systems. Dr. Samanta Roy urged the United States to continue to lead in bringing second-wave AI into operational use, citing the work of companies like Google, Amazon, and Microsoft. He also advocated leveraging the work of big tech companies and the government on third wave AI, and encouraged the Council to use its connections with the National Security Commission on AI to become thought leaders in this space.

Finally, Dr. Samanta Roy listed biotechnology and biopharmaceuticals as a critical platform, especially in dealing with pandemic preparedness and response. He encouraged the development of an open source platform for rigorous testing and evaluation to expedite the development of innovations in these fields.

Concluding Thoughts

Ms. Wince-Smith thanked the group for its discussion, and said the Council would have lots of ideas to synthesize as part of its transition to Phase II of the Working Groups. She characterized the imperative for U.S. leadership in microelectronics as the most important technological problem for innovation and national security, as microelectronics is the enabler of other key platforms and technologies. She added that in the next phase of discussions, new participants would be joining the Working Group. Mr. Evans reminded the group that Thursday's call will be combined with the Technology Leadership and Strategy Initiative Competitiveness Watch monthly call, and invited the participants to join the discussion. He highlighted the keynote presentation to be delivered by Dr. Victor Dzau, President of the National Academy of Medicine and a Commissioner, on the global effort to develop therapeutics and other responses to COVID-19.

Working Group 2: Exploring the Future of Sustainable Production and Consumption

Working Group 2 Summary

The virtual Working Group sessions began on March 31st and completed this first phase on May 22nd. This 'Phase I' of the Working Group sessions yielded insights and areas for further assessment ahead of the National Commissioner's meeting on June 16th, 2020. Below are highlights and themes from the Working Group.

This Working Group examined two aspects of sustainability: "hard challenges," such as material innovation and supply chain transformation, and the use of sustainable products throughout the supply chain; and "soft challenges," defined as related to consumer behavior and culture, as well as sustainability thinking. Solutions for these challenges generally take longer to implement and require multiple stakeholders such as industry, regulatory bodies, individuals, to succeed.

Working Group members focused on workforce challenges, including conversations related to: education, non-degree credentialing and training, reinvention of recruitment to engage more diverse and under-represented minorities—and retention strategies.

Areas for further discussion in the next phase of the Working Group dialogue include: the use of sustainable products in manufacturing; changing consumer behavior and shifting corporate strategies to value and prioritize sustainability actions; and determining how innovation can improve lives, with a particular focus on vulnerable groups across the country. The Working Groups explored a wide range of additional topics, including but not limited to the following:

- The Working Group began by focusing on ways to strengthen entrepreneurship and increasing entrepreneurial opportunity. Working Group members explored concepts and the beginnings of recommendations to: cultivate the talent pool for entrepreneurship; make the entrepreneurial environment more inclusive; prioritize attention (and funding) around innovation-based firms and industries.
- Working Group members discussed the tenets of sustainable production. They suggested policies to benefit U.S.-based manufacturers that produce sustainably and provide U.S.-based jobs (e.g., tax subsidies). Instead of more protectionist policies—such as increasing taxes on imported goods by "climate offenders"—this could create incentives for companies to settle in the United States, create jobs and make products available even to a wide-breadth of consumers.
- Regarding production, Working Group members agreed that a stronger, national emphasis on the importance of adopting smart manufacturing technology is essential to long-term innovation. Partnerships in this space could be vital, but Working Group members recognized there are challenges in execution. For example, they cited the challenges the Manufacturing USA Institutes are facing as they transition from a public-private partnership model to one that is self-sustaining.

- The Working Groups explored how to think about upskilling the workforce and aligning workers' capabilities with future industry needs, including skills in digitalization, artificial intelligence, and high performance computing.
- Working Group members discussed the evolving perspective on supply chains—in light of longer-term trends toward nationalism across the world, as well as the unexpected challenges posed by the global COVID-19 pandemic. In this context, the concepts of supply chain resiliency and the relocation of supply chains emerged here as well as in the other Working Groups.
- The Working Group also discussed the pros and cons of focusing less on efficiency and more on resiliency in the production equation—trading some of the cost gains from globally dispersed, production-sliced supply chains, to more redundant (perhaps more localized) supply chains. For example, as a risk hedge—a supply chain “inoculation”—several Working Group members promoted a rethink of the U.S. dependency on China and Southeast Asia—accepting perhaps higher prices for more secure/local (U.S.-based; Western Hemisphere-based; North America-based) access to critical supplies and parts for the nation's production enterprise.

In Phase Two 2020 of the Working Group process, this Working Group will split. First, a new Working Group has established to focus on the “Unleashing the Capabilities of Work and Entrepreneurship.” This Working Group will seek to identify the key challenges and opportunities reshaping the future of work—such as demographics, geography, changing skills needs and organizational models—and, in understanding those, spark entrepreneurial activity, enhance innovation and drive competitive advantage through the productivity and resilience of the American workforce. Working Group 2 will focus squarely on “Exploring the Future of Sustainable Production and Consumption,” and will identify long-term, productivity and prosperity-enhancing recommendations that harness the nation's abundance of natural resources, energy, talent and ingenuity to power and unleash the most productive economy in the world.

To view video and read full transcripts of each Working Group session, log in to the National Commission Community Online Portal. Video and transcripts are available within Working Group Rooms.

Working Group 2 Calls April 1

ASU Launch Conference Recap

Ms. Yasmin Hilpert summarized the Working Group's proceedings at the January Launch Conference at Arizona State University. The group identified three kinds of sustainability challenges. Hard challenges involve businesses choosing more sustainable production and packaging methods and striving to reduce their environmental impact and resource use. Many companies are beginning to incorporate these considerations into product design, but issues such as product durability and planned obsolescence remain. Soft challenges, like encouraging more sustainable behavior by consumers, take longer to implement and require both education about sustainable choices and efforts to make sustainability con-

venient for consumers. Finally, systems challenges, such as the policy environment and the incentives built into the American economy, have the longest time horizon. Here the United States should look at initiatives around the globe, such as in the European Union, to use tax and subsidy policies to incentivize sustainable production by firms. American specialization in high value-added manufacturing also means the U.S. economy faces a landscape of increasing manufacturing output and productivity but a declining manufacturing workforce, which has implications for the future of work.

The group also decided how to structure discussions after the Launch Conference. Each subsequent discussion would focus on one of the topics featured in the conference book: sustainability of production and

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luce Foundation

Dr. Carol Dahl
Lemelson Foundation

Ms. Tiffany Davis
Southern Company

Dr. Helene Dillard
University of California, Davis

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts-
Dartmouth

Ms. Ciannat Howett
Emory University

Mr. Noel Kinder
Nike

Mr. Jonathan King
Southern Company

Ms. Amy Lientz
Idaho National Laboratory

Ms. Stacy Lippa
Target

Dr. Kathleen Merrigan
Arizona State University

Dr. James Stock
University of South Florida

Mr. Luke Tate
Arizona State University

Dr. Maya Trotz
University of South Florida

Dr. Paul Wolpe
Emory University

Ms. Anna Herken
Allianz

Mr. Mike Cassidy
Emory Biomedical Catalyst

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

consumption, changing models of work and workplace organization, increasing entrepreneurship and entrepreneurial opportunity, and the development and allocation of human capital in a world transformed by disruptive technological innovation and global competition. Each discussion would be preceded by issue papers providing kickoff questions to begin the session, and Ms. Hilpert expressed a goal of having three to five draft recommendations following each call. Noting the disruption of the COVID-19 pandemic, she said the group will address COVID-19 related topics when it is relevant, but will not make it the sole focus of the Working Group's discussions.

Scheduling and Organization

Participants in the discussion expressed a variety of preferences for the organization and scheduling of future calls. Several members of the group suggested moving to Friday calls, while other members expressed a preference for the current schedule of Wednesday calls. Ms. Trimble suggested possibly breaking the weekly call into two different one-hour sessions to allow the maximum number of participants to contribute. She offered mid-morning and mid-afternoon Eastern time slots to accommodate both coasts. Mr. Chad Evans recommended conducting an online poll to determine how many weekly sessions to have, and at what days and times.

Entrepreneurship

Dr. Carol Dahl of the Lemelson Foundation and Dr. James Stock of the University of South Florida shared with the group a paper they co-wrote identifying areas where the United States can better leverage its entrepreneurial potential and provide support to entrepreneurs, which they also posted to the online collaboration portal for comment. They identified four major issue areas related to strengthening entrepreneurial opportunity. First, they called for starting the entrepreneurship pipeline in the educational system at an earlier age, which would help address inequities in the entrepreneurial system. Second, they called for the identification of missing

elements in the system to support entrepreneurs. Third, they advocated for an increased focus on human capital and the inclusivity of the entrepreneurial system. Finally, they urged that innovation-focused businesses be recognized and prioritized as the key to productivity growth, as the importance of these businesses is typically not recognized by local and regional programs to promote entrepreneurship.

Dr. Stock expressed the importance of learning from existing best practices in entrepreneurial development that could be scaled up and replicated elsewhere. He cited the example of the Angel Network of programs in the North Carolina Research Triangle, with the cooperation of the University of North Carolina, North Carolina State University, and Duke University. These programs have succeeded in nurturing entrepreneurs and have expanded to other institutions, such as the University of Miami. He also noted the variety of successful programs under the auspices of the Small Business Administration that could be scaled up with increased funding. Dr. Dahl discussed the success of the National Science Foundation's I-Corps Program, and "Invention Education" programs at the K-12 level as programs to be scaled and made more robust. In the chat, Dr. Michael Goodman of the University of Massachusetts-Dartmouth mentioned successful initiatives in the Boston metropolitan area, such as the Greentown Labs and Mass Challenge programs, but noted they had yet to successfully scale to other parts of the state.

Mr. Evans concurred with the idea of replicating and scaling best practices, citing the example of the Council's work on High Performance Computing with the National Laboratories. Beginning as a project in the energy sector, the High Performance Computing initiative has been expanded to other subjects, such as manufacturing and transportation. The governance structure, funding, and division of responsibilities for these later projects were informed by the example of the initial initiative. He also agreed that the paper could serve as a launching point for the Working Group's deliberations on this topic, especially since it is viewable via the online collaboration portal.

COVID-19, Sustainability, and Resiliency

A major theme of the discussion was the impact of the COVID-19 pandemic on the sustainability of the American economy and the resiliency of its supply chains. Some of the most prominent themes in the discussion were community resilience and innovation, reuse and sustainability, reshoring and relocation of supply chains, the need for national coordination of crisis responses, and the response of industry to new demands in crisis periods.

Dr. Maya Trotz of the University of South Florida highlighted the resiliency and innovation communities have demonstrated in response to the crisis, including creating face masks, face shields, and other personal protective equipment to aid medical workers. She also noted a renewed appreciation for sustainability emerging from the need to find local suppliers of goods and services due to supply chain disruption, and the observed drop in pollution due to reduced economic activity during the pandemic. She stressed the importance of ensuring these innovation-focused mindsets remain at the community level after the pandemic passes, unleashing greater community empowerment. Mr. Evans noted the parallels between innovative community responses and “shared infrastructure” like High Performance Computing consortia. He characterized the grass-roots responses to the pandemic as a potential next generation of shared innovation infrastructure.

Dr. Dahl expressed the importance of “redundancy” in supply chains and resources in responding to crises, but was concerned about the impact on sustainability of having duplicative structures and systems. Dr. Trotz believed that communities being left to determine their own COVID-19 responses has created demand for reusable resources, including face masks that can be sterilized via autoclave and reused. The crisis will spur the general public to find ways to reduce waste, which could be scaled up to industries looking to improve resiliency as well. Mr. Evans discussed the Council’s work with Caterpillar on sustainability and reuse in industry, which offers

a blueprint for companies looking to minimize waste, especially for difficult-to-acquire inputs like advanced materials and rare earth minerals.

Participants also discussed the relocation of supply chains. Dr. Tommy Gardner of HP Federal brought up the requirement in the CARES Act for the National Academies to study America’s medical supply chain resiliency, and gave an illustration of the dangers of unsecured supply chains. Following the 2008 financial crisis, many small businesses that acted as sub-suppliers for multiple competitors in different industries went bankrupt. This included the sole supplier of heated coils for car seat heating systems, leaving every major car manufacturer scrambling to develop their own technology. He expressed concern that many small businesses will not survive the current economic recession, and that this will jeopardize operational sustainability for many companies. The Honorable Deborah L. Wince-Smith asked if the crisis will prompt companies to seek greater vertical integration to secure their supply chains, and Dr. Gardner said it was likely, but not necessarily the best solution. He advocated for ensuring that small suppliers for companies exist in competitive industries, and called for companies to identify vulnerabilities in their supply chains and work together to fix them. He also pointed to his experiences in a Threat Evaluation Working Group comprised of representatives from 120 firms, where they identified 283 distinct threats to their business models. He said that firms must be mindful of the “broad” variety of supply chain threats.

Dr. Stock projected that in the coming decade American firms would engage in substantial reshoring of their products due to the fallout from the COVID-19 crisis and concerns about relying on foreign production of rare earth minerals and other essential components. Citing defective ventilators shipped to Italy during the COVID-19 crisis, he predicted firms would begin manufacturing things domestically for quality control purposes, and to avoid the worries of dealing with a managed economy and unpredictable governmental responses to crises and natural disasters. He

further predicted that some companies would relocate production from China to countries like Thailand, Vietnam, Indonesia, and Mexico. Dr. Goodman noted that he had not seen significant evidence of reshoring by American firms thus far.

The group expressed significant concerns about the lack of a nationally-coordinated response to the pandemic, and expressed urgency over the need to develop plans for future crises. Dr. Trotz questioned why there was no nationwide effort to coordinate among universities researching COVID-19 vaccines. Dr. Dahl added that having a plan for coordinating research and innovation in response to crises will be important in the future, and Dr. Trotz suggested devising one now for the coming months would be beneficial. Dr. Goodman described the efforts of universities in Massachusetts to coordinate with the state government and each other in their COVID-19 response, as well the coordination efforts among local manufacturers. Academia and industry in Massachusetts are “dividing and conquering” to address research on vaccines and treatments and manufacture of personal protective equipment, respectively. However, Dr. Goodman said the country was “paying the price” for a lack of national coordination. Dr. Helene Dillard of the University of California, Davis echoed this sentiment. She noted that universities across California have been much more willing to collaborate and share data than in normal times but that it would have been much better to coordinate a national response in advance. Ms. Ciannat Howett of Emory University also noted substantial academic coordination on vaccine research, but added that the crisis illustrated the importance of specifically including public health in plans to address global challenges. She said that both COVID-19 and other threats such as climate change require coordination and have public health elements, and argued that the United States should strive to be a global leader in both planning and intervention in the face of crises.

Finally, The Honorable Deborah L. Wince-Smith broached the topic of industry retooling to produce goods and services needed during crisis. She noted the reactivation of the National Defense Production

Act, which allow the government to direct industry to make products crucial to ongoing crises, and expressed interest in industry leaders' thoughts on COVID-19 response and supply chain vulnerability, especially pertaining to pharmaceuticals and medical devices. Dr. Noel Kinder of Nike described efforts by the company to retrofit domestic factories to produce face shields, but noted that their factories overseas are suffering from government-imposed shutdowns, rendering them unable to make use of them. Ms. Wince-Smith noted that China has nationalized 3M's plants located in the country, and asked if this was a concern at Nike. Dr. Kinder said that Nike had not experienced this issue, but acknowledged it may be a concern for other companies. He also noted that China, along with Japan and South Korea, had permitted the reopening of Nike stores and factories more quickly than in other countries. Ms. Stacy Lippa of Target described her company's efforts to minimize disruption via reallocating production across different locations and implementing contingency plans. She stressed the importance of flexibility in manufacturing for emergencies because of the time and expense of relocating production. Ms. Trimble also noted the significant variation in time frames for retrofitting factories and relocating production. Some manufacturers have been able to convert to producing protective equipment in a matter of weeks, but other transformations, such as retooling information technology, can take years.

Moving Forward

Ms. Hilpert reminded the group that she and Ms. Trimble would formulate a schedule of calls and topics from the results of the upcoming poll, and added that next week's call will focus on the first issue area (sustainability of production and consumption) outlined in the Launch Conference program. Ms. Trimble reminded the group about the online collaboration platform.

Working Group 2 Calls

April 10

Setting the Stage

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group and introduced the kickoff speakers, Dr. Carol A. Dahl of the Lemelson Foundation and Dr. James Stock of the University of South Florida. They introduced their paper on identifying ways to strengthen entrepreneurship and entrepreneurial ecosystems, and asked for feedback on which sections to modify and expand, as well as which solutions to prioritize in future iterations of the paper.

Background

Dr. Dahl identified four questions that she and Dr. Stock sought to answer. These are how to cultivate the talent pool for entrepreneurship, how to ensure enterprises receive the support they need to be

successful, how to make the entrepreneurial environment more inclusive, and how to get the government and the entrepreneurship community to recognize and prioritize innovation-based business, as opposed to mainstream or lifestyle businesses, in fostering entrepreneurship. She also identified key studies and recommendations that helped inform their work, including the Council's reports *Work* (2016) and *Transform* (2017), as well as the work done by Stanford economist Raj Chetty and colleagues on innovation and inclusivity. She further cited programs that provide prototypes for scaling due to their success, such as the National Science Foundation's I-Corps program, and urged earlier exposure to innovation and entrepreneurship in schools. Dr. Dahl noted that most students choose their general career path by middle school. Dr. Stock echoed the importance of drawing on previous successes and "not reinvent-

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luce Foundation

Mr. Mike Cassidy
Emory Biomedical Catalyst

Dr. Carol Dahl
Lemelson Foundation

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts-Dartmouth

Ms. Ciannat Howett
Emory University

Ms. Amy Lientz
Idaho National Laboratory

Ms. Stacy Lippa
Target

Ms. Jenny Sorensen
Lemelson Foundation

Dr. James Stock
University of South Florida

Ms. Erica Volini
Deloitte

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

ing the wheel.” He established a goal of identifying which recommendations for program adoption and scaling were most important.

Teaching Invention

Dr. Mike Goodman of the University of Massachusetts-Dartmouth asked if there was evidence supporting the efficacy of innovation curriculum in fostering greater entrepreneurship and invention, as such efforts seemed to founder at the state level in Massachusetts. Dr. Dahl noted that the effects of such programs can take years to manifest, and that it is important for any invention curriculum to involve experience of invention, rather than just learning about it. She emphasized that students need the opportunity to identify problems to solve rather than being assigned them, and need to actually go through the process of opening a business to learn firsthand the “soft skills” necessary for successful entrepreneurship. She added that this process has the further benefit of enabling students to see themselves as entrepreneurs, especially girls, students of color, and low income students. Dr. Stock added that students need to “catch” the spirit of invention through formative experiences, and that bringing in successful entrepreneurs to explain and demonstrate their work is far more valuable than “textbook” learning.

Inclusivity

Ms. Ciannat Howett of Emory University noted that women enter the corporate world at the same frequency as men, but that men are 142 percent more likely to reach the C-Suite level. She urged the promotion of universal pre-K education to help support women in the workplace and address this discrepancy in career advancement. Dr. Carlotta Arthur of the Luce Foundation worried that absent efforts to reduce bias, credentialing for entrepreneurial skills might disadvantage students from underserved backgrounds. Mr. Tommy Gardner of HP federal noted the importance of diversity in background,

thought patterns, and viewpoints in fostering innovations. He noted how the discovery of DNA was aided by combining scientists’ expertise in biology and chemistry. Dr. Dahl also stressed the importance of bringing inclusion from the educational system and into the corporate world. Mr. Evans discussed the Council’s previous work, including Transform, that identifies programs with success in increasing the diversity of the innovation landscape. In particular, he identified the efforts of the University of California, Riverside as a model that could be scaled elsewhere, as it combines clear metrics with proven results in fostering innovation, especially by underserved students. Dr. Dahl further suggested making use of the nonprofit Venture Well, which has a wealth of resources on successful and inclusive programs. Dr. Mike Cassidy of Emory University also suggested the Junior Achievement and First Robotics programs as models.

Cultivating and Measuring Skills

Ms. Erica Volini of Deloitte described the difficulty corporate recruiters have in trying to discern applicants’ innovation skills from their resumes, and wondered if there was a way to provide a credentialing program that would enable employers to find job applicants with the best soft skills to become entrepreneurs and inventors. She further added that providing students with a tangible asset for their job searches could motivate them to participate in innovation. Dr. Goodman further suggested using paid internships as an incentive for students to enter the entrepreneurial world in high school and college. Dr. Dahl suggested that such credentialing involve portfolio evaluation, as it would better capture the qualitative distinctions that soft skills present. Dr. Goodman worried about the challenge of conducting portfolio evaluations, because the skills in question are “know them when you see them,” and Ms. Volini wondered if artificial intelligence could help identify these skills. Ms. Stacy Lippa of Target asked if specifying traits, such as autonomy, risk-taking, and proactive thinking, could help with evaluations. Ms. Wince-Smith brought up the Smithsonian’s efforts to develop badging and credentials programs for both

STEM competencies and experiential learning and entrepreneurship skills. She also suggested modifying the Baldrige criteria developed by the National Institute of Standards and Technology, originally developed to certify quality in corporate manufacturing and production, to develop evaluation criteria for entrepreneurship.

Structures to Foster Innovation

Dr. Stock discussed existing institutions that could be leveraged to foster entrepreneurship, in particular to help companies cross the “Valley of Death” after initial funding has run out and before they have developed a scaled, marketable product. He said the U.S. landscape contains pockets of innovation and creativity, but that these need to become more widespread. He also warned that the COVID-19 pandemic, with its slowing of economic activity, could endanger cash-strapped startups. Among suggestions in his paper with Dr. Dahl, Dr. Stock suggested building upon the Small Business Administration, which he characterized as helpful to startups but with room for improvements in allocating funding and rates for loans, among other issues. He also urged combining the SBA’s programs with the SCORE program where retired executives act as mentors to entrepreneurs, and called for scaling up the SBA’s regional innovation cluster program. Finally, he suggested public-private partnerships in which firms could fund entrepreneurship programs at high schools and colleges, in a similar manner to their funding of research grants, endowed chairs, and professorships. He also noted that some of these programs would require no public money, and some would require no new funding at all, but instead a reallocation of existing funding.

Dr. Dahl echoed Dr. Stock’s call for mentorship programs, noting that studies have found mentorship to be one of the most important components in successfully establishing innovation ecosystems. Dr.

Stock was hopeful that companies would respond to calls for these programs, since the COVID-19 pandemic has led to companies engaging in social responsibility efforts not tied to their bottom lines.

Moving Forward

Drs. Dahl and Stock asked for feedback on future discussions. Dr. Goodman suggested identifying the problems the group would like to solve first, and then “dividing and conquering” on solutions. Dr. Dahl noted that some issues, like inclusivity, were cross-cutting, and Dr. Goodman suggested addressing these cross-cutting issues within each distinct issue that emerged. Dr. Stock noted Michael Porter’s research on value chains in businesses from the 1980s, and that this work separated out unique and cross-cutting issues in such a fashion. Ms. Trimble and Ms. Wince-Smith noted that the other working groups were experiencing similar challenges, and discussed plans for creating task forces to address cross-cutting issues that featured participation by members of all three working groups. In particular, Ms. Wince-Smith noted the importance of identifying ways to secure long-term, patient capital for investments in key technologies, and the need to approach policy makers with solutions that went beyond simply increasing research funding. Mr. Chad Evans noted that the discussion had illuminated the need for very extensive discussion of many of these issues, and Dr. Dahl suggested the group broaden its scope first to ensure it was not neglecting any topics before honing in on key issues. Ms. Trimble reminded the group that the next call will be on Monday, and will continue discussion of Dr. Stock and Dr. Dahl’s paper.

Working Group 2 Calls April 13

Recapping Last Week

Dr. Carol Dahl of the Lemelson Foundation opened the discussion with a summary of the previous call, in which she and Dr. Jim Stock of the University of South Florida discussed the first two pillars they identified as key to strengthening entrepreneurship and entrepreneurial opportunity: cultivating a pipeline of innovative talent and the role for education, and ensuring a robust ecosystem to help entrepreneurs turn ideas into businesses. Dr. Dahl discussed the importance of having a pathway for turning ideas into reality, generating dynamism and job creation and sparking further ideas for innovation. She described this virtuous circle as characterizing successful innovation economies in places like San Francisco, Seattle, and Boston, and also characterized the discussion as a starting point. She added that she

and Dr. Stock would love further input and feedback on other topics to consider and useful studies and information.

Responding to the COVID-19 Crisis

Members of the group discussed whether the Working Group, or the Commission as a whole, should issue a statement related to the government response to the COVID-19 stimulus bill, specifically pertaining to the guidelines for Small Business Administration assistance to distressed firms. Dr. Kathleen Merrigan of Arizona State University noted that many small businesses felt confused about the amount of assistance they are eligible to receive, as well as the timing of that funding, and Dr. Dahl observed that the rules around venture- and angel-funded businesses discriminate against the kinds of

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luca Foundation

Mr. Leslie Boney
North Carolina State University

Dr. Carol Dahl
Lemelson Foundation

Ms. Tiffany Davis
Southern Company

Dr. Helene Dillard
University of California, Davis

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts-Dartmouth

Ms. Ciannat Howett
Emory University

Mr. Noel Kinder
Nike

Mr. Jonathan King
Southern Company

Ms. Amy Lientz
Idaho National Laboratory

Ms. Stacy Lipka
Target

Dr. Kathleen Merrigan
Arizona State University

Dr. James Stock
University of South Florida

Ms. Jenny Sorensen
Lemelson Foundation

COUNCIL STAFF

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

innovative startups that are most important to driving economic growth. Mr. Chad Evans characterized these concerns as falling under the purview of the third Working Group, but he emphasized that the Council as a whole would issue a response to the COVID-19 pandemic and to economic relief efforts, as it was important for the response to come from the highest level possible. He also framed such a response around the idea of embedding resilience into innovation ecosystems, both for this crisis and for future events. Dr. Merrigan highlighted entrepreneur Mark Cuban's call for "America 2.0", and Mr. Evans agreed with this framing for rethinking the economy. He also encouraged members of the Working Group to see what other stimulus packages emerge from Congress, as some of them may target startups and innovative firms.

Inclusivity

The first major issue the participants discussed was inclusivity in innovation. Dr. Dahl referenced Harvard economist Dr. Raj Chetty's work on inclusivity, which found that if women, low income Americans, and minorities participated in the innovation ecosystem as high income white men, America's innovation rate would quadruple, with substantial impacts on economic growth and dynamism. She also discussed the problem of underrepresentation of marginalized communities in leadership positions in the entrepreneurial world, and added that people from low-income backgrounds face particular disincentives to innovate, even with access to higher education. This is due in large part to lack of access to networks and the unwillingness to take on financial risks to start a business. Dr. Dahl stressed the need for solutions that would reach all parts of society, and that the public school system was the best way to ensure innovation-supporting policies reach everybody. She called for greater access to mentorship, funding, business incubators, and other support for entrepreneurs from underrepresented groups. She also urged providing social services, including health insurance and student debt relief, to underrepresented groups in order to de-risk the process of innovation and reduce financial stress.

Dr. Carlotta Arthur of the Luce Foundation characterized the issues facing people of color, especially women of color, as systemic and said they would require major changes due to structural inequalities and unconscious bias. She noted that such bias manifested in the disparate impact the COVID-19 pandemic is having on African Americans. Dr. Arthur added that data focused on comparing outcomes along gender lines does not break out the discrepancies between white women and women of color in achieving parity and representation, and that there is also insufficient attention to achievement gaps between white men and men of color. She said that she would look for existing literature on best practices for addressing these inequalities. Ms. Stacy Lippa of Target asked whether "inclusion" by itself was sufficient for addressing inequity, or whether "diversity and inclusion" was a better framing. She asked how to build an educational and entrepreneurial environment around diversity and inclusion. Dr. Dahl said that people differ on whether inclusion is the "linchpin" for diversity.

Ms. Ciannat Howett of Emory University identified universal pre-K education and childcare as a key to improving the representation of women in leadership in innovative STEM disciplines. She said data now show that women are achieving parity with men in the educational system and at the junior ranks of the professional world in STEM fields, but that a persistent gap remains at senior positions. The data also indicate that this disparity is driven by women taking time out of the workforce when their children are young, which hinders their career advancement, and that better access to childcare would allow them to remain in the workforce and continue to advance at the same rate. Ms. Howett also shared that countries like the UK, France, and Germany have gender pay reporting requirements for large firms, and that this appears to impact pay disparity between men and women. She suggested such a policy would be especially useful in high-tech hubs like Silicon Valley and Seattle, where pay disparities are larger than for the United States as a whole. Dr. Merrigan suggested widespread adoption of the EU's requirement that companies have gender diversity on their board

of directors, which the state of California has already implemented. Dr. Dahl and Mr. Evans both encouraged more input on this topic, and urged Ms. Howett and Dr. Merrigan to share any useful literature on the online platform.

Ms. Amy Lientz of Idaho National Laboratory echoed Dr. Dahl's concerns with de-risking entrepreneurship. She noted that her laboratory frequently hears from startups that want to collaborate, and entrepreneurs that want to spin out technologies developed in the lab, but they face barriers due to concerns about benefits. The lab is not legally allowed to provide them with health insurance, 401(k) benefits, or other benefits that would provide them with financial security and reduce the risks of innovating. Dr. Dahl noted that some universities have addressed this issue by allowing students who develop intellectual property while researching at the university to remain affiliated as fellows while they pursue spin-off opportunities. Some schools also provide debt deferment and relief to help student entrepreneurs.

Dr. Dahl suggested that different dimensions of the inclusion issue may have different solutions, and emphasized that for many people from underrepresented communities, lack of access to innovation ecosystems begins early on. She said that many children from low-income backgrounds begin receiving negative messaging about their potential for achievement by middle school, preventing them from following the pathway to becoming innovators and entrepreneurs. Dr. Mike Goodman of the University of Massachusetts-Dartmouth stressed that assis-

tance to underrepresented groups would need to be targeted and emphasized in innovation policy, and he encouraged searching for best practices in this regard that could be scaled up. Mr. Evans mentioned the University of California, Riverside's effort to boost diversity in innovation as an example of such a model.

Prioritizing Innovative Businesses at a National Level

The other principal issue the group discussed concerned properly prioritizing innovative firms in the entrepreneurial space. Dr. Stock warned that insufficient investment in innovation would harm national competitiveness, and he called for a return to higher R&D spending, with a target of 2 percent of the federal budget. He also expressed concern about the federal government's preference for "spreading money around" to small businesses, rather than providing strategically targeted assistance to the biggest drivers of economic growth. In this vein, Dr. Stock suggested the development of a nonpartisan think tank to identify the most promising and innovative firms and startup ideas, and to encourage federal prioritization of those firms and ideas. He also called for more and better data, as companies and federal agencies often don't have the data on key performance indicators that is essential to identifying the best innovations. Dr. Stock further emphasized that more than 50 percent of ideas never make it

to prototyping, and that those that do often suffer from a lack of available investment. He urged more funding for research, and he also discussed the state of education funding in Florida. While state lottery revenue continue to flow into education funding, other funding sources had decreased, leaving no net increase in funding. Dr. Stock also lamented that the state government no longer matched donations to endow chairs or professorships at universities.

Participants identified particular avenues for greater funding of innovation. Dr. Stock suggested the Veterans Advantage program within the Small Business Administration (SBA), arguing that veterans were less risky to invest in compared to other entrepreneurs due to their work ethic and experience. He also urged more funding for the Small Business Innovation Research (SBIR) program. Dr. Merrigan encouraged participants to think beyond the SBA. She noted that the Department of Agriculture also operates small business programs, and that small farms will be especially hard hit by the COVID-19 pandemic because up to 50 percent of restaurants, their chief customers, will not survive the economic crisis. Dr. Stock expressed a desire for more input from the business community, alongside health experts, in shaping COVID-19 response, as there are important tradeoffs to consider between public health measures and economic relief, and because groups with more diverse stakeholders are more open to compromise and creativity.

Conclusions and Framing Further Discussion

Dr. Stock encouraged the group not to “reinvent the wheel,” and to make use of successful policies that could be scaled up to the national level. He described the University of South Florida’s efforts to boost diversity in its programs, noting that a majority of supply chain management majors at the business school were women, and that racial and ethnic minorities were also well represented, because the school made an effort to be inclusive. He further suggested that organizations and institutions outside the group’s nominal scope might have ideas that could be usefully scaled for the work of the Commission. Dr. Dahl wondered if the group should focus only on high-innovation firms in strengthening entrepreneurship, or if they should include more “mainstream” businesses’ concerns as well. Dr. Tommy Gardner of HP federal encouraged a focus on both kinds of businesses. He noted that the economist Joseph Schumpeter had found that both small and large firms were essential for innovation. He also urged members of the group not to hesitate in voicing their true feelings on discussion items, as a diversity of opinions generates better solutions and ideas. Drs. Dahl and Stock concluded by asking the group to help determine two or three priorities for policy solutions from each of the four sub-issue areas they identified in their paper.

Working Group 2 Calls

April 17

Introduction

Ms. Kathy Trimble welcomed the group and introduced the opening speaker, Mr. Leslie Boney of North Carolina State University. She said that the discussion would focus on very broad questions of human capital, skills, and the future of work.

Opening Remarks

Mr. Boney opened with a discussion of the massive rise in unemployment from 3.5 percent to 16 percent as a result of the COVID-19 pandemic, and how NC State's Centennial Campus had rapidly retooled its textile production facilities to make personal protective equipment for healthcare workers. He explained how both of these rapid changes foreshadow major disruptions to the labor market and the economy. The Institute for Emerging Issues at NC State predicted that 24 percent of current jobs in North

Carolina would cease to exist by 2040, with county-level variation from 15 percent to 41 percent. He added that worldwide, different locations could see from 10 percent to 70 percent of current jobs cease to exist in the coming decades. In the short run, he described how the pandemic had rapidly reorganized the economy, with grocery store revenue increasing by 27 percent and restaurant revenue decreasing by 25 percent. The pandemic has also caused rapid change in service delivery, with all the K-12 and college students in North Carolina transitioning to online learning, and up to 100 million students across the country.

Mr. Boney said that even before the pandemic, businesses were frustrated at the hard and soft skills possessed by graduating students, with surveys of employers showing satisfaction rates ranging from 76 percent for computer science graduates to just 18 percent for graduates' writing abilities. He added that job tenure is decreasing and career changes

WORKING GROUP PARTICIPANTS

Mr. Leslie Boney
North Carolina State University

Dr. Carol Dahl
Lemelson Foundation

Dr. Thomas Gardner
HP Federal

Ms. Ciannat Howett
Emory University

Ms. Amy Lientz
Idaho National Laboratory

Ms. Jenny Sorensen
Lemelson Foundation

Dr. James Stock
University of South Florida

Dr. Maya Trotz
University of South Florida

Ms. Erica Volini
Deloitte

Dr. Mohammad Zaidi
Braemar Energy Ventures

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswald

Mr. Tim Planert

Ms. Carol Ann Meares

are becoming more frequent, especially for younger workers, even as fewer people are moving for work than ever before. He identified two questions for the group to answer: what hard and soft skills will be necessary for the workforce of the future, and what kinds of collaboration between academia, industry, and government will be necessary to deliver those skills?

Skills for the Future

Dr. Carol Dahl of the Lemelson Foundation praised the Council's 2016 publication *Work*, particularly its listing of soft skills desired by employers on page 49. Mr. Boney discussed how his own field of engineering has seen a rapid change in needed skills, particularly an increase in digital skills requirements. Mr. Chad Evans identified digital skills as an example of changing competencies even in jobs that will continue to exist in the coming decades. Council Senior Advisor Ms. Carol Ann Meares argued for a generic skill base that will allow workers to transfer between roles and careers as the labor market changes ever more rapidly in the future, and Dr. Dahl also differentiated between job skills needed immediately in the economy, and the skills that will be needed for jobs in the future that don't yet exist. Ms. Meares also stressed the need to train teachers to quickly retool their curricula to prepare students for rapidly a changing job market, which would require consultations with employers and technology developers.

Other participants stressed the continued importance of non-technical skills. Ms. Ciannat Howett of Emory University emphasized that the broad skills developed by liberal arts schools, including adaptability, collaboration, and systematic thinking, will be increasingly important both for a rapidly evolving labor market and for addressing persistent threats like climate change. Dr. Maya Trotz of the University of South Florida discussed how many women were using sewing skills to create face masks during the pandemic, and consulting with healthcare workers to develop innovative masks with new materials. She

urged the group to remember that basic skills will continue to be important for innovation and supplying basic needs, and should not be overlooked.

Participants debated how best to actually develop skills in students and workers. Dr. Dahl referenced research showing the importance of hands-on and integrative learning, especially at the K-12 level, in developing "soft" and transferable skills like problem solving, creativity, adaptability, planning, and communications skills. Mr. Boney spoke of the need for developing credentials to illustrate these kinds of skills to employers and show them how they are transferable, such as "Learning Records" or "competency credentialing." Dr. Mohammad Zaidi, formerly of Alcoa, praised the quality of computer science education at many universities, describing the solutions computer science students developed to problems as "astounding." He urged the continued promotion of these skills and called on employers and venture capital to better recognize them.

Sustainability

Sustainability, specifically sustainable design of products and services, emerged as a problem-oriented skill in the discussion. Dr. Dahl stressed the need to begin educating students in sustainability early on, and of giving them the skills to design sustainable business models and products. Dr. Tommy Gardner of HP Federal underlined the importance of diverse knowledge backgrounds and collaboration by people with different skill sets in finding sustainability solutions, especially in engineering. Dr. Dahl added that engineering schools should fully integrate sustainability into their curriculum, rather than having brief and perfunctory coverage in students' coursework. The Honorable Deborah L. Wince-Smith praised the U.S. Naval Academy for integrating sustainability education into its engineering curriculum, and Dr. Trotz discussed the National Academy of Engineering's Sustainable Development Goals program, which has been adopted by many universities, and the American Society of Civil Engineers' adoption of sustainability skills as a component of their accred-

itation process. Dr. Dahl urged even deeper curricular incorporation of sustainability, saying that not every engineering student is exposed to it during their studies. Dr. Trotz also shared with the group the ENVISION credentialing program from the American Society of Civil Engineers, which pushes for sustainable infrastructure design, and Dr. Dahl shared a report from the nonprofit Venturewell on skill sets needed for sustainability. Finally, Dr. Trotz discussed the emergence of problem-focused sustainability initiatives, including the American Society for Engineering Education's Wicked Problems in Sustainability Initiative, which encourages students to find solutions for particular problems, such as food waste.

Middle-Skill Workers, the Skills Gap, and Job Mismatch

Ms. Yasmin Hilpert highlighted the importance of pinpointing which industries and jobs are most at risk of disruption, as this will enable better tailoring of recommendations on which skills and workers to focus on for re-skilling. In particular, she cited middle-skill workers as particularly vulnerable to job loss. She emphasized the need to better align skill sets with labor market demands, and called for the identification and sharing of innovative models and best practices. She also discussed the work of the Global Federation of Competitiveness Councils on a forthcoming report on workforce skills for the future. Ms. Meares elaborated that routine work will be increasingly automated, and that workers of the future will need to develop customer service, communication, collaboration, and thinking skills for non-routine tasks.

Mr. Boney concurred and referred to a "barbell economy" in which there is rapid job growth in low-skill service professions, which middle-skill workers are overqualified for, and in high-skilled technical and service professions they are underqualified for. He characterized this as an employment "Valley of Death" by way of analogy with the entrepreneurial phenomenon, in which low-skill workers lack upward

mobility because of a dearth of middle-skill jobs with attainable skill and experience requirements, and the inability to develop the high skills needed for higher paying jobs. Mr. Bill Bates noted that many workers were also unable to relocate to areas where jobs were available because of a lack of affordable housing or fears of leaving an existing job due to the lack of portability of health insurance. Dr. Dahl said such frictions explained why Seattle simultaneously struggles with unfilled software engineering jobs and a high homelessness rate, and she warned that the disconnect would worsen unless the country started preparing workers and students for future jobs, many of which don't yet exist. She added that this "future" was only a couple of years away in many cases.

Capabilities vs. Skills

Ms. Erica Volini of Deloitte predicted that workforce readiness and education would begin shifting from an emphasis on "skills" to an emphasis on "capabilities." She described Deloitte's upcoming annual Human Capital Trends Report, and how many organizations don't know what their short-term skills needs will be, let alone their long-term needs. She suggested that employers begin recasting job descriptions and roles to allow for greater movement over time, and to frame them in terms of broad capabilities rather than narrower skill sets. She further called for employers to begin defining and identifying these capabilities. Ms. Wince-Smith agreed and lamented the tendency of stale language to "stovepipe" thinking about problems. She described the continued use of rigid "skills" in evaluating government employees for promotion and tenure, and in job descriptions on job sites. Ms. Trimble shared the Council's descriptions from Work of needed capabilities in the future workplace, including complex communication, creativity, problem solving, adaptability, critical thinking, and planning and execution skills.

Talent Sharing

Ms. Volini described the rise of job transfer platforms as a solution to rapidly changing labor market needs. She described CVS's recent hiring of laid off hotel employees for customer service roles, and envisioned a new era of "talent sharing" where workers can quickly pivot to new roles that make use of their capabilities as the demand for labor changes. Mr. Evans praised Deloitte's work in helping laid-off service workers find new jobs created by the COVID-19 pandemic and its reorganization of the economy, and expressed hope that the economy would retain the capability to rapidly repurpose workers after the crisis has passed. Ms. Amy Lientz of Idaho National Laboratory described her lab's efforts to not only share talent as regional governments and contractors hire construction and energy employees in Idaho, but also to partner with schools and labor unions to help train workers for this shared environment. This partnership across sectors has allowed them to better communicate the needs of employers and design curriculum to match them, and it created a better understanding of the capabilities needed for new jobs. They have also partnered to recruit employees, apply for grants, and share training techniques and curricula.

Accelerating Transformation of Institutions

The theme of rapid transformation of institutions to adapt to changing needs and economic realities was another topic of discussion. Mr. Evans praised the rapid turnaround on NC State's Centennial Campus to begin manufacturing personal protective equipment, and Dr. Boney noted that the crisis forced the school to come to a much quicker agreement with manufacturers regarding the retooling and commercialization processes. Ms. Howett discussed a similar rapid transformation of healthcare capacity at Emory, with researchers working to rapidly develop

antibody tests and vaccines for COVID-19. Mr. Evans wondered if the crisis would provide institutions with lessons on how to develop solutions to problems faster, and find better and quicker ways to adapt and transform. Dr. Jim Stock of the University of South Florida urged K-12 and higher education to develop this capability, arguing that schools and colleges are too slow to adopt new curriculum and credentials. He said that by the time schools introduce new coursework or modules, the labor market has already changed, and urged greater institutional flexibility.

Communication and Collaboration

Participants identified insufficient communication and collaboration as a significant contributor to skills mismatch, as universities and schools were unaware of employers' needs. Dr. Zaidi discussed his frustration as a venture capitalist with entrepreneurs who could not explain the value proposition of their business to investors, as well as the inability of firms to respond to clear criteria set forth by venture capital firms. He described how it took nearly 60 tries to find a firm that could develop clean energy and carbon capture technology at a specific price point, because firms didn't understand what his company was looking for despite clear guidelines. He stressed the necessity of entrepreneurs understanding investors needs and interests. While he acknowledged the importance of broad capabilities, he called for curriculum to convey to students where these capabilities intersect with specific industry needs and goals.

Other participants shared examples of efforts at better communication. Dr. Gardner noted the Accreditation Board of Engineering and Technology's attempts to align curriculum and programs to employer needs, and Mr. Boney urged faster and more accurate communication between academia and business. Ms. Lientz discussed Idaho National Laboratory's use of labor economists to "translate" between employers' descriptions of their needs and educators' understanding of terms and concepts. Dr. Boney identified

the rise of “co-living spaces” where businesses share facilities and partner with universities as a way for employers to both find talent more easily and better communicate their needs to academia. He described how universities were responding faster than usual as a result of these efforts. These include granting credits for prior knowledge and demonstrated capabilities to expedite degree completion, and moving away from the standard semester model to tailor course and module length to the specific capabilities or skills being learned. He also described the rise in rolling start times for courses to offer greater flexibility to students, and industry-designed “Professional Science” Master’s degrees that are tailored to specific industry needs.

Conclusion and Further Discussions

Ms. Trimble, Ms. Wince-Smith, and Mr. Evans thanked the group for their thoughts, and Mr. Boney noted that the topic was worth far more extensive discussion than the session allowed for. Ms. Trimble reminded the group that next Monday’s session would continue with the same theme.

Working Group 2 Calls

April 20

Introduction

Mr. Chad Evans and Ms. Kathy Trimble welcomed the group to the discussion, and Ms. Trimble introduced the opening speaker, Mr. Leslie Boney of North Carolina State University. Ms. Trimble also shared a copy of the Council's 2016 publication *Work* with the group, as it contains substantial information on the issues discussed on the call.

Opening Remarks

Mr. Boney began by noting and praising the Council's extensive previous work on the future of skills and the nature of work, in particular *Work*. He summarized his experiences overseeing the Centennial Campus at NC State, where more than 75 private companies partner with the university to co-create curriculum and programs of study, and where partnering institutions employ over 1,500 students as

interns or full employees, and connected this innovation to changes in the global labor landscape. Mr. Boney discussed how the rise of skilled labor forces around the world, especially in China and India, has combined with AI and widespread automation to disrupt both blue- and white-collar occupations. He characterized the current U.S. economy as a “barbell” economy, where opportunities abound for low- and high-skill jobs, but middle skill jobs are disappearing. He said this problem was exacerbated by a shortage of labor in the skilled trades, where there are unfilled middle-skill jobs, because of a lack of interest and marketing, leading to issues of an aging workforce.

Mr. Boney then pivoted to the question of workforce skills. He asked the group what hard and soft skills educational institutions should develop in students, offering as an example high satisfaction among employers with graduates' computer literacy but low satisfaction with their writing abilities. He also asked

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luce Foundation

Mr. Leslie Boney
North Carolina State University

Dr. Carol Dahl
Lemelson Foundation

Ms. Tiffany Davis
Southern Company

Dr. Thomas Gardner
HP Federal

Ms. Ciannat Howett
Emory University

Ms. Amy Lientz
Idaho National Laboratory

Ms. Stacy Lippa
Target

Dr. James Stock
University of South Florida

Ms. Jenny Sorensen
Lemelson Foundation

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

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Ms. Carol Ann Meares

what the proper roles were for business and academia in developing these skills, and how they could more effectively partner. He noted that a survey of workers laid off during the COVID-19 pandemic showed many of them want to return to skill, especially if they can do so through their employers, and stressed the need for more lifelong learning opportunities as the economy and job market begin to evolve more rapidly.

Skills vs. Degrees

Dr. Ricardo Ernst of Georgetown University said that employers have traditionally relied on degrees as a proxy for skill sets, but that this was changing as firms begin to place more importance on what graduating students can do rather than what they studied. He said that universities are constrained by their need for revenue, and many view students as customers to satisfy, rather than products to develop, something he said was a mistake. He warned that treating students like customers leads universities to prioritizing what students find most enjoyable rather than what they will need to succeed in the workforce. Dr. Jim Stock of the University of South Florida said this mentality was beginning to change, and that leading universities were emphasizing the skills students develop during particular programs of study. However, he cautioned that this was primarily for required courses rather than electives. Mr. Boney said employers value work experience above all, and that they typically assume students have basic “hard” skills, but want to see they have experience applying them through prior work, apprenticeships, or internships. Conversely, Dr. Carlotta Arthur observed that many firms prefer to hire from a small set of “elite” institutions, and described the difficulties she faced upon graduation due to this bias. She noted minority-serving institutions were especially disadvantaged by this practice, and emphasized that the “degree” mentality is still widespread. Mr. Boney replied that many employers were afraid to break from their standard practices, but that he was hopeful this mindset would decline based on his experiences with organizations focusing more on competencies than degrees.

What Employers Look For

Mr. Evans asked the group what kinds of competencies employers were beginning to look for from new hires. Ms. Stacy Lippa of Target emphasized the importance of creativity, emotional intelligence and communication skills, and data literacy. She described the importance of effective communication when so much work is done remotely and so many conversations carried out over video or email, and of being able to not only understand data, but apply it to challenges facing a company. Dr. Stock said that at the University of South Florida, employers determine the skill sets that the school stresses in its coursework, particularly for the business and engineering schools. He stated that students needed to know how to use particular programs and technologies, not just about them. Mr. Evans added that the Council has also stressed the importance of learning by doing in its reports on skills and workforce readiness.

Incentives in Academia

Dr. Carol Dahl said that the discussion raised the issue of rethinking education delivery, and of aligning incentives for both K-12 and higher education. She spoke of the need to educate students for a world that is constantly changing, and that many university professors are concerned more with research than with teaching. This is due to both the primacy of research in determining tenure, as well as the lack of training professors receive on how to teach students and engage with them effectively. She detailed her experience of receiving no instruction on how to teach when she was in academia, and said developing professors' teaching ability was the key to developing successful lifelong learning programs. Dr. Ernst concurred on the problems of incentive alignment, and asked how universities could leverage incentives to encourage professors to focus more on teaching. He discussed younger professors' reluctance to engage in activities that don't help them secure tenure, and warned that greater collaboration with employers would not be effective if universities did not align incentives for professors to be responsive to employer needs.

Mr. Boney tied these issues to the “student as customer” mindset, and added that while in the long-run parents would be more satisfied if their child’s school prepared them to get a good job, universities were mostly focused on the short-term. Dr. Dahl asked if there was a way to tie funding to post-graduate outcomes, or encourage industry to engage with academia through funding of programs rather than just transfer of intellectual property, as ways to encourage academia to focus on workforce readiness. However, Dr. Arthur warned that many universities, especially elite universities, viewed themselves as educating students for life rather than for careers, and might balk at a “short-term” focus in education. Dr. Stock said that schools could learn from existing best practices, such as the state of Florida’s funding allocation mechanism that is based on universities’ abilities to develop skill sets in their students that have been identified as crucial by employers. Dr. Ernst discussed the idea of an SAT-like exam that would provide a standardized certification of skills for students across educational institutions. If developed by employers, it would be an accurate benchmark of students’ employability, and would not discriminate based on the reputation or perception of a student’s alma mater. Finally, Dr. Dahl worried that many of the skill sets employers desire need to be developed before a student reaches higher education, and that too much focus on universities would be ineffective in developing students’ skills.

The Role of Employers

Participants discussed how employers should become involved in designing curriculum, and how they should communicate their needs to academia. Dr. Stock described how firms regularly consult with USF’s business school to help design the curriculum for the supply chain management major, and how this has resulted in nearly 100 percent of graduates getting employed in the field or going to graduate school, as well as the highest starting salaries of any

major in the business school. He also mentioned the major’s internship requirement as a key to building relevant experience for students. Dr. Stock added that firms want new hires to be contributors right away, and want schools to train them in specific software programs and practices. He said these skills were as important as general skills like writing and communication. He characterized firms’ opinions of schools and their graduates, as reflected in their hiring decisions, as being the ultimate arbiter of a school or professor’s quality, rather than its reputation within academic circles.

Mr. Jonathan King of Southern Company discussed the importance of adaptability for his company’s employees. He said that with his firm comprising 80 different companies within its footprint, it was imperative for employees to be able to move to different roles and continue to be able to solve problems. He also discussed the importance of partnerships with academia and labor. One third of Southern Company’s workforce is craft labor, and Southern Company has co-designed curriculum and accreditation programs with both community colleges and labor unions for the building and electrical trades. Ms. Tiffany Davis of Southern Company added that they have seen a significant improvement in the talent pool as a result of these partnerships. Mr. Boney described the change in employers’ expectations of higher education over the years. Firms today expect schools to train students in specific workforce-relevant competencies, whereas in years past the role of schools was to teach basic skills while employers trained new hires for specific jobs. Dr. Stock echoed this observation, and added that schools now solicit input from firms on curriculum design rather than just financial donations. He added that USF was increasing its emphasis on working in disruptive environments in response to the COVID-19 pandemic. With a mindset of resilience in the face of uncertainty, workers will be able to respond to both familiar and novel emergencies, and curriculum can provide a structure for approaching disruption. Dr. Ernst noted

that companies that provide input on curriculum design can also scout potential hires up close, as they can see if the school is instilling the needed competencies in its students. Dr. Arthur expressed concerns that more accreditations and certifications might provide an additional obstacle for underserved students, and asked how these programs would be paid for, as well as whether employers were willing to invest in their employees. Dr. Stock said that at USF, the school negotiates discounts with the firms providing the certification services, and that it provides scholarships for students who cannot afford them.

Conclusion and Next Steps

Ms. Trimble encouraged the group to continue the conversation via the online portal. She also outlined the schedule for the rest of the week, including this Friday's upcoming call from 2 to 3 PM.

Working Group 2 Calls

April 24

Introduction

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group, and Ms. Trimble introduced the guiding questions for the discussion, focused on sustainability in production and consumption. She then introduced the two opening speakers, Dr. Tommy Gardner of HP Federal, and Ms. Ciannat Howett of Emory University.

Opening Remarks: The Business Case for Sustainability

Ms. Howett laid out the business case for sustainability, and the importance of sharing with industry the economic benefits of greater resource efficiency.

She cited research showing that companies with Environmental and Sustainability Goals outperform other companies, and that large companies benefit in particular from commitment to sustainability. She said that work done by Bob Willard at IBM found that small companies committed to sustainability grew on average by an additional 51 percent in their first 3-5 years, and that large companies with a similar commitment grew by an extra 81 percent on average in their first 3-5 years. Ms. Howett also discussed the recent trend in corporations' sustainability reports being focused on the UN's Sustainable Development Goals framework, and have also been paying more attention to diverse, locally-sourced supply chains that incorporate small businesses.

WORKING GROUP PARTICIPANTS

Dr. Carol Dahl
Lemelson Foundation

Ms. Ellen Donaldson
Davidson Community Foundation

Dr. Ricardo Ernst
Georgetown University

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts-Dartmouth

Dr. Jerry Haar
Florida International University

Ms. Ciannat Howett
Emory University

Dr. Bill Johansen
Lawrence Berkeley National Laboratory

Mr. Jonathan King
Southern Company

Ms. Amy Lientz
Idaho National Laboratory

Ms. Jenny Sorensen
Lemelson Foundation

Dr. James Stock
University of South Florida

Dr. Maya Trotz
University of South Florida

Ms. Erica Volini
Deloitte

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswald

Mr. Tim Planert

Ms. Carol Ann Mearns

Mr. Gourang Wakade

Opening Remarks: The Importance of Examples

Dr. Gardner discussed his experience working at one of the largest, and most sustainable, countries in the world, and the importance of leadership by large firms. He noted that because of their scale, large companies are in the best position to create a tangible impact from sustainable behavior, and to inspire other firms to imitate them. He also stressed the need to use case studies and examples to educate corporate leadership about the benefits of sustainability and offer them proof of concept. He gave the example of CAFE standards for automobiles in the United States, which were initially opposed by car manufacturers but ended up spurring increases in efficiency that improved their bottom lines due to increased consumer demand and new discoveries resulting from sustainability research. Mr. Chad Evans agreed on the importance of case studies, and discussed the Council's showcasing of PepsiCo's sustainability efforts in the primer to the National Commission's January Launch Conference in Arizona.

Economic Benefits of Sustainability

Dr. Ricardo Ernst of Georgetown University said he was glad to the group's emphasis on sustainability, as it had become an increasingly important topic for businesses even before the COVID-19 pandemic disrupted supply chains. He discussed a shift in mindset from individual components of supply chains trying to economize on costs for efficiency's sake to companies taking a holistic view of their supply chain and identifying ways to make the chain as a whole more effective. He gave an example of a company spending to build a healthcare facility near one of its plants. The extra up-front costs pay off in the long run because of improvements in employee health, morale, and productivity. He added that companies were beginning to share best practices across their industries because they believed widespread adoption of these norms benefits them in the long run, as competitors striving for sustainability generates new ideas, and a set of best practices that makes all players in the industry more efficient develops

through synergy. Dr. Ernst suggested the group compile a report highlighting examples of sustainability benefiting companies to catalyze corporate interest. Mr. Evans noted that the Council had found that 85 percent of S&P 500 firms had a sustainability report in 2017, 52 percent said climate change and sustainability were important concerns, and 40 percent reported investor pressure for sustainable practices. Ms. Amy Lientz of Idaho National Laboratory said her lab was forming more partnerships with companies to improve sustainability as those firms began to realize the extent of consumer demand, but worried that this demand would diminish with the advent of record low prices for fossil fuels.

Disconnects and Implementation Challenges

Dr. Carol Dahl of the Lemelson Foundation described her organization's discussions with businesses about adopting sustainability, and the disconnect she found between the enthusiasm of senior leadership and certain departments, like public relations, and the inability to install best practices in sustainability throughout the organization. She asked what companies were looking for from their workforces in terms of mindset and skill sets, and how they could accelerate a mindset for sustainability in employees. Ms. Howett noted similar challenges, including widely varying quality in corporate sustainability initiatives, and pointed out that often foreign companies are the leaders in successful sustainability policy. She expressed hope that sharing case studies of sustainability improving productivity, employee retention, and brand loyalty would spur other firms to increase their focus on sustainability.

How to Incentivize Sustainability?

Mr. Bill Bates asked whether market incentives would be sufficient in spurring adoption of sustainability measures by companies, or whether the government would need to intervene. Dr. Gardner said that the government would be most effective by setting standards and encouraging norms, but allowing compa-

nies to develop their own methods of achieving broad goals, as this would encourage more innovation and potentially result in larger sustainability gains that could come from government mandated practices. Dr. Mike Goodman of the University of Massachusetts-Dartmouth expressed disappointment in the track record of deregulation in incentivizing sustainability, while Dr. Ernst suggested developing certification criteria to encourage changes in corporate behavior. He said well-designed sustainability criteria could become a proxy for quality, and encourage companies to take pride in their environmental responsibility. Ms. Carol Ann Meares of Tech Vision 21 likened such a program to the Baldrige Awards for quality in business practices, which she noted were used as benchmarks by companies even when they did not compete for the award. Dr. Gardner used the example of corporate responses to COVID-19 to illustrate the power of norms and expectations in shaping companies' decisions. He noted that companies were offering assistance even when it hurt their bottom lines because they believed it was the right thing to do, and suggested widespread pressure to adopt sustainability standards could reach a "tipping point" where they became universal. Mr. Evans offered the Global Federation of Competitiveness Councils' Competitiveness Principles, which are mapped to the Sustainable Development Goals, as a potential framework for evaluating corporate sustainability.

Unique Challenges Facing Small Businesses

Dr. Jerry Haar of Florida International University expressed concerns that small and medium-sized firms, especially distributors and suppliers working with major firms, would fail to appreciate the importance and benefits of sustainability, citing his own conversations with small business owners. He said "elite" firms had done a poor job in conveying the importance of sustainability, with relatable examples, to smaller firms. Ms. Howett noted that Bob Willard's studies at IBM found significant growth benefits for small businesses from adopting sustainability prac-

tices, including from reductions in energy cost and wasted materials. Mr. Evans said that the Council previously used a public-private partnership to correct a similar disconnect between small and large firms regarding the importance of high performance computing and advanced modeling and simulation. Working with the White House and Department of Commerce, the Council created a program to connect small and large firms and bridge gaps of resources and understanding. As a result of the program, small firms gained knowledge of how high performance computing could enhance their own businesses, expand market opportunities, and improve relationships with suppliers. He said a partnership to convey similar information about sustainability would be interesting to explore.

Solutions for Small Businesses

Dr. Haar suggested developing a certification program for small businesses to encourage uptake of sustainability best practices, in which large firms provided technical assistance in transforming their operations. He added that certification could become a signal of quality to firms' potential customers. Dr. Dahl worried that firms in industries where there were not large buyers with the leverage to encourage best practices would lack the inclination and the resources to retool their businesses. She wondered whether some form of assistance might be necessary to help small firms make the necessary investments in sustainability. Dr. Haar said that the key to encouraging change was in leveraging intermediary organizations consisting of peers to make the case to small businesses for sustainability, and likened such efforts to political campaigns that win voter support through relatable messaging.

Best Practices and International Examples

Throughout the discussion, participants identified domestic and international examples of guidelines and best practices that could help companies improve their sustainability. Dr. Maya Trotz of the

University of South Florida shared several examples, including the UN Global Compact's report on Sustainable Supply Chains and the American Chemical Society's 12 Design Principles of Green Engineering. These documents provide best practices, case studies, and other resources. Dr. Trotz also expressed interest in learning how firms were instilling commitment to sustainability in their workforces, and in how they were connecting with and developing customer bases hungry for environmentally friendly products. Dr. Goodman highlighted the EU's environmental certification guidelines, and urged the group not to "reinvent the wheel." Finally, Dr. Dahl shared the nonprofit VentureWell's Environmentally Responsible Engineering Guidelines.

Local and Regional Governments and Sustainability

Ms. Trimble asked how to encourage commitments to sustainability by state and local governments and other non-corporate entities. Ms. Howett detailed Emory's efforts to encourage sustainability in the greater Atlanta region, including programs to purchase recycled water and to purchase land in the region to establish sustainable farms. In addition to providing local, environmentally responsible food sources, the latter initiative addresses problems of aging and lack of diversity in the agricultural workforce, and helps increase food security in a region of the United States that will be heavily impacted by climate change. Dr. Trotz also mentioned the city of Atlanta's water-recycling project as a useful case study.

Sustainability, Urbanization, and COVID-19

Dr. Gardner described how engineers were turning their attention to sustainable production of food in a world with an increasing population and growing demands on resources. He mentioned vertical farming as a practice that enhanced productivity and reduced resource usage, and noted that increased density in living patterns reduces transportation costs and pollution and improves the efficiency of mass transit. Mr. Evans discussed predictions from the first Working Group that the COVID-19 crisis might reverse urbanization trends as people became uncomfortable living in densely populated areas. Dr. Goodman said it was too early to tell what the long-term effects of the pandemic would be, and noted that jobs and healthcare were concentrated in urban settings. Dr. Gardner acknowledged the possibility of reversal, and added that the pandemic could permanently reduce demand for air travel, as people increasingly choose to meet virtually rather than spend time and resources traveling around the country or world. Ms. Howett also emphasized the importance of proximity to healthcare in people's housing decisions, and Dr. Trotz suggested the pandemic might lead to a rethinking of housing for the urban poor, who are at greater risk because they rely more on public transit and often live in older, poorly ventilated buildings. Ms. Meares directed the group to Council Chairman Emeritus Mr. Chad Holliday's article "Production, Place, People: The Sustainability Opportunity for Business" for an in-depth exploration of these topics.

The Role of Large Businesses in Pioneering Sustainability

Ms. Wince-Smith encouraged the group to consider the role large firms play in driving sustainability practices. She discussed the Council's work with Wal-Mart, profiled in *Drive* (2009), and how Wal-Mart's requirement for suppliers to meet sustainability metrics throughout their supply chain transformed business practices throughout their supplier network. She said other large companies, including Target and Unilever, had made similar impacts, and noted the importance of these firms to economic resiliency, including after events such as Hurricane Katrina and during the ongoing pandemic. She added that in many parts of the country, large firms like Wal-Mart are the only source of safe, reliable goods, and because of this their sustainability efforts have both societal and bottom-line benefits.

Identifying and Addressing Gaps in Sustainability Adoption

Ms. Howett expressed support for gathering "success stories" of corporate sustainability to encourage widespread adoption of sustainability practices. She said this would have the added benefit of identifying gaps and shortcomings in corporate sustainability efforts and their promotion. She also encouraged the group to think of ways to advance the manufacture of recyclable goods, like biomaterials that mimic plastic, as China has stopped accepting the United States' plastic waste and many products are incorrectly labeled as recyclable. Ms. Howett added that consumers will increasingly demand sustainability, as climate change and the COVID-19 crisis will be seen as harbingers of dramatic future changes.

Dr. Dahl said that many sustainability efforts will require innovations that will come from small firms. She said larger firms mentoring and funding these

startups will not only provide needed capital to generate sustainability technology, but also provide larger firms with networks of sustainable suppliers. She noted a lack of venture capital interest in physical products and the low likelihood of short-term funding from the government for such initiatives. Dr. Dahl further stressed the importance of the workforce development pipeline for providing firms with a supply of workers who are skilled in developing and implementing sustainable practices and products. Dr. Haar urged the cross-pollination of engineering and business curriculum in higher education, in which each discipline incorporates basic principles of the other, to improve knowledge of the importance of sustainability and expertise in achieving it.

Concluding Thoughts

Ms. Wince-Smith emphasized the importance of building sustainability into innovation for the future of the economy and the planet, characterizing it as being as vital as improving resiliency in preparing for future challenges. Mr. Evans encouraged the group to examine the resources shared and discussed by the participants during the call, which will be posted to the online portal, and Ms. Trimble reminded the group about the second call on this subject next Monday.

Working Group 2 Calls

April 27

Introduction

Ms. Kathy Trimble and Mr. Chad Evans welcomed the group, and Ms. Trimble said the discussion would continue from last Friday's session on sustainability of production. Ms. Trimble then introduced the two opening speakers, Ms. Ciannat Howett of Emory University and Dr. Tommy Gardner of HP Federal.

Opening Remarks: Business Case for Sustainability

Ms. Howett summarized the group's discussion on Friday, which focused on convincing businesses of the benefits of sustainability, and on ways that larger businesses could help drive sustainability in their suppliers. She mentioned The Honorable Deborah L. Wince-Smith's discussion of the success companies

like Wal-Mart and Unilever had in spurring sustainability among their suppliers, and of the challenges identified by Dr. Jerry Haar of Florida International University and Dr. Carol Dahl of the Lemelson Foundation around small business buy-in and of large corporations' uneven appreciation of sustainability, respectively. She also discussed Mr. Bill Bates' question about the necessity of government action to inspire sustainability in businesses, and Dr. Maya Trotz of the University of South Florida's highlighting of the importance of equity in sustainability discussions.

Ms. Howett cited the economist Dr. Nicholas Stern in characterizing climate change as the "largest ever externality," arguing that government action would be needed in spurring companies to act more sustainably within the required time window. She also expressed her surprise at the lack of standardization across states in sustainability policy, especially when

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luce Foundation

Mr. Leslie Boney
North Carolina State University

Mr. Mike Cassidy
Emory Biomedical Catalyst

Dr. Sue Clark
Pacific Northwest National Laboratory

Dr. Carol Dahl
Lemelson Foundation

Dr. Ricardo Ernst
Georgetown University

Dr. Thomas Gardner
HP Federal

Ms. Ciannat Howett
Emory University

Ms. Stacy Lippa
Target

Dr. Kathleen Merrigan
Arizona State University

Ms. Jenny Sorensen
Lemelson Foundation

Dr. James Stock
University of South Florida

Dr. Mohammad Zaidi
Braemar Energy Ventures

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

compared to countries and supranational organizations like the EU. She concluded with an example of successful, bipartisan action on sustainability at the state level. In Georgia, environmental groups like the Sierra Club and the conservative Tea Party Patriots group formed the “Green Tea Alliance” to create an allowance for private corporations to help nonprofits take advantage of power purchase agreements to install sustainable energy sources. The nonprofits were unable to take advantage of tax incentives because of their nonprofit status. Ms. Howett also described the difficulty of updating building codes for Emory’s medical facilities to reduce their carbon footprint. She encouraged the Commission to identify other opportunities for bipartisan action on clean energy, recycling, and other sustainability measures at the federal level.

Opening Remarks: Convincing Corporate Leadership

Dr. Gardner discussed the importance of illustrating to corporate leadership why sustainability was in their best interest, and of using specific examples to underscore this argument. He noted that corporations are motivated by the drive to grow their businesses and make their companies self-sustaining, and to successfully commit them to resource sustainability, they must see how those goals are aligned. He also discussed the difference between regulation and standards-setting. He noted that “you get what you inspect,” and that when companies are required to meet specific standards and report on their progress along the way, they are motivated to meet those standards rather than follow procedures without a defined target. He described how HP’s use of standards and annual progress reports had enabled it to reach its goal of net-zero paper consumption three years early. He said this goal would not have been met on time, let alone ahead of schedule, without clear metrics.

A Previous Example of Partnership on Production and Manufacturing

Mr. Evans discussed at length the Council’s previous work in creating public-private partnerships between Original Equipment Manufacturers (OEMs), their Small and Mid-Sized Enterprise (SME) suppliers, and government. He described how in-kind engagement, training, and support from OEMs makes SMEs more competitive, and how it provides a multiplier effect for OEMs in the form of greater productivity through improved supply chains. He described how the initiative included models of successful partnerships, and added that there was ample opportunity in this space for public engagement and support. In particular, he discussed the use of modeling and simulation in supply chains and the development of specific metrics to ensure progress. Mr. Evans described how the partnership led to 20 pilot programs, 160 new jobs, \$20 million in annual revenue, and the development of three new products.

Mr. Evans also discussed the takeaways of this initiative. These include the need for state support whenever a new “industrial commons” or novel infrastructure is needed to support the efforts of an entire industry, as SMEs cannot build this infrastructure on their own, but can pay for access, consulting, and training in using it. Other best practices included deployment of software-as-a-service to help SMEs reduce their time-to-market for new products, buy-in from senior management, clear goals, expectations, and understanding of the efforts required, making the “business case” for the partnership, and providing hands-on support and training. He added that the initiative became the basis for the National Manufacturing Innovation Institute, a much larger effort, on digital design and manufacturing. He said a similar national effort could be adopted for sustainability.

Tailoring Sustainability Metrics

Dr. Jim Stock of the University of South Florida spoke about how companies were changing the sustainability metrics they used, as many of them were costly to measure and not very significant for

the firm's sustainability. He discussed how companies were designing hybrid metrics that incorporated the Global Reporting Initiative's guidelines with their own proprietary metrics, and reporting these in their annual reports, rather than issuing conventional Corporate Sustainability Reports. Dr. Gardner said that sustainability standards needed to be tailored to different sectors, and that encouraging companies to compete to best meet those standards would facilitate the adoption of best practices as firms incorporated successful practices from their competitors. He added that consumer demand for more sustainable products creates further incentive for companies to strive to meet sustainability benchmarks. Ms. Howett said that external metrics were better than company-designed metrics for sustainability, as they enabled easy comparison and were designed by disinterested third parties.

Efficient vs. Resilient Supply Chains

Dr. Ricardo Ernst of Georgetown University discussed the distinction emerging between "efficient" supply chains, that strive to economize on inputs and resources, and "effective" or "resilient" supply chains, that are most robust against stress tests and ensure best results for end users. He said firms should begin thinking of competition as their supply chain competing with other firms' supply chains, rather than firm vs. firm. He said the "black swan" event of the COVID-19 pandemic was leading companies to rethink the potential benefits of redundancy, and urged the use of case studies to help expedite the adoption of this thinking, suggesting this as an idea for the Commission. Dr. Gardner characterized resilient supply chains as geographically diverse supply chains, where a disaster in one part of the world would not shut down the business's entire operation. He discussed his work on identifying threats to the U.S. economy with the Department of Homeland Security, and how he identified diversity of suppliers as the key to coping with natural disasters. He noted that HP has over 10,000 suppliers around the world, and if one is affected by a crisis, the company has numerous alternatives.

Dr. Ernst also distinguished between having a single supply chain and having a portfolio of supply chains. He described how companies benefited from tailoring their supply chains to specific products. He gave the example of a company locating its supply chain for a good with steady and limited market demand abroad for cost efficiency, while locating its supply chain for items with more varying and quickly shifting demand domestically to enable quicker response to market fluctuations that won't be disrupted by crisis. This duplicative supply chain structure also enables the firm to shift production from one chain to another in the event of a "black swan" event like a pandemic. He again discussed the importance of providing concrete illustrations of the benefits of "leveraging variability" through multiple supply chains, and noting that a one-size-fits-all approach generates mediocrity as the most efficient producers and suppliers are balanced out by the least efficient. He argued that a tailored portfolio of supply chains would maximize the potential of each link in each chain.

Climate Change and Sustainability

Ms. Howett pivoted to Dr. Trotz's idea of "ramping up" production for the COVID-19 pandemic, and discussed the need for a similar "ramp up" to deal with climate change in the needed time window. She mentioned the Sweden-based Center for Resilience, and similar institutions in South Africa and Australia, that focused on proactive development of resiliency in the face of crises. Ms. Howett urged the creation of a similar center in the United States, noting that university-affiliated disaster preparedness studies centers tended to be reactive rather than anticipatory. She envisioned such a center as including collaboration between universities, industry, all levels of government, philanthropy, and the scientific community. She compared this idea to the Jet Propulsion Laboratory developed during World War II at Cal Tech, which helped the United States develop effective rockets before the Third Reich, and which was later instrumental in the Space Race with the Soviet Union. Ms.

Howett said this quick, “think tank” approach was essential in combating climate change. Dr. Carol Dahl of the Lemelson Foundation asked to what extent companies considered their carbon footprint in developing their supply chains.

Trends Towards Consolidation in Agriculture

Dr. Kathleen Merrigan of Arizona State University expressed her concern that government stimulus programs to help the food production and agricultural industries would reinforce the existing, rigid supply chains in those sectors, as policy makers focused on shoring existing firms up. She warned that such a policy would drive greater consolidation among a handful of large firms, and that this would leave the system more vulnerable to the next stress test. She asked how to encourage policy makers to be forward-thinking in crisis response. Ms. Carol Ann Meares of TechVision 21 noted the tension between building long-term relationships with suppliers, which encourages the consolidation of a firm’s supply chain, with the need for diversity and resiliency. She said it was important for firms and government officials to strike a balance between these two models.

Thinking Holistically About Value Chains

Ms. Stacy Lippa of Target said that companies were beginning to bridge gaps between different elements of their production, including merchandising, sourcing, and supply chains. In particular, she noticed these changes in the food industry, which is working to improve traceability and transparency in its supply chains. Ms. Lippa spoke of the importance of understanding the “circular value chain,” incorporating raw materials, human resources, and common standards, and the learning networks necessary to ensure all stakeholders contribute to the firm’s value stream. She said more holistic thinking allows stakeholders to see how changes in one part of the production process impact the rest of the value chain, and that this integration was crucial to ensuring sustainability throughout a firm’s supply chain and production

process. Dr. Gardner said that emphasis on sustainability across the value chain encourages firms to focus on product design. If they must spend more on supply chains to ensure they are both resilient and resource efficient, the only way to increase or maintain their profit margins is by redesigning their products to generate less waste (and cost) in production.

Revamping Universities to Address Sustainability

Ms. Lippa asked how the academic world was working to shape its curriculum to account for the importance of sustainability. Dr. Merrigan discussed the emphasis at Tufts University on co-creation of knowledge between academia and the wider community, and discussed Arizona State’s efforts to develop tailored certificate programs for specific audiences. During the COVID-19 crisis, ASU is working to certify unemployed chefs on plant-forward cooking, and Dr. Merrigan spoke of the need to improve the availability, customization, and quality of online education. Dr. Ernst described Georgetown’s efforts to use corporate leaders as a sounding board for curriculum design in its business school. He said that while the internet means answers are abundant, the challenge in education is asking the right questions, and that industry feedback helps academics design curriculum that focuses students minds on the questions that companies most want answered. He linked this mindset to the skills-not-degrees paradigm shift in higher education that develops students who can solve problems.

Developing Certifications for Sustainability

Dr. Ernst also advocated for the Commission to develop a set of standards for sustainability that could be used to certify businesses in a similar fashion to the Baldrige awards for product quality. He said widespread adoption of these standards would spur an economy-wide push toward sustainable business practices. Dr. Gardner agreed with the idea, but questioned how to balance the need for certi-

fications tailored to each industry with the costs of doing so. He warned that one-size-fits-all standards would be less relevant and set to the lowest common denominator. He suggested using engineering certifications, which include a basic general certification followed by more extensive certifications in particular fields like civil or mechanical engineering, as a potential model.

Dr. Ernst suggested the group devote more time to fleshing out the idea of standards and certification development if it was worth pursuing, and suggested using the Baldrige criteria as a blueprint for a baseline sustainability metric, with input from group members' companies in designing industry-specific criteria. Ms. Howett suggested the Sustainable Accounting Standards Board's model of certification as a blueprint for highly sector-specific standards, and urged the development of a national research agenda for corporations and universities around climate change. She said stakeholders needed to identify the most important things they did not know and use them to identify specific research questions to focus climate change mitigation efforts more effectively.

Dr. Stock discussed his belief that research on sustainability metrics and the development of certification programs would come from university-affiliated think tanks and research centers, rather than "traditional" academia. He described one such effort at USF on supply chain management, which includes senior executives from a variety of industries on conjunction with university faculty. He said that if lots of universities and companies participate in these initiatives, the collective benefits to society will be substantial. He also discussed the tradeoff between including suppliers at all levels of supply chains in discussions of sustainability and making the complexity and logistics of such discussion manageable.

Ensuring Certifications Do Not Produce Obstacles

Dr. Carlotta Arthur of the Luce Foundation warned that certifications costing money could disadvantage women and minorities, as well as women- and

minority-owned businesses, as they were less likely to have the resources required to complete such programs. She discussed how she did not pursue an engineering certification after graduation due to the prohibitive costs, and she encouraged the group to think of ways to mitigate this and ensure that any certification programs were open to businesses and individuals regardless of background or resources.

Dr. Merrigan echoed this sentiment, and urged higher education to rethink its structure in order to improve its affordability. She discussed her desire to recruit more students from underrepresented backgrounds and the cost challenges providing full scholarships presents. Ms. Howett agreed and said that racism and poverty were "perversely resilient" systems that would require targeted measures to address and disrupt.

Concluding Thoughts

Dr. Gardner continued the theme of the importance of diversity, relating his experience with online games. He said that players from different backgrounds came up with different approaches and solutions to problems, which expedited discovery and innovation. Dr. Gardner described how the same principle applied to academic and corporate efforts to answer research questions and solve problems.

Ms. Howett described Emory Healthcare's position that the healthcare industry will not return to its old normal following the pandemic, and said it would be wonderful if the group could develop a positive vision for the United States moving forward that is not an attempt to return to normal. Instead, the focus should be on making the United States better, stronger, and more resilient in the face of future challenges.

Ms. Trimble said that in the weeks going forward, the group would engage in deeper explorations of the topics discussed today.

Working Group 2 Calls May 1

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and discussed the unconventional format of the day's call, which was focused on drawing on the Council's past work as a framework for promulgating recommendations and reinvigorating and updating the Council's message to reflect new challenges and the ongoing importance of sustainable production and consumption. She noted that the Council has been involved in thought leadership around clean energy, advanced manufacturing, and their intersection since 2008. She discussed past Council engagement with sustainability and low-carbon technology, and the Council's dialogue with the Obama administration on these issues. She described how the Council's work in this space underscored the importance of manufacturing in establishing clean energy supply chains, and prompted a series of sectoral explorations on the

convergence of advanced manufacturing and energy. These efforts culminated in Accelerate (2018), which provided a portfolio of insights, thought leadership, and actionable recommendations.

Mr. Chad Evans discussed the Council's National Innovation Initiative, which culminated in Innovate America (2005), and its connection to the present work of the National Commission. This initiative provided an innovation agenda for the country, and foreshadowed tremendous transformations in both energy and manufacturing that would shape the Council agenda for the next decade. In particular, the renaissance in U.S. manufacturing made possible by a changed energy landscape inspired numerous Council initiatives that are predecessors for the National Commission. Mr. Evans cited these previous initiatives as examples of prior reforms and recommendations that the National Commission can build on, draw inspiration from, or even revive if they remain relevant.

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luce Foundation

Dr. Carol Dahl
Lemelson Foundation

Dr. Ricardo Ernst
Georgetown University

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts-
Dartmouth

Ms. Ciannat Howett
Emory University

Ms. Stacy Lippa
Target

Ms. Jenny Sorensen
Lemelson Foundation

Dr. Maya Trotz
University of South Florida

Ms. Erica Volini
Deloitte

Dr. Mohammad Zaidi
Braemar Energy Ventures

COUNCIL STAFF

Mr. Chad Evans

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Mr. Gourang Wakade

Past Council Initiatives

Mr. Bill Bates provided further background on previous Council initiatives on energy and manufacturing. He discussed the Energy Security Innovation and Sustainability Initiative, which ran from 2007 to 2009 and included a “First 100 Days” plan for both presidential campaigns in the 2008 election, called Prioritize that included goals for energy efficiency, infrastructure investments, technology breakthroughs, and workforce development. This publication was later expanded into Drive (2009), which laid the foundations for much of the Council’s future work. Shortly afterward, the Council commenced the U.S. Manufacturing Competitiveness Initiative, which focused on generating a manufacturing renaissance in the United States and led to the publication of Make (2011). Make focused on five challenges: fueling the innovation and production economy, expanding manufacturing exports, leveraging smart manufacturing to unleash next generation productivity, fostering talent development, and upgrading and updating manufacturing supply chains and logistics. Many recommendations from Make were implemented, including the creation of regional manufacturing hubs to boost advanced manufacturing, and the Council pivoted to working on the intersection of clean energy and advanced manufacturing.

Public-Private Partnerships and the AEMC

Mr. Evans discussed the Council’s work during the transition between President Obama’s first and second terms on using high performance computing, modeling, and simulation to enhance productivity in advanced manufacturing, which inspired the Advanced Energy and Manufacturing Competitiveness Partnership (AEMC). The Council proposed the AEMC to the Department of Energy’s Office of Energy Efficiency and Renewable Energy, and had the dual goals of improving competitiveness in the production of clean energy products and improving manufacturing competitiveness writ large through increased energy

productivity. This project ran from 2013 to 2015 and included the development of public-private partnership initiatives to advance these goals.

Much of the groundwork underpinning the public-private partnership recommendations flowing from the AEMC was laid by the Council’s work on public-private partnerships in December 2012 and January 2013. During this period, the Council researched over 190 such partnerships from around the world related to energy and/or manufacturing competitiveness, and developed a framework for establishing successful public-private partnerships from this research. In *The Power of Partnerships* (2013), the Council investigated obstacles to U.S. leadership in manufacturing clean energy and energy efficient products. It found that high capital requirements, a lack of national innovation infrastructure, low investment in advanced manufacturing, large structural costs, and cyber infrastructure challenges all contributed. The Council also identified essential ideas and strategies for co-creating successful clean energy and manufacturing public-private partnerships. These included strong leadership, a clear and compelling mission, early funding from the public sector, and flexible intellectual property practices to entice corporate participation. The Council’s work on these partnerships catalyzed nine regional dialogues, four national summits, and three webinars, as well as the creation of a Clean Energy and Manufacturing Analysis Center. This center was established in Colorado in conjunction with the Department of Energy, and helped rebuild U.S. manufacturing infrastructure and launch over \$1 billion worth of new public and private investment. Notable projects funded by these investments include a network linking national laboratories working on advanced materials.

Other Council output during this time frame included a new public-private partnership for high performance computing in energy, manufacturing, and materials that not only continues to the present, but has expanded to encompass transportation. The Council’s work on partnerships led to two other public-private partnership ideas: a Clean Energy Mate-

rials Accelerator to de-risk investment in products and provide new standards for novel technology, and a Manufacturing and Energy Technology Accelerator to provide a platform linking labs, corporations, and other stakeholders for the development of new products and services. The Council established five criteria for evaluating partnership ideas. The proposed partnership must address a high-impact problem, the public sector must be capable of making a large impact relative to private efforts alone, the problem addressed must be broad enough to concern the public sector but open to new approaches and performers, government participation and investment must have an enduring economic benefit, and government participation and investment must not duplicate or crowd out the work of the private sector.

The Energy and Manufacturing Competitiveness Partnership

Mr. Bates discussed the Energy and Manufacturing Competitiveness Partnership (EMCP), a private-sector analog to the AEMC that resulted in six sector-specific studies that took deep dives into the intersection of manufacturing and energy for water, agriculture, energy, aerospace, advanced materials, and biosciences. Each sector study put forth specific recommendations, and the Council also published an overarching report, *Accelerate*, in October of 2018. During this process, the Council found cybersecurity to be such an important cross-cutting issue that it amalgamated the cyber-specific recommendations into *Secure*, published in December of 2018. Important recommendations stemming from these reports span regulations, infrastructure, the energy market, research, scaling technology, the Internet of Things, big data, workforce development, and cybersecurity.

Accelerate encourages states and local governments to experiment with new, more effective regulatory regimes that foster innovation, including Arizona's allowance of autonomous vehicle experimentation on its roads. The report also encouraged making permanent the executive order that two regulations

be repealed for every new regulation issued in order to lighten the regulatory burden. The report repeated the Council's longstanding call for greater infrastructure investment, and Mr. Bates characterized the lack of action on this front during a period of low interest rates as a missed opportunity for the nation. Because much of America's infrastructure comes with high legacy costs, the Council called for setting aside a percentage of infrastructure spending for research on "leapfrogging" technologies that would allow the telescoping of infrastructure improvement, such as moving directly from landlines to 5G technology. The report also urged expanding investment in nuclear energy and modernizing the power grid. In particular, the Council called on states to allow utilities to recoup R&D investment in the form of rate increases, and to allow them to depreciate equipment more rapidly.

The Council issued many recommendations governing research in *Accelerate*. These include establishing a baseline of 1 percent of GDP for federal research funding and developing a national research agenda prioritizing disruptive technologies with major economic and societal impacts through the position of a national Science Advisor. Other recommendations included continued support for the Manufacturing USA institutes and investments in advanced technology, better technology transfer policies including streamlined and simplified intellectual property rules, and funding to help technologies scale successfully (crossing the "Valley of Death"). With the major impact the rise of sensory technology and the "Internet of Things" will have on resource use and efficiency, the Council called for incentivizing investments in these technologies, as well as developing uniform standards and security features in consultation with stakeholders. Finally, the Council advocated the creation of a federal verification system for crowdsourced data, to ensure that firms could productively use the information generated by the "data tsunami" to draw valuable insights.

Issues to Consider with Commission

Ms. Wince-Smith mentioned subjects that previous Council efforts have not addressed, including the security of America's healthcare, pharmaceutical, and medical device supply chains, as well as rare earth minerals. She noted that Chinese dumping on the U.S. market had devastated the domestic rare earth market, but that many initiatives were underway in the United States to develop sustainable synthetic rare earth minerals, including one at the Colorado School of Mines. Mr. Evans also discussed the potential for the group to discuss additive manufacturing, including the emerging fields of 4D and 5D manufacturing. He also stressed the importance of U.S. leadership in advanced microelectronics, noting that new microprocessors would have massive ramifications for energy efficiency and sustainability in advanced technologies across all sectors, and that the investments required for new technology were too large for any single stakeholder.

Dr. Maya Trotz of the University of South Florida discussed the Council's previous engagement with the Energy 2030 roadmap, and asked how much of it remained relevant. Mr. Evans noted that the current administration had prioritized other initiatives, but added that it was an interesting avenue for further exploration. He said it provided an interesting roadmap for many sectors of the economy to transform their productivity. Mr. Evans emphasized the importance of sustainable production and consumption for the group, as it was the only working group with sustainability as a key part of its mandate. Dr. Carol Dahl of the Lemelson Foundation observed that many of the Council's previous energy recommendations could be updated with a simple pivot to low-carbon, carbon-neutral, or carbon-negative technology and remain highly relevant. She spoke of the need to prioritize investment in carbon capture and reuse technologies because of lack of federal or investor interest in a potentially substantial market. Ms. Ciannat Howett of Emory University discussed how the COVID-19 pandemic had actually bolstered renewable energy markets because of the collapse of fossil fuel prices from reduced demand and

the increased effectiveness of solar panels due to reduced air pollution. She urged the group to remain alert to the potential implications of the COVID-19 pandemic on sustainability.

Supply Chains

Ms. Trimble asked the group for thoughts on the role of supply chains in sustainability. Dr. Ricardo Ernst of Georgetown University predicted that the substantial disruption to supply chains caused by the COVID-19 pandemic would alter the future policy landscape, potentially altering the relevance of many recommendations concerning supply chain sustainability. He expected increased political considerations for supply chain management in the future, compared to the previous paradigm that prioritized efficiency. He also said he was intrigued by the implications of supply chain relocation on infrastructure. Other disruptions he identified include companies reducing R&D as they struggle to maintain operations with reduced cashflow, as well as changing public demands for sustainable products in the face of disruptive crises. He discussed how a friend's company in Mexico had seen an upsurge in demand for plastic bottles as people became less concerned with sustainability during the COVID-19 pandemic.

Presidential Administrations and Federal and State Policy

Mr. Bates discussed how the political landscape can affect the audience for policy recommendations. He said that with a divided political landscape, it is often easier to find receptive audiences at the state level, and that states are more willing to conduct bold experiments and test out reforms. He expected this to continue if there is no change in administration after 2020, but said that a new administration might be more interested in bold reforms because of the desire to "run with" something new and make a mark on the policy landscape. He encouraged the preparation of federal proposals similar to those in Prioritize for the first 100 days of a new administration in the event of a regime change next year.

Addressing Short-Term and Long-Term Challenges

Ms. Wince-Smith expressed concern at recent GDP and unemployment numbers, and advocated for a large-scale investment in infrastructure to ensure the entire country benefits from the new economy that will emerge from the current crisis. She described how American roads, airports, and wireless connectivity lag behind competitors, and asked how the group could encourage the funding released into the economy as stimulus to flow into developing state-of-the-art advanced infrastructure. She further encouraged making investment in carbon-neutrality a “given”, and noted that it was much more difficult for manufacturers to become green than companies providing services. She also discussed feedback from the Council’s University membership encouraging focus on the long-term future of the economy, not just short-term challenges provoked by the COVID-19 pandemic, even with the grave stresses universities are facing currently.

Engaging the Public

Dr. Trotz drew on Dr. Ernst’s anecdote about plastic bottle production, asking how to ensure continued public engagement on sustainability. She said providing an outlet for the public to be heard was especially important because regulators were relaxing environmental rules for firms, and public concerns about more sustainable commuting and transportation in the Tampa area were falling on deaf ears. Dr. Ernst said that people are very responsive to numbers, and are more willing to engage with stories and narratives when they have quantifiable information. He suggested the group gather these kinds of numbers and begin monitoring their trends during weekly discussions. Eventually, the Commission could publish these numbers, organize them into general topics or clusters, and use these statistics as a “hook” to encourage greater public interest in

the Commission’s work on sustainability. Mr. Evans responded that this could be a topic of discussion for the Outreach and Engagement Committee, and said that the Competitiveness Decoder, developed by the Global Federation of Competitiveness Councils in conjunction with other organizations, could serve as a starting point for gathering data. The Decoder contains information for over 130 countries spanning over 30-40 years, with over 100 metrics, including many surrounding sustainability, manufacturing, and energy. The Decoder also enables comparisons across countries, within a country over time, and across clusters. He also encouraged members of the group to share other metrics, reports, and interesting materials via the online collaboration portal.

Concluding Thoughts

Ms. Wince-Smith thanked the group for their participation, Ms. Trimble announced that the discussion would continue on the same topic on Monday. In the next session, Dr. Mohammed Zaidi of Braemar Energy Ventures will share his experiences working at Alcoa and in the startup world on putting sustainable production and consumption into practice.

Working Group 2 Calls May 4

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the opening speaker, Dr. Mohammad Zaidi of Braemar Energy Ventures. She discussed his experiences both as Chief Technical Officer of Alcoa, where he was involved in implementing sustainability practices in the company's production, and his current involvement in the venture capital space with sustainable companies. Ms. Kathy Trimble expressed interest in hearing his perspective on broader sustainability and security risks facing the economy.

Mr. Chad Evans announced two structural changes for the Commission: the spinning off of a fourth working group focused on Unleashing Capabilities for Work and Entrepreneurship and the pivot for this group toward The Future of Sustainable Production and Consumption; and the introduction of group

co-chairs who will lead discussions following the launch of the National Commission's second phase. These changes will begin the week following the June 16th virtual meeting of the Commissioners, and during this period calls will move from twice per week to once per week, and will focus on developing detailed policy recommendations. Each call will include a primer with background information and specific policy proposals for the group to discuss.

Sustainability Threats

Dr. Zaidi identified four major sustainability threats that posed danger to companies and to the United States and world economy as a whole: cybersecurity, pandemics, terrorism/armed conflict, and climate change. He said firms are increasingly focusing on these topics in their Enterprise Risk Management strategies, and warned that both the private and

WORKING GROUP PARTICIPANTS

Dr. Carol Dahl
Lemelson Foundation

Dr. James Davis
UCLA

Ms. Tiffany Davis
Southern Company

Dr. Ricardo Ernst
Georgetown University

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts-
Dartmouth

Ms. Ciannat Howett
Emory University

Mr. Jonathan King
Southern Company

Ms. Amy Lientz
Idaho National Laboratory

Ms. Stacy Lippa
Target

Ms. Jenny Sorensen
Lemelson Foundation

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Josh Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

public sector were behind the curve in preparing for these threats, which are unpredictable, hard to manage, crippling, and long-lasting in their impacts.

Dr. Zaidi said that cyberattacks and other cybersecurity threats were responsible for \$600 billion in economic losses in 2019, with that number set to approach \$5 trillion per year by 2023. He characterized this risk as unsustainable for businesses, and by extension, for society. While healthcare, defense, finance, energy, advanced materials, and other major sectors are investing heavily in infrastructure to withstand cyberattacks, they are still behind the curve and face constant attacks designed to black-out cities and cripple computer systems. Dr. Zaidi said companies already have large teams of engineers working around the clock to prevent attacks on America's electrical grid, and that we are still far below the peak level of cyber threats the nation will face in the future.

Another major risk comes from pandemics. Even before the current COVID-19 crisis, many companies, especially those with global operations, were vulnerable to disruption from previous outbreaks, including SARS, MERS, and Ebola. Dr. Zaidi said that attempts to control pandemics are nearly always erratic, and noted that the World Economic Forum had raised the dangers of pandemics to global supply chains at Davos neatly a decade ago. He also warned that for all the devastation of COVID-19, it could become worse if the pandemic reappears or repeats itself in the future.

Wars and terrorism represent a third major threat to sustainability. While there are lots of policies and initiatives designed to counter these threats, the risks to our economic system from terrorism and conflict remain considerable, especially with the advent of cyber warfare. Dr. Zaidi noted with alarm that the Russia-Ukraine conflict represents a new era of large scale electronic warfare, and warned that China represents both a physical and cyber military threat.

Finally, Dr. Zaidi discussed the threat of climate change, extreme weather, and pollution. While this concern is at the forefront for every major business and government, both public and private sector actors are behind the curve in addressing the risks of climate change. Most data indicate that climate risks are continuing to rise, and that government and corporate actions alone will not be enough to address the issue. While investments in renewable energy, carbon capture and sequestration, efficient farming, and waste reduction are all crucial, Dr. Zaidi argued that society as a whole must be given the tools to self-organize for sustainability and better manage risks.

Frameworks and Examples for Addressing Sustainability Threats

Ms. Ciannat Howett of Emory University asked Dr. Zaidi to elaborate on the nature of distributed self-organizing tools. Dr. Zaidi cited the proliferation of information and communication technologies as an example of low-cost, easy to use innovation proliferating organically and dramatically altering society and the economic landscape. He also discussed examples of people creating and installing their own solar panels and other energy efficient technologies, and the growing use of telemedicine to more effectively address health needs in response to the COVID-19 pandemic. Dr. Zaidi said that the proliferation of tools and innovations like these throughout the population will enable people around the globe to begin implementing solutions for sustainability themselves. He also suggested leveraging public policy to encourage the proliferation of these tools and encourage the population to take the initiative on making their lifestyles more sustainable.

Dr. Carol Dahl of the Lemelson Foundation asked what role corporations should play, both individually and systemically, in mitigating the four risks Dr. Zaidi outlined, and whether those risks could be reframed as opportunities. Dr. Zaidi responded that most businesses will invest in mitigation when the business

case is strong, and that businesses initially focus on efficient production before incorporating other concerns as they move along the cost curve. He described Alcoa's long-term, large-scale investments in sustainability that are only beginning to come to fruition, but could reach market values that exceed the current value of the whole company. He added that companies are increasingly developing protocols to address specific risks and their responses to them. Dr. Tommy Gardner of HP Federal discussed his advisory work with a Department of Homeland Security task force on threats to supply chains, and said that the group had identified 282 different supply chain threats across nine broad categories. He added that the CARES Act directs the National Academies to examine the risks to America's supply chains from pandemics, particularly those relating to health care, and said that disruptions in one supply chain will cascade into other sectors as markets try to reestablish themselves in the wake of the COVID-19 pandemic.

Ms. Amy Lientz of Idaho National Laboratory noted that many national laboratories are doing extensive work on cybersecurity and critical infrastructure protection. She encouraged the group not to duplicate the efforts of other groups and task forces in this space, and she suggested approaching these groups to see if they would share findings and information with the working group. Ms. Wince-Smith supported this idea, and asked if participants would be willing to volunteer to approach task forces or groups in their networks. She stressed the desire to build upon, and not simply rehash, the work of other groups.

Dr. Zaidi discussed the real-world applications of risk mitigation in the case of extreme weather. Citing studies that estimate the costs of repairing damage from extreme weather to be seven times the costs of investing in prevention, he said there was already a strong business case for infrastructure resilience, and forecasted trillions in new spending on these efforts in the United States and around the world.

Examples of Sustainable Production

Dr. Zaidi continued his remarks with several examples of sustainable production in practice. Most of these involved renewable energy and energy efficiency, but some also involved cybersecurity investments. One example is the rapid adoption of renewable and low carbon energy as its price declines relative to fossil fuels. He cited the example of a utility in Florida that converted a planned natural gas plant into a solar plant because of the rapid cost reduction in solar panels. He also promoted the idea of a circular economy, in which waste from production is used in creating new products rather than thrown out. In Japan, a government mandate banning the dumping of fly ash from power production into landfills inspired engineers to develop a way to turn it into cement for construction. Dr. Zaidi said these types of policies are easy to implement and should be adopted globally.

Other examples of sustainability in practice come from Dr. Zaidi's former company, Alcoa. Thirty years ago, Alcoa pledged to plant 1.3 trees for every tree it cut down during its mining operations, and also developed a means of pumping carbon dioxide underground, reducing the pH of mining waste and allowing livestock to graze on the green space above aluminum mines. He said that besides gaining community support as consumers increasingly demand sustainable products, these measures drastically reduced Alcoa's costs by reducing the expensive hazards stemming from mining waste, and enabled Alcoa to secure much longer leases and extensions on its aluminum mines than other resource extraction firms can secure. Alcoa has also made use of locally abundant but difficult to transmit hydroelectric power at many of its locations in countries like Iceland, and now generates 70 percent of its power supply via hydroelectricity. Yet another sustainability-enhancing innovation is the development inert anodes that enable companies to generate oxygen, rather than carbon dioxide, during the aluminum mining process.

While Alcoa has invested hundreds of millions on developing this technology over the years, it only recently made it to market, with Apple purchasing zero-carbon aluminum for laptop casings.

Alcoa has also retrofitted its facilities to use recycled aluminum, resulting in a 90 percent reduction in energy use, and Dr. Zaidi described efforts by beverage companies to produce containers that do not make use of fossil fuels. He described a college-aged inventor's solution for a non-plastic bottle that he predicted would be purchased by major producers, as well as Coca-Cola's development of a plant-based bottle.

Another arena where sustainability has been put into practice is additive manufacturing, or 3D printing. Dr. Zaidi predicted that most companies working on producing the same product at lower prices will fail unless they incorporate new functionalities only available from additive manufacturing, which significantly reduces waste in production. He also discussed how one of Alcoa's subsidiary companies is using additive manufacturing to produce airplane parts. Companies are also investing AI and sensors to reduce wasted energy while lowering costs and emissions. "Early warning systems" using these technologies can identify accidents, inefficiencies, and even cyber attacks with record speed, enabling much faster response times and easier mitigation. Dr. Zaidi said that utilities were already implementing these systems, and went so far as to suggest they become mandatory for future plants and facilities as part of the permitting process. He closed his remarks by reiterating his call for all of society to take the initiative in using self-organizing tools to adopt and promote sustainable behavior, as he did not believe government and industry action alone would produce change on the necessary scale.

Cultivating Talent and Workforce for Sustainability

Dr. Dahl asked if there was a sufficient talent base for companies to begin incorporating and developing sustainable technologies and practices, and what could be done to improve the talent pool. Dr. Zaidi said there was a shortage of necessary talent, especially in fields like AI and autonomous systems. He said this was especially true for firms like Alcoa, who get outbid for top talent by big tech companies. However, he noticed during his time at Alcoa that the company's reputation for sustainability was a major draw for talented applicants, and suggested that companies invest in sustainability as a method of attracting talent.

Venture Capital, Startups and Test Beds

Mr. Evans asked Dr. Zaidi about his concerns in the startup field, given the importance of small and medium-sized firms to future innovation. Dr. Zaidi identified connectivity between universities and entrepreneurship programs and the needs of the market as a major issue. He said that venture capital invests \$50 billion, and other entities like large firms a further \$30 billion, in startups, but that much of that will be wasted if startups, including those spun off from university research, don't understand what will work in the marketplace. He said there were around 1,000 different startups working on energy storage, but they were not connecting with investors in a way that made economic sense. Dr. Zaidi expressed particular concern about the belief that startups primarily need money from larger firms, when access to test beds is a much larger obstacle for scaling innovations. He described Braemar's work brokering deals with established firms to get them to provide test bed capabilities for promising startups, and said it has been a powerful tool in helping companies scale. He gave an example of a firm that developed software to monitor electrical

signals to identify peak load usage and cyberattacks ahead of time, but had no place to test it out. When Braemar connected them with a utility company that could benefit from the technology, they were able to develop and scale their idea, and the company is now worth tens of millions of dollars. Mr. Evans connected this idea to Dr. Dahl's remarks about the importance of human capital, and he noted the role of investors and large firms could play in brokering connections between innovators and small and medium-sized businesses. He also expressed support for the idea of test beds and said that while some large companies were already engaged in this space, it was ripe for further exploration.

Incentives and the Business Case for Sustainability

Mr. Jonathan King of Southern Company discussed the importance of incentives in encouraging companies to partner with startups for test bed capabilities. He discussed Southern Company's significant investments in sustainability, to the tune of nearly \$1 billion, as part of a goal to reduce greenhouse gas emissions by 50 percent relative to 2007 levels by 2030. He said the company was well on track to meet this target due to shifting its energy mix from 70 percent coal to 22 percent, with a significant increase in natural gas and renewables. He said the

most difficult component of investing in startups and granting access to test bed facilities was flexibility, and he spoke of a need for policies that would enable companies like Southern Company to balance obligations to risk-averse shareholders with the need to stay on the cutting edge. He also discussed the challenges of cost-benefit analysis in determining when to incorporate a renewable energy technology, as many of them are still far costlier than fossil fuels. He also spoke of the importance of maintaining a reliable energy supply for Southern Company's customers. Mr. King said any policy that would reduce the downside risks to companies willing to provide test bed capacity to startups would be highly impactful.

Dr. Gardner said a major challenge in the adoption of sustainable technology is lack of knowledge by both companies and the general public about the progress that has been made in recent years in clean energy. He discussed the case of a fuel cell company in Connecticut that has developed a technology that not only reduces greenhouse gas emissions from fossil fuel power plants, but also enables them to produce 20 percent more energy from the same inputs. However, because of the high initial capital investment required to install it, the company is struggling to find buyers for its technology, even though it almost pays for itself. Dr. Dahl discussed Lemelson's work in cultivating a public-private partnership with the government of India, philanthropic

organizations, and industry to develop more energy efficient air conditioning systems, called the Global Cooling Prize. She also discussed the government's traditional role in providing test beds for technology through agencies like DARPA and the National Institutes of Health, adding that including private industry in these efforts would ensure that the innovations tested corresponded to market needs. She asked how to encourage more companies to become involved in brokerage and test bed activities.

Mr. Evans identified several potential policy levers, including accelerators, incubators, and demonstration platforms, that could de-risk investments in technologies, as well as tax incentives for investment in sustainable technology. Mr. King said that policies granting firms flexibility would be even more valuable, such as allowing them to exclude these investments from reported earnings, and allowing them to partner with regulatory bodies to approve investments in test bed projects. Ms. Lientz shared a recent Executive Order on securing America's bulk power system, noting that it identified the connection between cybersecurity and a reliable, sustainable energy grid.

Concluding Thoughts

Ms. Wince-Smith thanked the group for its discussion, and noted that many clear recommendations were emerging for the Commission to build upon. She emphasized the need to show the business and productivity benefits from sustainable production, and expressed great interest in exploring the test bed issue. She said that government has already been active in running carbon capture and carbon sequestration test beds through the national laboratory system, and she suggested cross-pollinating the test bed idea with Working Group Three. Ms. Wince-Smith suggested the idea would benefit from input from experts on finance and the tax system, and stressed the need for a bottom-line driven incentive to encourage companies to invest in test beds. She closed by reiterating her interest in having people share recommendations and policies from task forces focused on similar issues, and said that the Council could share its 2018 cybersecurity-focused report, *Secure as a Baseline* to build upon for cybersecurity recommendations.

Working Group 2 Calls May 8

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the featured speaker, Mr. Noel Kinder, the Chief Sustainability Officer for Nike. She noted that Nike is a leader in the corporate world for sustainable business practices. Ms. Kathy Trimble said she was struck by Nike's sustainability goals, which incorporate measurement indices across all product lines in addition to greater use of recycled materials and sustainable clean-up practices. She also said that today's discussion would include the topic of product innovation, and how sustainability practices have altered the production process and the experience for the end user.

Mr. Chad Evans announced two important shifts in the Working Group discussions following the June 16th virtual meeting of the National Commissioners. First, the current Working Group 2 will split into two groups. Working Group 2 will focus on the future of sustainable production, manufacturing, and consumption, while the newly formed Working Group 4 will focus on unleashing capabilities for work and entrepreneurship. Additionally, beginning the week of June 22nd, working groups will convene once per week and discussions will be led by co-chairs nominated by the Council. The topics will be preceded by a primer with background reading and policy recommendations to consider, and the discussions will be focused on distilling actionable recommendations from the working group deliberations ahead of the National Competitiveness Forum in December.

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luce Foundation

Dr. Carol Dahl
Lemelson Foundation

Dr. Helene Dillard
University of California—Davis

Ms. Ellen Donaldson
Davidson Community
Foundation

Dr. Ricardo Ernst
Georgetown University

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts—
Dartmouth

Dr. Jerry Haar
Florida International University

Ms. Ciannat Howett
Emory University

Mr. Noel Kinder
Nike

Dr. James Stock
University of South Florida

Ms. Jenny Sorensen
Lemelson Foundation

Dr. Maya Trotz
University of South Florida

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Ms. Yasmin Hilpert

Mr. Josh Oswald

Mr. Tim Planert

Featured Remarks

Mr. Kinder said that when he assumed the role of Chief Sustainability Officer at Nike, there was broad consensus within the company on the need to integrate sustainability experts throughout Nike's portfolio of products and various departments, rather than having a centralized sustainability team. He said this change has helped Nike develop more effective sustainability solutions for each aspect of its business.

Mr. Kinder noted that Nike is primarily a "consumer products company" and has a core customer base of Millennials and Generation Z, who expect large companies to both be sustainable and contribute to improving the world. He added that nearly all of Nike's 76,000 employees around the globe have a passion for sustainability, and that sustainability is of paramount importance for the incoming Chief Executive Officer. Because Nike makes physical products, sustainability in its production process is the key to becoming sustainable overall. As a result, Nike has invested in sustainable materials, becoming the largest industry consumer of recycled polyester and making use of recycled "fly leather," among other innovations. However, Mr. Kinder said that many of these practices had not been successfully scaled yet.

A major theme of Mr. Kinder's remarks was the need for industry-wide sustainability. He said that Nike is only one stakeholder in an industry that accounts for 5-8 percent of the global carbon footprint, and that Nike going carbon-neutral tomorrow would have no significant impact on the environment. Mr. Kinder said Nike's greatest asset for driving sustainability is its brand and ability to inspire and connect with consumers. Because of this, in order to alter consumer behavior and encourage the prioritization of sustainability, Nike needs to "put its own house in order" first and lead by example. One way in which Nike seeks to use its influence is through pre-competitive collaboration. Mr. Kinder said that Nike shares production facilities with companies in other industries, meaning securing cooperation on issues like labor practices and climate responsibility is essential to

encourage their suppliers to adopt new practices. He gave an example of Nike's efforts to fight climate change through forming a coalition for sustainable apparel, and setting public targets to meet the UN's Framework Convention on Climate Change commitments.

Mr. Kinder closed with an example of Nike's collaborative work to encourage sustainability. In Vietnam, many of Nike's plants rely on coal supplied by China. To help them afford the switch to renewable energy, Nike and other tenants of these factories helped create a Power Purchasing Agreement that would subsidize the cost of renewable energy, with the cost shared among the United States Agency for International Development (USAID), the Vietnamese government, and other major companies like Apple.

Supply Chains and Re-Globalization

A major theme of the group's discussion was the shifting nature of globalization. Ms. Ellen Donaldson of the Davidson Community Foundation discussed her background working in pharmaceutical production and pharmaceutical services, and her alarm at the shift in the supply chain for critical drugs from North America and Western Europe to China and India. She expressed similar concerns about the supply chains for critical technology, and noted the geopolitical (China) and product quality (India) concerns stemming from this evolution. She warned that China has taken over products that were formerly strengths of the United States, and said that companies were learning the hard way that there were considerations other than short-term cost efficiency. Dr. Jerry Haar of Florida International agreed and added that there were challenges even in decoupling from China, as other competitors might fill the void created by U.S. withdrawal and out-compete U.S. companies on cost. As a hedge against this risk, he suggested relocating factories not to the United States, but to Western Hemisphere nations that were somewhat more expensive than China but also much closer, enabling a shorter product delivery time.

Dr. Ricardo Ernst of Georgetown University expanded upon this theme of regionalization of supply chains. He said that companies had previously focused primarily on efficiency and minimizing costs, but that he foresaw an increasing focus on delivering products quickly, which meant locating supply chains in nearby nations. He said that rather than de-globalization, the COVID-19 pandemic was leading to re-globalization, and that the economic downturn had illustrated the extraordinary degree of interconnection and interdependence between companies and countries. He also said it was crucial for the group to carry this message to the wider public, and praised the Global Federation of Competitiveness Councils' Competitiveness Decoder project for its comprehensive information on all aspects of competitiveness. He said that the volume of information could be overwhelming to the general public, but encouraged the Commission to provide examples of relevant data and frame it for the public in a way that sparks broader interest in the Commission's work.

Ms. Donaldson asked if re-globalization signaled a shift to reliance on Western Europe and North America for supply chains rather than China and India, and Dr. Ernst said that it did. He added that the reshoring movement he foresaw would be of particular benefit to Mexico, which is more expensive for manufacturers than China but has major geographic advantages, enabling them to respond more quickly to shifts in consumer demand. He stressed that re-globalization was not equivalent to economic nationalism or isolationism, and instead framed it as a shift in the decision making process of manufacturers from solely focusing on efficiency to also prioritizing effectiveness, or the ability to satisfy customers in a timely manner. He added that the United States should engage Mexico during this time, as the country is facing major challenges and the new version of NAFTA requires readjustment.

Dr. Michael Goodman of the University of Massachusetts-Dartmouth questioned whether the current supply shocks from the COVID-19 pandemic were the result of just-in-time inventory practices. He noted that if companies had stored critical supplies on location, they would have had weeks of lead time

to establish alternative supply chains, but that such practices are ordinarily considered wasteful. Dr. Ernst strongly agreed, and said that just-in-time inventory was developed in Japan, where space constraints made it essential for production facilities not to have extra supplies occupying floor space, but that for all its efficiency gains in normal times, it is not resilient during "Black Swan" crises like a global pandemic.

E-Commerce and De-Materialization

Another trend that emerged as a topic of discussion was the rise of E-Commerce and what Dr. Ernst referred to as "de-materialization." He said that in the wake of the pandemic, consumers were becoming much more comfortable ordering products online and purchasing without physically examining or inspecting the product, and that this made "last mile" considerations essential for supply chains. He added that this shift toward delivery meant that many companies were rapidly increasing their production of waste from packaging and shipping materials. He observed that companies often used standard-sized boxes for efficiency and time-saving, even when the product is much smaller than its container. However, he noted that some retailers like Amazon are increasingly soliciting customer feedback on their packaging in an attempt to recalibrate. He also stressed the need to bring awareness to the sustainability costs of dematerialization, and highlighted the importance of finding business opportunities for companies to incorporate recyclable or reusable packaging material to reduce the environmental impact of E-Commerce.

Product Integrity and Consumer Protection

Many participants expressed concerns about certifying the authenticity and quality of products in an era of widespread online shopping. Ms. Wince-Smith said that concerns about substandard or counterfeit materials purchased online were eroding consumer trust in companies, and called for greater data transparency and standards for product verifica-

tion and quality control. Dr. Ernst said that retailers like Amazon, by agreeing to sell products for other companies, are increasingly assuming responsibility for the quality of the products they sell, and urged certification of vendors as being beneficial for both consumers and producers as a stamp of quality.

Dr. James Stock of the University of South Florida agreed on the need for certification, but warned that many companies do not re-certify vendors and suppliers to ensure they are continuing to follow proper quality and sustainability practices. Dr. Ernst said that the group could provide substantial value by working with major producers to identify similar constraints and obstacles, and help brainstorm ways around them. He said that in this “new normal” such actions were an opportunity to make a major impact. Mr. Evans highlighted examples of certification best practices in the Working Group 2 primer from companies like PepsiCo and Levi’s and encouraged the identification of more general lessons to be drawn from companies’ experiences. Dr. Haar said working with members of groups like the American Apparel Manufacturers Association, which have experience certifying suppliers and suppliers’ suppliers, would be a great opportunity to identify wisdom and best practices in developing effective certification.

Ms. Wince-Smith called for building integrity of intellectual property ownership into supply chains, and criticized the current standard in which the burden of proof of an IP violation is on the injured party rather than the supplier of the good. She said such requirements, along with burden-of-proof laws regarding safety and quality already existed for food products and imports, but should be adopted more generally. She added that people are often willing to pay a premium for these guarantees of integrity, especially for healthcare products. In particular, she called for stronger source-of-origin requirements for product components, especially pharmaceuticals. Dr. Carlotta Arthur of the Luce Foundation noted there was some precedent in this regard, as many companies require their suppliers to meet ASTM standards for materials, as confirmed by outside laboratories. Dr. Haar said that some accountability was provided by customer evaluation platforms like Yelp!, TripAdvisor,

and CNet. Dr. Arthur said that grassroots, consumer-driven demands for sustainability and quality were essential to ensuring companies implement these best practices.

Implementing Sustainable Innovation

Dr. Carol Dahl of the Lemelson Foundation said that some problems could be reframed as major opportunities to develop innovations. She cited the example of environmentally friendly compostable packaging developed by the company Ecovative. Dr. Maya Trotz of the University of South Florida asked if localizing supply chains offered opportunities to incorporate new, sustainable manufacturing techniques like 3D printing into the production process, and Mr. Evans said there would be many opportunities to leverage technology-based innovations to energize new supply chain relationships. He added that there was a link between this topic and one of the focuses of Working Group 4, which will be on the democratization of production and innovation. Dr. Ernst agreed that demand-driven innovation was essential to adopting more sustainable production practices.

Portfolios, Redundancy, and the End of One-Size-Fits-All

Dr. Haar characterized non-redundant supply chains focused only on efficiency as being like high-wires with no net underneath, and said that the customer needed to count in production decisions, not just cost savings. Dr. Ernst encouraged the conception of efficiency as just one of a portfolio of concerns facing companies, and said that one-size-fits-all is a poor model for supply chains, especially for companies that make different kinds of products. He suggested companies develop more geographically compact and resilient supply chains for products marketed on quality, essential products, and products where demand changes more quickly and requires faster responses to consumer behaviors. Ms. Wince-Smith suggested including reliability and performance alongside efficiency as criteria in supply chain location.

The Brand Impact of Sustainability

Citing Dr. Kinder's remarks about the effects of Nike going carbon-neutral, he asked if doing so would impact Nike's brand and reputation. Dr. Kinder, while questioning the wisdom of committing to targets so far in the future that the executives making them would not oversee their completion, said that committing to science-based benchmarks and targets, such as the Paris Agreement, does have a positive brand impact. He added that Nike found that to meet the sustainability goals outlined in the Paris Agreement, it would need to reduce the carbon footprint of its extended supply chain by 30 percent by 2030, and of its owned and operated supply chain by 65 percent during that time. He also said that during its investigation of how to reach these goals, Nike realized the crucial importance of materials sustainability, including making totally circular (reusable) and even carbon-negative products. He discussed the importance of Nike's sustainability team in serving as an "innovation engine" that generates ideas based on these external targets. Mr. Evans underscored the importance of science-based recommendations, and noted that many policy makers are craving these kinds of metrics.

Concluding Thoughts

Ms. Trimble and Mr. Evans thanked the group for their discussion, and reminded the group about next week's calls on Monday and Friday. Mr. Evans also said that further discussions of Nike's innovation process and connections with stakeholders in Nike's supply chain would provide valuable perspective and lessons for the group.

Working Group 2 Calls May 11

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the featured speaker, Mr. Bill Johansen of Lawrence Berkeley National Laboratory. She said that the discussion would focus on developments in the bioeconomy and their connection with sustainability, and discussed the Council's previous work with Lawrence Berkeley on biomufacturing in *Leverage: Advancing U.S. Bioscience* (2017), which she said would be available via the online portal.

Featured Remarks

Mr. Johansen opened by discussing the importance of sustainability to Lawrence Berkeley National Laboratory, and connected sustainability to the discus-

sion by the Working Group at the January Launch Conference, in which it discussed the importance of changing consumer behavior, the role of employee expectations of leadership in creating a culture of sustainability, and the constraints facing leaders who want to be more sustainable. Notable obstacles facing organizations trying to increase their sustainability include the availability of sustainable and recycled materials for use in products, potentially prohibitive costs for engaging in sustainable behavior, and limited supplies more generally, especially during the COVID-19 pandemic.

Mr. Johansen said that *Leverage* contained several recommendations that remain relevant and should be up for discussion by the group. These include developing a nationwide strategic roadmap for investment in sustainability, coordinating investments across

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luce Foundation

Dr. James Davis
University of California
Los Angeles

Ms. Tiffany Davis
Southern Company

Ms. Ellen Donaldson
Davidson Community
Foundation

Dr. Ricardo Ernst
Georgetown University

Dr. Tommy Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts-
Dartmouth

Dr. Jerry Haar
Florida International University

Dr. Nathan Hillson
Lawrence Berkeley National
Laboratory

Ms. Ciannat Howett
Emory University

Mr. Bill Johansen
Lawrence Berkeley National
Laboratory

Ms. Amy Lientz
Idaho National Laboratory

Ms. Stacy Lippa
Target

Dr. James Stock
University of South Florida

Ms. Jenny Sorensen
Lemelson Foundation

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Ms. Yasmin Hilpert

Mr. Tim Planert

government agencies, finding ways to leverage bio-science to address knowledge- and cost-prohibitive technologies for industry, and creating successful public-private partnerships. He warned that if laboratories do not create materials and products that the private sector can use, their efforts and funds will have been better spent elsewhere.

Next, Mr. Johansen discussed why the Department of Energy, including the National Laboratory system, is concerned with sustainability. Not only does the U.S. economy need to minimize the environmental impacts of its supply chains while simultaneously enhancing the competitiveness of its industrial sector, there is an urgent need to generate less waste for landfills producing more efficiently and reusing resources. He also emphasized the need to use energy more efficiently, and said energy and materials were both critical components of reducing greenhouse gases and conserving resources.

Mr. Johansen also detailed several initiatives by the national labs to galvanize innovation in sustainable products and processes. The Innovation XLAB program, which consists of a series of Department of Energy initiatives in different areas, includes a Biomanufacturing project. Lawrence Berkeley hosted a dialogue as part of this endeavor that brought together stakeholders from industry, labs, and other research institutions. The dialogue focused on bridging gaps between stakeholders and ensuring better alignment of research projects with industry needs, and he shared a link to a summary on the Lawrence Berkeley website. He also said he would look for a white paper or other formal publication from the event to share with the group.

Another major initiative Mr. Johansen discussed was the Department of Energy's Plastics Innovation Challenge, first released in November of 2019. This challenge consisted of five goals to accomplish by 2030. First, to develop novel technology to prevent plastic from entering the ocean. Second, to develop processes to deconstruct plastic waste effectively into new chemical compounds that are environmentally friendly and can be reused. Third, to increase

the rate of upcycling, or reusing products in new, higher-value products. Fourth, designing new products with recyclability in mind, including new kinds of recyclable plastics. Fifth, bolstering the domestic supply chain for upcycling plastics to enable American companies to scale and deploy new technologies in the domestic and international marketplace.

Related to the third challenge, Mr. Johansen discussed the BOTTLE Initiative, announced in March. This upcycling consortium is a joint effort of the Department of Energy's Advanced Manufacturing Office (AMO) and Bioenergy Technologies Office (BETO). It provides \$25 million in funding for the development of new plastics capable of recyclability and for new strategies that can break existing plastics into chemical building blocks that can be used to make higher value products. Additionally, the project will seek to develop consortium collaborations to tackle challenges in plastic waste.

Mr. Johansen concluded his remarks by establishing that the Department of Energy has had a long-standing interest in sustainability research, and has stepped up these initiatives in recent years. However, as the Council recommends in Leverage, better coordination within the government and between government and external stakeholders like industry is essential for further progress. He discussed efforts to make solar energy cheaper to make it easier to commercialize, and said other renewables and sustainable materials need similar price reductions in order to be widely adopted in the marketplace.

Private Sector Leadership in Biomanufacturing

Ms. Ellen Donaldson of the Davidson Community Foundation asked which firms were taking the lead in innovative biomanufacturing efforts, and how nations around the globe were investing in biomanufacturing. Mr. Johansen said that the United States had a strong advantage and head start in its biomanufacturing research, although he noted that the United States relies on much research stem-

ming from international partnerships. He said that numerous companies across a variety of sectors were displaying leadership in this space, and that industry is very interested in the subject beyond questions of optics. He noted that many companies are already facing constraints of dwindling supplies and have strong incentives to engage in sustainability research. Dr. Nathan Hillson of Lawrence Berkeley National Laboratory shared links to the Global BioFoundries Alliance and Synbiobeta, both of which provide case studies of exemplary firms in biomanufacturing and sustainable materials research.

Ms. Ciannat Howett of Emory University discussed the importance of highlighting companies making strides in sustainability, both to spread best practices across industry and to educate the general public about the importance of such endeavors. In addition to HP, she discussed the Georgia-based Interface Flooring Company, which makes carpets out of recycled plastics and has inspired competitors to try and outdo its own sustainability efforts. She asked if the Commission could play a role in highlighting these kinds of efforts to encourage other firms to follow suit. Mr. Evans agreed on the importance of case studies, and he encouraged the group to pass along other examples of best practices they are aware of.

Metrics, Targets and Parameters

Dr. Ricardo Ernst of Georgetown University asked if there were existing or potential metrics that could be used to gauge progress on plastic waste reduction and other sustainability efforts. Mr. Johansen said that Lawrence Berkeley's Applied Research and Materials and Biotechnology teams were both working on new metrics, and that he would share some of this work with the group.

Ms. Howett discussed Emory's challenges in establishing a circular economy, including the difficulty of buying back products made from the material it has recycled and the challenges in finding a certification process for recyclability that is accurate and consistent. She expressed hope that a market would develop among individual and corporate buyers of

recycled products, but also asked who should be in charge of the certification process. Dr. Hillson said that the Department of Energy's Office of Energy Efficiency and Renewable Energy is funding research on increasing the varieties of plastic that can be recycled, which could alleviate concerns about the advertised recyclability of plastics by merchants.

Dr. Carol Dahl of the Lemelson Foundation asked how stakeholders should set targets and parameters for the characteristics of sustainable new materials, and how to publicize and share those specifications outside of labs. She also asked how researchers were evaluating downstream investment opportunities for companies that might commercialize technology developed during these efforts, and how to support technology spinoffs that are likely to successfully scale. Mr. Johansen said that while the Department of Energy has a detailed roadmap for plastics by 2030, there is no national roadmap for any aspect of new materials, including parameters and standards. He said this was one reason dialogue between the private and public sectors on this issue was so important. Concerning scalability, he described AMO's efforts to evaluate the potential of new technologies, and said that Lawrence Berkeley, like other national labs, has an accelerator program. He said accelerators were especially important for biotechnology, because there are not investors willing to make large, high-risk investments the way there are industries like pharmaceuticals. Partnering with startups and to de-risk their products for investors is crucial to attracting enough capital to scale them up and bring them to market.

Dr. James Stock of the University of South Florida expressed concerns about FDA regulations governing the use of recycled materials in packaging of food products. He said products with recyclable packaging have to use multiple layers because of rules forbidding direct contact between recycled materials and food or beverages. Mr. Johansen said he would ask the team at Lawrence Berkeley about that issue, and added that it was important to make packaging that keeps products safe from contamination but that is also environmentally friendly and easy for the consumer to open.

Gaps in Public Knowledge and Merchant Claims About Recycling

Ms. Howett discussed the growing problem of merchants touting the recyclability of their products when only some components are recyclable, and the inability or unwillingness of consumers to separate these components out for proper disposal. She also reiterated the challenges in finding a reliable certification system that accurately tracks whether products can be recycled or composted. She said Federal Trade Commission efforts to prosecute “greenwashing” only punish violators after the damage has been done. Mr. Johansen said this issue reminded him of the challenges that Lawrence Berkeley has had in changing behavior by employees. Even for scientific professionals, the rules and procedures for properly disposing of waste have proved confusing. Dr. Stock concurred with this, and added that his own research has also indicated many consumers do not know how to properly recycle materials and said that many of the group’s recommendations will require public education for successful implementation.

Ms. Stacy Lippa of Target said efforts at public education need to be balanced with the reality that our society is currently exhausting natural resources faster than innovation can keep up. Mr. Johansen said that it is difficult to get people and companies to make sustainable choices when they are difficult or expensive, and that products made with recycled materials suffer from perceptions that they are poor quality. He said the rapid changes unleashed by the COVID-19 pandemic offered a window of opportu-

nity to implement changes in mindset as the public conception of “normal” is rapidly evolving. Dr. Tommy Gardner of HP Federal added that his own company was reevaluating its practices, and had cancelled all travel until October not just for safety reasons, but because employees are productive working from home, and the company is saving money and being more sustainable by not commuting or traveling.

Mr. Evans asked the group what technological developments and research projects were on the horizon. He noted that researchers possess the ability to probe, manipulate, and analyze biological molecules, and wondered about the innovation possibilities inherent in this capacity. Mr. Johansen identified new materials and micro-engineering of biological molecules as promising lines of research, but urged a collaboration across disciplines and subject areas to maximize innovation. He called for a “Manhattan Project” mindset focused on solving grand challenges. Dr. Gardner offered the Manufacturing USA institutes as a model for a grand challenge initiative in sustainability, because it is easy for policy makers to understand due to its familiarity. In this model, the government and industry partners provide matching funds for five years, at which point the initiative is expected to stand on its own without public funding. Industry participants all have access to intellectual property developed during the research. He suggested starting with four consortia located in different regions of the country focused on developing

products and processes that reduce waste, develop new materials, and facilitate recycling and upcycling. Dr. Michael Goodman of the University of Massachusetts-Dartmouth observed that the historical record suggested shortages of resources provide strong incentives for innovation and the development of substitute materials.

Private and Public Sector Drivers of Sustainability

A major topic of discussion for the group was what roles the private sector and the government should play in driving sustainable products and processes. Ms. Kathy Trimble noted that Leverage had shown that some changes only take when they occur organically through market processes. Mr. Johansen said both private sector and public sector initiatives are needed, because the optimal actions are often not the easiest ones, and the government has a role in ensuring that private actors either want to make sustainable choices or at least don't stand in the way of others making sustainable choices. He gave the example of potentially incorporating AI into recycling facilities to sort products through software that scans micro-bar codes and tells people how to sort their recycling rather than requiring them to do the logistical work themselves.

Dr. Gardner said that government regulation often distorts markets, and creates unpredictable second- and third-order consequences. He said policy makers need to provide incentives for companies to be

sustainable for economic reasons. Dr. Gardner said that HP is a leader in sustainability primarily because its leadership has seen clear business benefits in both resource use and in attracting consumers, who are increasingly demanding more sustainable products. As an example, he discussed how HP's sustainably-made printers were popular with health-conscious consumers because they did not pollute indoor spaces with off-gassing of toxic chemicals. Dr. Stock called for the creation of a centralized platform where individuals and companies could find easy information on questions about sustainability. He said existing resources were too far-flung and only consulted by people with vested interests in specific topics. He also touted the benefits of cross-fertilization if people came to the platform with a specific question and then saw information on related topics in sustainability housed in the same place.

Ms. Amy Lientz of Idaho National Laboratory said there were many opportunities for the government to improve sustainability in its own operations. She discussed how both the Department of Defense and national labs have incorporated sustainable production criteria into their procurement bid evaluation process, but that these measures could be expanded to other agencies and implemented more consistently. She also described efforts at Idaho National Laboratory to do the same for locally-sourced materials.

Dr. Gardner cautioned against implementing standards that backfire. He said that without a binding global agreement similar to the Paris Climate Accords, new sustainability requirements for U.S.

companies will lead to offshoring of jobs as companies relocate to cheaper countries without those standards. He also gave the example of American car manufacturers. While they did face government mandates in the form of CAFE standards, they also faced strong economic incentives to produce more fuel efficient cars, and this pressure resulted in a burst of creativity and innovation, with cheaper, higher quality, and more environmentally friendly vehicles hitting the roads. However, he stressed the importance of more sustainable production, referring to research suggesting we would need 2.3 earths worth of resources to provide a decent standard of living for the projected 2050 population at our current standard of resource efficiency. In particular, he discussed the challenges the computer industry faces with the growing shortage of rare earth materials, and the need to recycle them to stay in business.

Dr. Dahl discussed her experience with the Advanced Technology Program, developed by the federal government in the 1990s to encourage private investment in long-term, high-risk research. She asked if there was a role for government in subsidizing the kinds of high-risk, high-reward investments corporations will not make on their own. Dr. Gardner said the existing tax credits for research and development are valuable because they allow companies to spend their research money on whatever projects they deem most important. He also advocated greater use of public-private partnerships, and discussed HP's many investments in initiatives ranging from modu-

lar nuclear reactors to micro-biomanufacturing. He said that without government and national laboratory partnerships, HP would not be able to make these potentially groundbreaking investments, including those that could help combat COVID-19, because of the risk to shareholders.

Concluding Thoughts

Ms. Wince-Smith thanked the group for their discussion, and said she noticed many areas of overlap with the discussions of the other Working Groups. She discussed her own involvement in the Advanced Technologies Partnership and the controversy at the time over funding going to large companies rather than to smaller firms more in need of assistance. She observed similar concerns about relief funding from the recent CARES Act stimulus passed by Congress in March. She encouraged the group to think about accelerating America's value creation and sustainability and driving it to a new place rather than merely returning to normal, and to frame recommendations for policy makers in a way that highlights the role they will play. She concluded by noting that many valuable recommendations had emerged from the day's discussion.

Working Group 2 Calls May 15

Introduction

Mr. Chad Evans welcomed the group, and Ms. Kathy Trimble introduced the featured speaker, Mr. Jonathan King of Southern Company. She said that Southern Company's connections with every facet of the group's mandate allowed for a unique perspective on issues of sustainable production and consumption, as well as the future of the workforce.

Featured Remarks

Mr. King opened by providing a background on Southern Company. The utility is one of the three largest in the United States, serving over 9 million customers. Although primarily based in the southeast, the company's renewable and natural gas branches operate throughout the country. He then discussed Southern Company's efforts and challenges in sustainability and in developing the workforce of the future.

In 2007, Southern Company set a goal of reducing greenhouse gas emissions by 50 percent by 2030, and to be net carbon-neutral by 2050. This required a significant shift in energy sources, as the company relied on coal for 69 percent of its power generation in 2007. As of 2020, the company has cut its coal usage by 50 percent and increased renewable generation twelve-fold, and is constructing a large nuclear plant outside Augusta, Georgia. Mr. King said that investor pressure for sustainability is making Environmental, Social, and Governance (ESG) scores as important to corporations as credit ratings for attracting investors. He said that Southern Company has become focused on making its energy generation not only sustainable, but also resilient and reliable for consumers.

A significant challenge in pursuing further sustainability improvements, including adding more renewable energy to the grid, is recouping the costs of investments. While Southern Company has found some investment support through its participation

WORKING GROUP PARTICIPANTS

Mr. Mike Cassidy
Emory Biomedical Catalyst

Ms. Ellen Donaldson
Davidson Community Foundation

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts-Dartmouth

Ms. Ciannat Howett
Emory University

Mr. Noel Kinder
Nike

Mr. Jonathan King
Southern Company

Ms. Amy Lientz
Idaho National Laboratory

Dr. Kathleen Merrigan
Arizona State University

Ms. Jenny Sorensen
Lemelson Foundation

Dr. Mohammad Zaidi
Braemar Energy Ventures

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Mr. Tim Planert

in the Energy Impact Partners confederation with over 20 other companies, utility regulations make it extremely difficult to secure approvals to raise rates on customers to recoup the costs of investments. This remains true even when those rate increases will fund the incorporation of renewable energy that will make the grid more sustainable and lower costs in the long run.

Mr. King also talked about Southern Company's workforce development efforts. He said that the company employed 27,000 people, 1/3 of whom were unionized skilled labor, and the other 2/3 of whom were white collar professionals. He said that 42 percent of the workforce were women or minorities, and that the workforce spanned five generations. He discussed the challenges the company faces as the older generations, who make up the bulk of the workforce, reach retirement age, and how the long tenure of the average worker is a benefit for worker experience but has led to a shortage of training and worker development resources.

To address these issues, Southern Company has created partnerships with the International Brotherhood of Electrical Workers, the North American Building Trades Union, and local community colleges for an Apprenticeship Readiness Program. This collaboration establishes curriculum and training for skilled laborers and includes a 2-year community college degree and workforce training that enables graduates to go straight to the workforce upon completion. Through three graduating classes, 70 percent of workers have been hired immediately after finishing the program. Nevertheless, the company has seen high turnover in its skilled blue-collar positions, as well as slow uptake of training opportunities, and Mr. King said that it remains important for the stakeholders involved to showcase the importance and high wages of these jobs. He reported that workers who maintain utility poles earn between \$65,000 and \$100,000 per year, and characterized the apprentice program as a collaboration between industry, labor, and higher education to bolster a sustainable middle class.

Mr. King concluded his presentation by calling for feedback from participants on similar challenges in workforce or sustainability they have encountered with their organizations, and whether or not it was possible to scale up collaborations between different stakeholders in workforce development like the Energy Industry Partners. He also stressed the importance of finding a way to reduce downside risk to making investments in education and sustainability for companies. Mr. Evans expressed interest in learning more about the Energy Industry Partners initiative, and said that perhaps the Commission could help amplify any recommendations or best practices emanating from its work.

Models for Workforce Development

Dr. Mohammad Zaidi of Braemar Energy Ventures discussed the effectiveness of the German technical education system, comparing his experiences opening plants producing cars in Germany and in Toledo in the United States. He found the German workers to be more productive and that they required far less supervision, even to the point of not requiring floor engineers. He attributed this difference to both the level of resources Germany commits to skilled technical education and to the heavy emphasis on theory in addition to practice in their technical curriculum. He asked if the United States should consider incorporating elements of this system, especially as new energy technologies and the growing importance of cybersecurity increase the skill demands on the technical workforce. Mr. King agreed that this was an important consideration, and said he felt the right stakeholders were already invested in improving workforce development in the United States in the form of labor, industry, and higher education.

Dr. Thomas Gardner of HP Federal described the findings of several studies of the German technical education system in comparison with the United States, and that they all came to the conclusion that there were both challenges and opportunities in incorporating elements of the German system in the United States. Of particular importance in this regard was the need for taxpayers to support an expanded

technical education system and a relative shift in the allocation of educational resources. He also called for building up the community college system in the United States, and for changing the culture around credentials away from the belief that a bachelor's degree is essential for entry into the middle class. A two-year degree and an apprenticeship can provide an equivalent standard of living.

Human Resources and the Skills Gap

Dr. Kathleen Merrigan of Arizona State University asked how diverse Southern Company's Board of Directors and C-Suite were, and what kinds of skills were the hardest to find among skilled workers. Mr. King provided a link to information on the company's Board of Directors and identified electricians, welders, pipe fitters, and field engineers as particular areas of need. Ms. Amy Lientz of Idaho National Laboratory concurred, and said that in the Pacific Northwest, there were needs for welders, masons, and electricians. She added that many of the professionals in those fields are nearing retirement age, but that companies are having trouble finding and retaining apprentices to replace them. She discussed Idaho National Laboratory's efforts to encourage greater collaboration between community colleges, unions, and businesses, and noted the challenges of navigating tensions between the different stakeholders. Mr. King said that Southern Company was fortunate to have few tensions, as all of their unionized workers were from the same organization, and the contract workers they engage with are part of unions that are all within the larger North American Building Trades Union umbrella.

Regulatory Policy to Spur Investment in Clean Technology

The Honorable Deborah L. Wince-Smith asked what regulatory changes would allow Southern Company to make more investments in advanced technologies like batteries, as well as better deployment and optimization of resources. Mr. King said that the biggest challenge was convincing regulators to allow utilities

spend money on projects, and to pass those along to consumers. He described an ongoing project in renewable natural gas, and how securing approval for exploratory research would enable the company to incorporate lower cost and more sustainable energy generation into the grid, resulting in long-term cost reductions for consumers. He also described a microgrid the company maintains for backup generation during surges in power usage or power outages, and how being able to raise funds to invest in battery technology would enable the company to power that grid with stored renewable energy. Mr. King said that the Energy Industry Partners coalition offset some of the risk from investing, but that allowing the company to recoup its research costs more fully would enable them to engage in even more innovation on their own. Ms. Ciannat Howett of Emory University discussed the importance of working with subsidiaries to garner support for investment projects. She described Emory's attempts to secure a backup microgrid for its hospitals, and the initial rejection of the plan because of opposition from Georgia Power. Ms. Lientz said that the Department of Energy has recognized the labor-intensive nature of the energy industry, and discussed Idaho National Laboratory's four major nuclear projects.

Dr. Thomas Gardner of HP Federal said that he had seen success from pre-competitive collaborations on military technology, in which stakeholders shared intellectual property up until the prototyping stage. He mentioned a recent National Renewable Energy Laboratory initiative providing matching funds to manufacturers investing in advanced manufacturing technology. He said that private industry needs large returns in order to take significant risks in attempts to improve its capabilities, and that reducing the risk to industry will encourage more investment in new technologies.

Cybersecurity and Resiliency

Ms. Wince-Smith asked how Southern Company was addressing challenges related to cybersecurity, and Mr. Evans asked whether customers looked to Southern Company for cyber solutions in their own

enterprise. Mr. King said that cybersecurity was an increasingly important issue, and that Southern Company responded to cyberattacks every day. He said that consumers don't generally look to Southern Company for guidance on cybersecurity issues, but that they do rely on the company to keep their electricity supply flowing. He stressed the importance of gathering information about the location and nature of cyberattacks, and noted that the current Presidential Administration issued a recent Executive Order clarifying that the electrical grid is a critical part of the national infrastructure. He also discussed the need to develop more cybersecurity professionals. Dr. Gardner warned that an attack on America's oil refineries could cripple the national grid and transportation system, and would require six to twelve months to recover from. He strongly agreed that the cybersecurity of critical infrastructure should be a major national priority.

The Circular Economy and Sustainability

Mr. Noel Kinder of Nike discussed Nike's work on reusing its own products to create new ones, including a shoe that Nike is developing made out of recycled consumer and industrial waste. He suggested that with the proper infrastructure in place, people would be able to recycle their consumer products to be used in new goods, similar to the bottle deposit programs in place in many states. Consumers would pay a deposit when purchasing a good, and if they turned it in to a recycling facility, would receive their deposit back. Dr. Michael Goodman of the University

of Massachusetts-Dartmouth discussed the value of power purchasing agreements. In Massachusetts, the state government mandated the use of these agreements to procure power from renewable energy sources, and the developers bidding on contracts offered bids that priced electricity from renewables below the cost of fossil fuels without any incentives or public subsidies.

Encouraging the Development of Test Beds

Dr. Zaidi praised Southern Company for its investment in what he saw as four critical technologies for the future: cyber security, renewable energy, carbon capture, and low-cost storage of renewable power in batteries. He noted that all of these items require innovation, workforce training, and other significant investments, and observed that industry was reluctant to offer test beds for these projects. He asked what it would take to encourage industry to provide these test beds, and what the Department of Energy or other government agencies could do to help. Mr. King said that the regulatory environment was the biggest obstacle, and that making it easier to invest in projects without significant downside risk would remove a major barrier.

Ms. Wince-Smith asked how the regulatory framework should be altered to catalyze test beds, and Ms. Howett suggested building relationships with all the stakeholders involved in such an effort. She described Emory's efforts to secure battery storage

capacity for research and operational purposes on campus, and how the school needed to separately liaise with the utility and the state public service commission. She suggested framing the issue as one where the parties want the same outcome, and need to find a unified way to approach regulators with a proposal. Mr. King agreed and said there were two dynamics at play in the case of Southern Company. The public service commissions the company deals with prefer proven solutions, and are reluctant to approve projects where they have not already seen previous examples succeed. He added that both solar energy and batteries have yet to reach the tipping point where they are always more economical than fossil fuels for both commercial and residential energy. Ms. Lientz agreed with these assessments, and added that the Department of Energy has developed various resources to encourage greater uptake of renewables. Dr. Zaidi discussed Alcoa's frequent outsourcing of research and leveraging of external technology to solve challenges, and noted that the automotive industry was excellent at developing new capabilities in its suppliers. He suggested there was potential for cross-industry learning, and noted that cybersecurity, battery storage, renewable energy, and carbon capture combined to offer a compelling national security and competitiveness case for investment in upgraded capabilities. Ms. Wince-Smith said the Chief Technology Officer of the United States, the Honorable Michael Kratsios, was interested in reforming regulatory bottlenecks that delay the deployment of advanced technology systems.

Concluding Thoughts

Mr. King summarized three key takeaways from the group's discussion. First, more discussion was needed on how to best partner at the regulatory level to engage in allowing companies to invest in improvements more effectively. Second, stakeholders should explore ways to partner with the Department of Energy to fund test beds and incubators for sustainability innovations. Finally, there is a huge opportunity to strengthen the middle class through improving the size and training of the craft labor workforce, as well as a great need to continue to attract talent to those fields and to newer positions that are emerging in sustainable energy. Ms. Wince-Smith thanked him for the outstanding presentation, and said that this summary provided a roadmap of where the group should proceed on these issues.

Working Group 2 Calls May 18

Introduction

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group and introduced the featured speaker, Dr. James Davis of the University of California, Los Angeles. Ms. Wince-Smith discussed Dr. Davis's previous work with the Council on the Clean Energy Smart Manufacturing Innovation Institute (CESMII), housed at UCLA, which formed the basis of a conference in June 2019 and a report and Congressional briefing this past February. She added that Dr. Davis has an extensive background in smart manufacturing. Mr. Chad Evans discussed upcoming changes to the weekly Working Group calls as the National Commission proceeds toward Phase II over the summer and fall. This includes a

hiatus beginning next week while the Council synthesizes the contents of the various Working Group discussions and prepares for the second phase of their work, during which discussions will be led by co-chairs.

Featured Remarks: Framework and Overview

Dr. Davis opened his presentation by discussing the Council's workshop with CESMII in June 2019, and the Council and CESMII's Capitol Hill briefing on smart manufacturing in late February 2020. He said it was prescient that the discussion at the latter event focused on pharmaceutical manufacturing given the subsequent COVID-19 crisis. He added

WORKING GROUP PARTICIPANTS

Dr. Carlotta Arthur
Luce Foundation

Mr. C. Michael Cassidy
Emory University

Dr. Carol Dahl
Lemelson Foundation

Dr. James Davis
University of California
Los Angeles

Dr. Helene Dillard
University of California—Davis

Ms. Ellen Donaldson
Davidson Community
Foundation

Dr. Ricardo Ernst
Georgetown University

Dr. Thomas Gardner
HP Federal

Dr. Michael Goodman
University of Massachusetts
Dartmouth

Dr. Jerry Haar
Florida International University

Ms. Ciannat Howett
Emory University

Mr. Jonathan King
Southern Company

Ms. Amy Lientz
Idaho National Laboratory

Ms. Stacy Lippa
Target

Ms. Jenny Sorensen
Lemelson Foundation

Dr. James Stock
University of South Florida

Mr. Luke Tate
Arizona State University

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Mr. Tim Planert

Ms. Carol Ann Meares

that the themes of the June 2019 workshop, Democratization and Innovation, remain relevant today. Dr. Davis also went into the background of CESMII, which is housed at UCLA and sponsored by the Department of Energy as part of the Manufacturing USA Institutes program. It has \$35 million in project funding in its third year, and by the end of next year will have \$50 million in project funding.

Dr. Davis described the digital transformation of manufacturing as a “frontier” that would fundamentally reshape manufacturing operations going forward, and said that in spite of the immense economic incentives for American manufacturing to adopt smart manufacturing techniques, the United States does not have the same interest and drive in coordinating a national transformation of the manufacturing sector that many European countries have. He attributed this to a combination of industry voice and the sheer scope of the transformations required in the United States. He added that much of the considerable American investment in advanced manufacturing practices is siloed and focused on one-off innovations without broader application. This leads to missed opportunities as those funds could have been directed into programs with much broader applicability that could help expedite the universal adoption of smart manufacturing in the United States.

The Democratization of Innovation

Dr. Davis categorized the necessary transformations of manufacturing as building the talent for the workforce of the future, “data and infrastructure thinking” to address challenges and implement best practices, “market thinking” for strategic investment in smart manufacturing, and “data opportunity and security thinking” to ensure smart and secure manufacturing. He said that the first pillar, developing the workforce, was essential to the success of the other three objectives, and he spoke of the need to get rid of the notion that manufacturing was “dirty, dumb, and dangerous” and to replace it with an inspirational vision of what manufacturing is and can be. Dr. Davis

expanded upon this theme by distinguishing between a “manufacturing” mindset and a “making” mindset, the latter of which he characterized as thoughtful and innovative.

Another important distinction Dr. Davis drew was that between “digitization”, or putting operations into digital format, and “digitalization”, or restructuring operations as a result of data. He said the latter term was more precise and better captured the transformations necessary for smart manufacturing. Dr. Davis then went on to describe the primary objectives (competitiveness, consumption, data opportunity and security, and resilience) and means (productivity, precision, performance, and innovation) of digitalization.

Dr. Davis defined the objective of competitiveness in terms of market share, global economic value, and the safety and environmental impact of manufacturing operations, which he emphasized are increasingly important components of global competitiveness. Regarding consumption, Dr. Davis stressed the imperative of using less energy and fewer materials more effectively as a key objective of smart manufacturing. He described data security as a major sustainability issue, and emphasized that it was an opportunity as well as a challenge because of its potential to enhance productivity. Finally, he noted that the importance of resilience was finally becoming clear to manufacturers in the wake of the COVID-19 pandemic, after thought leaders in manufacturing had stressed it for years with little success. He included supply chains, re-shoring, workforce safety, and the ability to retool production and operations in response to crises as components of resiliency. He also discussed the importance of data security to resiliency, noting that advanced manufacturing can be hampered by cyberattacks and by the failure to identify opportunities revealed in data. Dr. Davis added that manufacturers were already discussing resiliency as it pertains to both physical equipment and intellectual property in the wake of the pandemic.

For means, Dr. Davis discussed the importance of improved productivity across the production process. He also emphasized the need for precision as demand for purpose-built products continues to grow and products come with more and more specifications. Related to precision is performance, which Dr. Davis defined as being efficient on a local level and doing things right the first time. Finally, he framed innovation in the context of smart manufacturing as the product of data in context, with the right kind of data in the hands of anyone who can drive value across the entire manufacturing ecosystem, supply chain, or value chain.

Case Studies in Smart Manufacturing

After this framing, Dr. Davis gave several case studies of the benefits of smart manufacturing. First, he discussed the use of sensor technology in furnaces that convert methane into hydrogen. Because running furnaces at a higher, more even temperature yields increases in productivity and efficiency, a manufacturer began placing infrared cameras around the outside of its furnaces, and converting the scans from those cameras into temperature data across all 96 furnaces. This real-time data enabled the factory to maintain constant, high temperatures across all its furnaces, enabling much higher productivity and efficiency. The keys to this data collection were image processing, feature extraction, modeling, and machine learning, all of which helped convert the scans from the cameras into temperature data.

Another application of smart manufacturing is in steel making. The components of steel are heated, mixed, and poured through a funnel that turns into a slab, that is then rolled and sent off to secondary manufacturers, like car companies. With conventional techniques, imperfections that render the steel unusable are not detectable until the rolling stage, but using cameras during the casting and pouring processes, as well as putting sensors on rollers, allow steel makers to identify and even predict imperfections, and consequently intervene to prevent them, at an earlier stage of the process.

Glass making also benefits from smart manufacturing. The glass maker Corning Incorporated procures its supplies from specialty small suppliers, and widely distributed data collection tools among its supplier base allows it to know the particle size distribution of all its component ingredients. This gives the company much greater precision, and thus efficiency, in its manufacturing process, and is an example of the benefits from interoperability between companies in a supply chain.

The food processing industry also benefits from smart manufacturing. General Mills has over 4,000 suppliers that contribute materials to its gluten-free Cheerios, and a single grain elevator that is contaminated with gluten would normally require the company to throw out entire batches of raw material. However, sensors that detect gluten and model how it is mixed, matched, and removed in the supply chain enable suppliers to identify and prevent cross-contamination at a much earlier stage, drastically reducing wastage.

Finally, Dr. Davis discussed the case of a small specialty cardboard packaging manufacturer. Just one sensor on their equipment enables them to manage their volume and assets at such an improved level that they can save 20 percent in production costs. Dr. Davis continued by noting that smart manufacturing can add 15-25 percent to a company's economic value. He said that if just 10 percent of manufacturers across the country adopted the sensory and modeling technology he discussed, the economy would see \$200 billion in new production, 1.5 million additional jobs, and two quads (quadrillion British Thermal Units) of energy.

The Socio-Technical Dimension of Resilience

Dr. Maya Trotz of the University of South Florida asked if more smart technology in socio-technical systems could reduce food waste. She discussed public reactions to farmers dumping milk supplies in the midst of an economic crisis, and asked if better data would

allow oats contaminated by gluten to be used for other purposes rather than thrown out. Dr. Davis said that in addition to companies with more digitalization capabilities faring better during the COVID-19 crisis, General Mills could use information about those batches and their location and condition to find another use for them. He said that this idea was an example of the importance of data to resiliency.

The Evolution of Smart Manufacturing Technologies in the United States

Next, Dr. Davis discussed the evolution and incorporation of technology into U.S. manufacturing, including why the United States is much more siloed in its adoption of advanced manufacturing technology. He characterized the four waves of industrialization as (steam) mechanization, electrification, digitization, and smart manufacturing/machine learning. He said that the data revolution was missing from this paradigm. He described early examples of digital transformation in manufacturing, including the movement from manual to voltage-driven machine controls, and the advent of modular coding, including initiatives like the Aspen Project, in the 1970s. Dr. Davis said these early data-using technologies were asset-oriented and functional, engineered to the specifications of a particular industry regardless of the processes or supply chain. By the 1990s, the rise of the internet made a new kind of data possible, but Dr. Davis said the real distinction was not “big” versus “little” data, but contextualized versus non-contextualized data. Contextualized and interpreted data is the key to smart manufacturing, and Dr. Davis said that industry, having moved from passive to reactive data, now needs to move to predictive data with AI and machine learning. He summed up contextualized data as the right information at the right time and place in the right form, fed into the right technology for the right people to make smart decisions.

One particular feature of the internet is its use of “layered” or “network” thinking. Underlying code, whether HTML, XML, or any other code, is horizontal

and can be used across technologies. It can also be layered on top of other codes to produce more complex machines. Dr. Davis said that AI and machine learning also operate in the same object-oriented fashion: the code sets up “classes of objects” and code is reusable in a horizontal way between objects in a given class. He said that while AI did not gain traction in manufacturing in the 1980s, the internet and information technology provide examples of the benefits of horizontal coding with reusable classes and data. By contrast, manufacturing coding is vertically-oriented, leading to extensive compartmentalization in manufacturing technology despite strong economic pressures for interoperable technology. Because technology, data, and coding designed for one kind of manufacturing equipment are not interoperable, up to 90 percent of the cost of advanced manufacturing projects comes from data, presenting major constraints as technology is managed to the level of greatest complexity. Dr. Davis described trying to create interoperability in functional or asset-developed coding was essential for the effective widespread implementation of smart manufacturing technology.

Dr. Davis concluded this section of his presentation with a warning that while AI and machine learning provide many tempting opportunities for one-off investments, they can badly malfunction in the absence of contextualized data. He said that CESMII was focused on thinking carefully about the horizontal infrastructure and layering necessary to make AI-based smart manufacturing technologies viable.

“Market Thinking” and the Value Proposition of Smart Manufacturing

Finally, Dr. Davis spoke of the need to alter the value proposition for manufacturing. He said that currently it still makes economic sense for companies to invest in siloed technology, even with the proliferation of cloud products that should make interoperability easier. He said that this combination of “island” technologies and cloud capability is increasing, rather than

decreasing, the complexity of smart manufacturing. He said that because only large companies can afford smart manufacturing technologies, the widespread adoption of smart manufacturing practices is impossible. Moreover, small and medium-sized companies account for 99 percent of manufacturing supply chains, yet many small firms have trouble installing even one sensor into their factories. Dr. Davis said he was hopeful that sufficient economic incentives were accumulating to shift the value proposition toward horizontal integration, but it is still an open question how to move out of the existing environment. He said that a stronger voice from manufacturers on the importance of adopting smart manufacturing technology and making the case for the value proposition in infrastructure will be essential to securing the necessary investment to bring this transformation to fruition.

Challenges and Opportunities for Public-Private Partnerships

Mr. Evans asked what opportunities and challenges CESMII was seeing with public-private partnerships, noting that it is putting into practice many of the ideas discussed regarding new forms of public-private partnerships. For opportunities, Dr. Davis identified the ability of public-private partnerships to bring “critical mass” to initiatives in order to demonstrate the value of the changes the institute advocates, as well as the ability of these partnerships to act as neutral bodies promoting best practices and innovations without concerns of ulterior motives that would arise if any individual stakeholder was spearheading the effort. For challenges, Dr. Davis cited conceptualizing how the partnership will play out in practice as the most difficult obstacle, noting that most of the Manufacturing USA institutes operate on a five-year timeline, and that they need to align their mindsets to properly tackle challenges. He distinguished between institutes focused on a particular technology, which can build coalitions for the expansion of said technology, with those like CESMII that have a more abstract focus. He noted that CESMII, with its

focus on digitalization, has the ability to move quickly compared to many institutes, but that it also faces organizational, market, and risk barriers around the leveraging of data in the manufacturing process.

The Geography of Smart Manufacturing

Dr. Helene Dillard of the University of California, Davis asked where smart manufacturing operations would be located, and if they were located in rural areas, what barriers internet service would create. Dr. Davis said that CESMII has developed a concept of innovation centers located throughout the country, and emphasized a mentality of taking the institute to industry, rather than bringing industry to the institute. He added that small and medium-sized manufacturers in rural areas were a critical part of the manufacturing sector, and finding a way to incorporate smart manufacturing into their operations was crucial. He added that the internet was not yet a barrier because so many small and medium-sized manufacturers have “low hanging fruit” with regard to basic data and sensor incorporation, and that existing initiatives are not yet at the level of data intensity where internet capacity has become an issue. However, he did foresee these challenges being an issue in the future.

Workforce Upskilling and Training

Ms. Amy Lientz of Idaho National Laboratory asked about the importance of upskilling the workforce and aligning workers’ capabilities with future industry needs, including skills in digitalization, AI, and high performance computing. Dr. Carlotta Arthur of the Luce Foundation said that as a quality control engineer, smart manufacturing is a dream come true because it is more efficient, less wasteful, and higher quality than conventional manufacturing. However, she echoed the importance of changing manufacturers’ mindsets and upskilling the workforce. Dr. Davis said he was seeing interesting trends in workforce development, including reverse mentorships, apprenticeships, and other initiatives. He characterized the

major challenge as trying to scale and repurpose these programs across the manufacturing sector, and institutionalizing many of these educational programs in four-year and vocational institutions. Dr. Davis said that layering and horizontal thinking skills were as important for workers as they are for manufacturers, and should be considered as part of their training along with training in particular technologies. He noted that the most pressing challenge facing manufacturing was encouraging adoption of smart manufacturing practices without scaring away industry with the return on investment.

Challenges and Opportunities for U.S. Manufacturing

Ms. Wince-Smith asked Dr. Davis what gaps he saw in the Manufacturing USA institutes, and where he would invest in, ramp up, or combine efforts of different institutes if he had a mandate to better coordinate them. Dr. Davis identified developing a stronger and more consistent voice for the U.S. manufacturing industry as a key component of such efforts, as the U.S. manufacturing industry has a relatively sporadic and weak voice compared to the industries of other countries. He said U.S. manufacturers need to develop a more concerted and coherent value proposition regarding digitalization, and that the compartmentalized efforts of individual institutes do not have same impact as all of them, or the industry as a whole, speaking as one. He also called attention to the need to emphasize the risk to industry from out-date equipment and information technology, as well as the current intellectual property regime, and the need to establish a value proposition for mitigating or managing those challenges. He particularly identified shared infrastructure as a critical component in doing so, because of the role it plays in facilitating layered or horizontal thinking.

Ms. Wince-Smith also asked what the state of the U.S. manufacturing supply chain was, and whether it had the capability to quickly scale production of vaccines or other treatments for COVID-19. Dr. Davis

said that he could only speak anecdotally, but that the consensus among CESMII's membership base was that the United States possesses the production capabilities needed to produce large quantities of vaccines, but that further, more coordinated efforts at digitalization will be needed. He expressed optimism but again stressed the need for industry to speak as one voice on the importance of encouraging this digitalization and then to work together to implement it. Ms. Wince-Smith asked if there was a role for the federal government in coordinating this response, and Dr. Davis said that orchestration by a coordinating body was needed to ensure the response of industry is coherent and does not result in unnecessary duplication of effort. He added that a similar coherence was needed for nationwide cybersecurity efforts, as the United States becomes increasingly vulnerable to cyberattacks.

Concluding Thoughts

Ms. Wince-Smith thanked Dr. Davis for his presentation and the group for its discussion, and said that the Council would welcome any disruptive recommendations participants have that emerge from these discussions. She observed that the United States possesses lots of pieces that could be synthesized into a dynamic innovation ecosystem for smart manufacturing, but that more integration is needed rather than the current approach of splintered individual efforts.

Working Group 2 Calls May 22

Introduction

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group, and introduced the featured speaker, Dr. Ricardo Ernst of Georgetown University. Ms. Trimble announced that this call would be the end of the first phase of the Working Group discussions, and that the Working Groups would reconvene for Phase II the week of June 22nd. She added that more information would be coming soon.

Featured Remarks: Overview and Framing

Dr. Ernst opened his remarks by discussing his work with colleagues on the impact of the COVID-19 pandemic on global supply chains, and the increasing importance of supply chain resiliency. He discussed how the crisis had revealed the dependence of supply chains for chemicals, textiles, pharmaceuticals, and other goods on multiple countries all over the world, driven by more demanding consumers and a drive for cost efficiency. He noted that there

was concern about global supply chains even prior to the pandemic because of the escalating tariff war between the United States and China, and that interrupting global supply chains inevitably creates major disruptions because of the interconnectedness of the world economy. Dr. Ernst also noted increasing media interest in supply chains during the pandemic.

De-Globalization or Re-Globalization?

Dr. Ernst discussed a book he recently co-authored called *Globalization, Competitiveness, and Governability*, and its central theses that globalization was here to stay, and closely linked to and influenced by competitiveness and governability. He said although globalization is going to change in the wake of the pandemic, it is very unlikely to disappear, as each successive disruption reveals the increasing interconnectedness of the world. Dr. Ernst described the globalized economy as one in which companies compete “with everyone, from everywhere, in everything,” and observed that a single cup of Starbucks coffee involves 19 different countries in its supply chain. As supply chains expand across the globe, companies

WORKING GROUP PARTICIPANTS

Dr. Ricardo Ernst
Georgetown University

Ms. Ciannat Howett
Emory University

Ms. Jenny Sorensen
Lemelson Foundation

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Mr. Tim Planert

follow a mantra of “produce nowhere to sell everywhere,” and the heated competition between firms in the global marketplace has shown that customers care about brands, not where products come from. Dr. Ernst said that companies respond to this incentive by building their supply chains based around leveraging brand. While the idea that the era of globalization is over has become popular recently, and has even been entertained by magazines like *The Economist*, Dr. Ernst argued that the pandemic would lead not to de-globalization, but to re-globalization, or a reorganization of the relationships between and among companies and countries.

Supply Chains and Inventory

Dr. Ernst argued that competition between firms should not be seen as “my company vs. your company,” but as “my supply chain vs. your supply chain.” He predicted that with the disruptions to supply caused by the pandemic, firms would begin to rethink their opposition to inventory, which becomes very valuable when disruptions prevent new supplies from arriving and cripple the “just in time” model that prevails among cost-conscious firms. While acknowledging that this would increase the expense of supply chains, and consequently of products, Dr. Ernst stressed the benefits of adding a “safety net” back into the production process, and avoiding the economic contraction that began when quarantines shut down the supply chains of all firms with suppliers or distributors in China, Italy, and South Korea. He added that while supply chains initially went to China because of the low labor costs, the renewed push for resiliency is revealing that there are costly risks to only focusing on efficiency.

Classifying Disruptions and Describing Resilience

Drawing on the work of management consulting firm McKinsey and Company, Dr. Ernst characterized resilience as being composed of resistance to disruptions, including avoidance and containment, on the one hand and recovery from disruptions, includ-

ing both stabilization and reopening, on the other. He also drew on a conceptual framework developed by McKinsey for characterizing business risks. Highly predictable disruptions with a small business impact are considered “Business Challenges”, and include labor disputes, regulatory changes, and changing customer requirements. They can be managed within a framework of other business development decisions. Unpredictable but minor disruptions are “Manageable Surprises” and include supplier bankruptcies and localized conflicts in countries with few company operations. These disruptions can easily be avoided or accepted as a part of doing business. Highly impactful but predictable disruptions are “Brewing Storms” and include events like Brexit and the tariff escalation between the United States and China. These risks are significant enough that they require contingency planning. Finally, highly damaging and unpredictable disruptions are “Black Swans” and include wars, natural disasters, terrorist attacks, cyberattacks, and pandemics like the current COVID-19 outbreak. These disruptions require a robust crisis management plan that is in place before a disaster.

Dr. Ernst also discussed typical versus atypical risks, and discussed how COVID-19 is the epitome of an atypical risk. It is affecting the entire planet rather than a locality or region, it is affecting all industries instead of just some, it is affecting both supply and demand instead of just supply, and there is no recent prior experience to guide policy response. Further, it has been highly correlated with the performance of the financial system, is of an uncertain and extended duration, and will have a large, unpredictable impact on people’s long-term behavior.

Recalibrate, Reevaluate and Redefine

In response to the unprecedented disruption of COVID-19, Dr. Ernst argued that economies and companies need to recalibrate their expectations, reevaluate scenarios, and redefine their businesses and business models. He said that thinking in terms of re-globalization will enable firms and countries to successfully transition their supply chains. Critical to the redefinition of supply chains is distinguishing

between “efficiency” and “effectiveness.” Dr. Ernst defined efficiency as reducing costs in facets of production that are internal to the organization and within its control, including labor, equipment, raw materials, money, and operations. He defined effectiveness as a company’s ability to satisfy its customers and respond to their needs. He described four types of companies based on their ability to anticipate market changes and their need to be proactive or reactive, and gave examples of industries and firms fitting each archetype.

Firms that are reactive and able to anticipate market shifts are “Agility” firms, and include fashion companies like ZARA. Their business models are built on being able to respond quickly to changing customer tastes, like new fashions for clothing. Firms that are reactive but have low anticipatory ability are “Efficiency” firms, and include makers of commodities and consumer goods, like Proctor & Gamble. These firms focus on cost minimization in their supply chains above all else. Firms that are proactive and have high anticipatory ability are “Effectiveness” firms, and include makers of luxury or higher goods like Apple, as well as makers of essential supplies like vaccines. These firms need to prioritize quality, safety, and customer service to thrive. Finally, firms like Amazon and makers of durable goods are “Flexibility” firms, with low anticipation and a proactive business model. These firms try to find a balance between efficiency and effectiveness. Dr. Ernst noted that Amazon is not always the cheapest provider of a given product, but it sells over 560 million different products, allowing it compete on efficiency, effectiveness, or both depending on the circumstances.

Dr. Ernst concluded his remarks by emphasizing that one size does not fit all for supply chains, and that different firms will need to prioritize different elements depending on their industry and circumstances. He said firms also need to view themselves as having a network of multiple supply chains and organizing them to maximize resiliency. He added that supply chain experts have begun asking busi-

nesses questions about their supply chains, including how they define resilience, what resiliency measures they are taking, how involved suppliers are in their decisions, how they categorize and define their products, whether they are proactive or reactive, how they measure the resilience capability of their supply chain(s), whether their supply chains vary for different products, if they link risk management to supply chain management, and if they prioritize cost or response time in their product lines.

Amazon and “Inoculating” Supply Chains

Mr. Chad Evans asked if Amazon’s \$400 million effort to “inoculate” its supply chain from disruptions and increase its resiliency will be successful, and if being able to brand themselves as having the most secure and reliable supply chain will provide them with a competitive advantage. Dr. Ernst said that it would not be easy to do and will necessitate increasing costs, but that it is possible as Amazon’s competitors, especially brick and mortar stores, will be facing higher supply chain costs as well. E-commerce firms like Amazon also have a significant advantage in convenience, and by competing on quality, safety, timeliness, and convenience, Amazon can maintain or even expand its market share.

Special Considerations for National Security

Mr. Bill Bates asked if there should be different rules or regulations for supply chains that are purely commercial and those that have national security or public health implications. Dr. Ernst said they there should definitely be different rules, and discussed his experience working in humanitarian logistics, where organizations placed a premium on safety and responsiveness as opposed to low costs. Ms. Wince-Smith said it was important to rebuild trust in supply chains, and predicted that companies would increasingly compete on safety, security, integrity, convenience, and timeliness. She discussed problems with tainted food supplies from China and said that Japan

does not allow Chinese products in its food supply chains. Ms. Wince-Smith also advocated restarting pharmaceutical production in Puerto Rico, and forging closer economic ties with Mexico and other Latin American countries, building on the reworked North American Free Trade Agreement. She added that U.S. firms should incorporate labor standards into their supply chain decisions, and she discussed the importance of the rule of law and good governance, as corruption and fiscal mismanagement led pharmaceutical companies to leave Puerto Rico in the first place. As another national security concern, Ms. Wince-Smith discussed the need to end China's dominance of the global rare earth mineral market. She noted that the United States, Australia, and Kazakhstan all had rare earth mineral supplies, but that they could not compete with China on cost, leading to a major national security challenge.

De-Sinization of Supply Chains

Mr. Evans asked if relocating supply chains from China was feasible or even possible, especially in a short time frame. Dr. Ernst said that the shock to companies of the tariff wars between the United States and China had already caused firms to rethink their supply chain decisions, and that quality and stability of governance is an important factor in competitiveness. He noted that China was offshoring some of its own manufacturing as well. Ms. Wince-Smith added that firms also chose to set up in China in order to be close to the potentially enormous Chinese market. She asked if there was an opportunity to realign supply chains at a regional level, with the United States moving toward more supply chains based in the Americas. Dr. Ernst said there was, and that while Latin American countries cannot compete with China on cost, they have much higher quality manufacturing, including state-of-the-art Audi and Whirlpool factories in Mexico, and are much closer, giving them a time-to-consumer advantage that China cannot compete with. Ms. Wince-Smith said that supply chain decisions needed to have a strategic component, and Dr. Ernst agreed, while adding that the importance of strategy would vary depending on the product in question.

Regional Supply Chains and the Latin American Opportunity

Dr. Ernst warned that there was a short window of opportunity for U.S. firms to relocate production to Latin America and take advantage of its security and proximity, and he urged firms to take action as soon as possible. He said that China would no longer be the world's preferred supplier for everything, and paraphrased Darwin in arguing that responsiveness to change, not size, strength, or intelligence, is the key to survival, both in nature and in business. He said it was important to come up with normative recommendations for companies to follow to become more resilient. Ms. Wince-Smith noted that China cannot compete on time and convenience in its supply chains, and Dr. Ernst agreed. He discussed Ikea's investment in delivery services, and their increased competitiveness from being able to deliver high-quality products and eliminate the need for consumers to travel. He said this was indicative of long-term trends as people become more willing to pay for convenience and added free time, and that this would impact what companies prioritize in their business models.

Concluding Thoughts

Ms. Wince-Smith thanked Dr. Ernst for his presentation, and said she hoped he would be able to speak to the Global Federation of Competitiveness Councils on the topic of supply chains. She said the Council was looking forward to Phase II of the Working Group discussions, and noted that the Council had previously formed a close connection with a similar organization in Mexico.

Working Group 3: Optimizing the Environment for the Nation's Innovation Systems

Working Group 3 Summary

The virtual Working Group sessions began on March 31st and completed this first phase on May 22nd. This Phase I of the Working Group sessions yielded insights and areas for further assessment ahead of the National Commissioner's meeting on June 16th, 2020. Below are highlights and themes from the Working Group.

Working Group members explored areas concerning capital, infrastructure and legal frameworks to support and optimize the entire system in which the nation's innovators and enterprises operate. And though the private sector takes the lead—applying strategies, technologies, business models and capital that address genuine market needs—there are critical roles local, state and federal governments must play.

- The Working Group focused on an initial challenge: what sort of policy recommendation (or set of recommendations) could unleash, free up the tremendous amounts of idle cash held by U.S.-based hedge funds, pension funds, private equity, and other entities to support the long-term, patient capital needs of non-app/non-software, innovation-based industries. The Group noted current venture capital models are insufficient to encourage such long-term investments, and that the focus of the National Commission's work should be on articulating a range of incentives, regulatory environment changes, and other solutions to free up that capital. For example, could incubation and accelerator spaces—coupled with venture and co-located with other national, shared innovation infrastructure (labs, unique and/or large tools, demonstration platforms)—help startups move up the exponential innovation growth curve?
- The United States must develop an infrastructure agenda that is framed around American strengths, values, and interests. This will require coordinating and harmonizing activities with our allies, as well as a combination of bilateral and multilateral approaches (like, revitalizing multilateral development banks). Working Group members suggested the United States develop means to co-invest, de-risk, and provide technical assistance to make large infrastructure investments worthwhile to private finance.
- Domestically, the COVID-19 pandemic has further exposed the infrastructure issues facing many regions of the country. For example, in Appalachia and other rural areas, K-12 schools lack the bandwidth and equipment to transition to remote learning. Working Group members also warned the rapid reorganization of work in response to the pandemic could leave certain parts of the country behind others, as people may be unable to work remotely. Working Group members noted that the lack of infrastructure—like broadband access—can make some investments difficult. The Working Group discussed ideas like creating a federal broadband authority to leverages state programs and public-private partnerships to achieve universal broadband access.

- The Working Group also identified the need to bolster regional competitiveness for national gain. Working Group members agreed that regional innovation needed to be a high priority on the national innovation agenda and that this requires metrics to demonstrate the value of widely distributed innovation. The Working Group discussed, for example, significantly expanding the Economic Development Administration (EDA)'s Build Regional Innovation Systems to Scale program.
- The Working Group also started to tackle the issue of expanding access to capital to traditionally under-represented innovators and entrepreneurs. The Group discussed expanding the Small Business Innovation Research (SBIR) program, with a particular focus on Minority/Women-Owned Business Enterprises (MWBEs). Working Group members also discussed the creation of a new federal equity capital bank, modeled after the State Small Business Credit Initiative created in 2010 that phased out in 2017. This program would include \$10 billion in funding over 10 years to leverage state partnerships with the private sector to invest in underserved regions.
- Working Group members also considered the concept of place-based immigration visas to generate a flow of talent and economic activity to rural areas and small towns, revitalizing areas in demographic decline.
- Working Group members spent multiple sessions discussing the need to reexamine intellectual property, patents and anti-trust laws. Intellectual property (IP) was identified as an often-used mechanism to stifle innovation when patents are held by non-practicing entities—creating a chilling effect on innovation in that space. The Working Group committed to exploring ways to encourage licensees to commercialize technology and to promote active innovation.
- Working Group members did note that during the COVID-19 pandemic, the crisis opened up a reconsideration of traditional views of intellectual property protection. For example, the members cited many examples of ventilator makers opening up their intellectual property to enable mass production of needed medical equipment. Working Group members explored whether intellectual property protection should take into account the national interest during times of crisis. Additionally, Working Group members discussed whether there is a need to rein in firms using intellectual property claims to dominate markets and keep out new entrants.
- Historically, antitrust policy has been used to prevent patent claims for “standards-relevant” technology such as mobile communication innovations. The Working Group considered issuing a recommendation against aggressive antitrust enforcement if the expert consensus was

trending in that direction. Furthermore, Working Group members suggested developing a new executive branch agency to challenge hostile antitrust rulings from abroad and encourage widespread adoption of American antitrust policies.

- Working Group members discussed whether, on a global scale, there is a need for an international body to specialize in antitrust policy, similar to existing international organizations for white collar crime, narcotics trafficking, and securities fraud. Overall, the Working Group agreed that the entire topic of competition policy as an important enabling framework for innovation required additional thought and consideration.

To view video and read full transcripts of each Working Group session, log in to the National Commission Community Online Portal. Video and transcripts are available within Working Group Rooms.

Working Group 3 Calls March 31

Recapping Arizona State

Ms. Kathy Trimble summarized the Working Group's discussion at the January Launch Conference at Arizona State University. The group's discussions centered around three broad topics. The first was redefining "capital" to extend beyond mere financing, encompassing human capital, access to resources and facilities, and infrastructure, among other topics. The topic of intellectual property protection included debates over patent lifespan given the time it takes to bring products to market after they are patented, licensing structures and who owns and uses patents, and how the group could think about IP in different ways to maximize its value. Dr. Lee Cheatham of the Pacific Northwest National Laboratory emphasized the issues with existing IP policy in regulating digital innovations, and Ms. Trimble concurred, citing

recent discussions around patenting advances in artificial intelligence. Finally, the group spent a significant amount of time discussing competition from China, although Ms. Trimble noted that the COVID-19 pandemic may shift discussions away from trade and toward financial and regulatory policy. The Honorable Deborah L. Wince-Smith discussed China's predatory debt-financing of infrastructure projects in developing countries and its Belt and Road Initiative, and expressed concerns about these actions, as well as China's violation of WTO rules for infrastructure financing.

Ms. Trimble then presented guiding questions for the group for today's call. These included how to increase America's entrepreneurial potential, how to enhance innovation, and whether the United States should consider adopting an industrial policy.

WORKING GROUP PARTICIPANTS

Mr. Ryan Abbott
Sundt Construction

Dr. Branden Brough
Lawrence Berkeley National Laboratory

Mr. Jim Carlisle
Bank of America

Dr. Russell Carrington
Lawrence Berkeley National Laboratory

Dr. Lee Cheatham
Pacific Northwest National Laboratory

Ms. Hanna Dooley
Arizona State University

Dr. Lloyd Jacobs
University of Toledo (Emeritus)

Dr. Ushma Kriplani
Argonne National Laboratory

Mr. Tad Lipsky
Antonin Scalia Law School

Dr. Sunil Mithas
University of South Florida

Ms. Christina Orsi
University at Buffalo

Mr. Greg Pellegrino
Deloitte

The Honorable Branko Terzic
Berkeley Research Group

Ms. Anne Tucker
Georgia State University

Dr. Rao Unnava
University of California—Davis

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Joshua Oswalt

Mr. Tim Planert

Group Structure and Subgroups

Participants on the call agreed that having subgroups to take deep dives on topic areas of greatest interest to, or most aligned with the expertise of, participants would be the best path forward. Several subgroups were suggested. Dr. Rao Unnava of the University of California, Davis suggested a group dedicated to the first topic, as it is an emerging issue within academia. Schools across the country are developing entrepreneurship centers, but there is no coordination to enable them to make use of common resources or share ideas. He also cited the example of numerous disparate federal incubators as an opportunity for cross-pollination. Dr. Sunil Mithas of the University of South Florida seconded his call for subgroups. Dr. Cheatham asked if there were challenges that prevented the country from boosting its entrepreneurial potential, and whether the Working Group should focus on “what” questions in addition to “where” questions. Mr. Chad Evans highlighted the many recommendations the Council, and other groups, have made over the years, and that there is “low hanging fruit” that has yet to be enacted.

Several participants expressed an interest in an intellectual property subgroup. Dr. Lloyd Jacobs, formerly of the University of Toledo, shared that many universities are concerned with their level of return on investment from patents and technology transfer. Ms. Wince-Smith asked whether the regime for academic IP developed in the 1980s with the Bayh-Dole Act needed to be modernized. Mr. Tad Lipsky spoke of his background in antitrust law, and how antitrust policy has been used to prevent patent claims for “standards-relevant” technology such as mobile communication innovations, and that the group should consider issuing a recommendation against aggressive antitrust enforcement if the expert consensus was trending in that direction. He also brought up the controversy around non-practicing entities, sometimes derisively known as “patent trolls,” as an area of focus. Ms. Wince-Smith described the entire topic of competition policy as an important enabling framework for innovation, and worthy of a subgroup, and brought up other competition issues such as non-tariff trade barriers.

Ms. Trimble asked the group if there were other topics that should serve as the focus of a subgroup. Dr. Mithas mentioned high-skill immigration and human capital as an important topic, because of the resources universities spend on nurturing foreign-born talent that they are not always able to retain due to immigration laws. Mr. Evans noted the overlap from this topic with the mandate of the second Working Group, which includes the future of work, and discussed the possibility of cross-Working Group subgroups as cross-pollination increases. Mr. Greg Pellegrino of Deloitte suggested focusing on supply chain resiliency in light of the COVID-19 pandemic, and mentioned that the stimulus bill includes a required government report on the resiliency of the nation’s public health supply chain.

COVID-19 and the Council on Competitiveness

Mr. Evans discussed the upcoming Board and Executive Committee meeting of the Council, which includes the National Commission Co-Chairs, and that the meeting will include discussion of how the Council in general, and the National Commission in particular, will respond to the COVID-19 pandemic. He mentioned discussions in Working Group 1 about the immediate and longer-term impact of the pandemic, especially as it intersected with the Council’s focus on resiliency and sustainability. Ms. Wince-Smith recalled the Council’s thought leadership in the wake of the September 11 attacks on reconceptualizing resiliency as a driver of productivity rather than a cost of doing business, and the influence the Council’s work had on the Japanese government’s response to the Fukushima nuclear disaster. She also noted how this pandemic has highlighted America’s lack of resiliency in its public health infrastructure, especially compared to other questions of national security. Mr. Pellegrino expressed the belief that the world has been changed by the pandemic, and that the Commission should remain alert as those changes unfold in order to respond effectively.

Industrial Policy and Related Questions

Ms. Trimble asked the group whether the United States should consider using industrial policy as a tool to deal with Chinese and other foreign competition. Dr. Mithas mentioned the threat posed by Japanese competition in the 1980s, and how the National Institute of Standards and Technology developed the Baldrige criteria for quality control to encourage competitiveness. He said that American companies have largely stopped adhering to the Baldrige criteria, but that it remains an important driver of competitiveness in other countries, and suggested the Council consider recommending a return to those standards. He also mentioned that the Baldrige Foundation is looking to increase its public engagement, and suggested the Commission consider partnering with them. Ms. Wince-Smith discussed her role in helping develop and deploy the Baldrige criteria, and how a lack of adherence by the software industry is responsible for much of its vulnerability to cyberattacks and need to patch flaws in its programs. Mr. Pellegrino questioned whether the World Bank's metrics for determining which countries possessed the most competitive environment for doing business was obsolete in today's digital economy.

Next Steps

Ms. Trimble encouraged participants to continue their conversations on the online collaboration platform. She also laid out the tentative topics for calls over the next few weeks, noting that the Council would accommodate any sub-groups that form from the larger Working Group discussions. Ms. Wince-Smith emphasized the importance of feedback from the Working Group members, and suggested that experts in particular subject areas help catalyze deep dives on topics by sharing basic background information on the issues at hand in future calls. Ms. Trimble reminded participants that summaries and transcripts of the calls would be shared to the online collaboration platform.

Working Group 3 Calls April 2

ASU Recap and Stage Setting

The Honorable Deborah L. Wince-Smith welcomed the participants and praised the level of discussion at the January Launch Conference at Arizona State University. She encouraged members of the Working Group to volunteer to lead discussions on “deep dives” into issues in their areas of expertise. She noted that this Working Group has an especially complex task because of the wide-ranging nature of its subject areas, particularly regarding “enabling” structures and systems that accelerate innovation. Mr. Chad Evans provided a calendar update, noting that the June in-person Commissioners’ meeting will instead take place virtually, but that the Commission’s Year One Findings are still scheduled to be released at the National Competitiveness Forum in December. Ms. Kathy Trimble summarized the group’s

discussions from the January Launch Conference, in particular the themes of broadening the definition of “capital” to include human capital, infrastructure, facilities, and other resources, and of making existing capital more efficient in driving innovation. The group also discussed intellectual property, including the patent life cycle, patent holders’ use of patents, and patent licensing. Finally, the group discussed China and whether the United States should coordinate between the public and private sectors to compete with them in emerging technologies.

Access to Capital

Ms. Wince-Smith noted that startup firms often have difficulty attracting the interest of venture capital when trying to scale up their products, especially

WORKING GROUP PARTICIPANTS

Ms. Laure Bachich Ergin
University of Delaware

Dr. Robert Bishop
University of South Florida

Dr. Gerald Blazey
Northern Illinois University

Dr. Lee Cheatham
Pacific Northwest National
Laboratory

Ms. Ji Mi Choi
Arizona State University

Mr. Thomas Dailey
Dailey Strategic Advisors LLC

Ms. Ann Gabriel
Elsevier

Ms. Vickie Lonker
Verizo

Dr. Anthony Margida
TechGrit

Dr. Cheryl Martin
Harwich Partners

The Honorable Olin
Wethington
Wethington International LLC

Dr. Ken Poole
Center for Regional Economic
Competitiveness

The Honorable Branko Terzic
Berkeley Research Group

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Joshua Oswald

Mr. Tim Planert

Mr. Gourang Wakade

Ms. Carol Ann Meares

for high-risk, long-term investments in advanced manufacturing, infrastructure, and emerging technologies. Mr. Evans mentioned the work the Advanced Research Projects Agency-Energy (ARPA-E) has done in this space, and Dr. Cheryl Martin of Harwich Partners, formerly of ARPA-E, agreed it would be a good topic for a deep dive discussion. She also spoke about the difficulties startup firms are having accessing capital in general due to the ongoing COVID-19 crisis, and that this has major implications for innovation. Ms. Wince-Smith discussed recent correspondence from colleagues indicating that Chinese investors are approaching many cash-strapped American startups impacted by the pandemic. Ms. Ji Mi Choi of Arizona State University echoed Dr. Martin, saying that many startups in Arizona were being forced to pivot or contract due to lack of cash. She noted that some startups have been shielded thus far because their losses have mostly come in the form of paper valuation rather than actual cash flow, but that the situation is evolving.

Regional Issues

Dr. Ken Poole of the Center for Regional Economic Competitiveness detailed the regional impacts of the COVID-19 crisis, and of the recovery legislation intended to mitigate it. He said that states are very concerned with helping businesses survive the downturn, and that the Small Business Administration's Disaster Loan program has been difficult to access for startups and venture-backed businesses. He stressed the importance of supporting these firms in future recovery initiatives. Dr. Poole also noted the infrastructure issues facing many regions of the country the pandemic has revealed. In Appalachia and other rural areas, K-12 schools lack the bandwidth and equipment to transition to remote learning, and he warned that the rapid reorganization of work in response to the pandemic could leave these areas behind as people are largely unable to work remotely. As the COVID-19 pandemic begins to more deeply impact rural areas, this issue will become an increasing problem. Finally, he discussed the supply chain crisis affecting different regions of the country. Citing breakdowns in the medical equip-

ment supply chain due to international suppliers of components and looming issues of food security, he advocated for greater domestic supply chain presence, for reasons of resiliency rather than protectionism. He also highlighted the privacy and data security problems facing the Bureau of Labor Statistics and other government and industry organizations as they migrate secure data to remote work environments on the fly. Dr. Jerry Blazey of Northern Illinois University shared Dr. Poole's concerns about regional responses to the pandemic, and expressed hope that upcoming relief legislation would not concentrate investment or recovery in a few geographic areas, but instead be widely distributed.

Infrastructure and Enabling Factors

A major theme in the discussion was infrastructure as an enabling factor for innovation, especially cyber infrastructure in light of the massive disruptions caused by the COVID-19 pandemic. Dr. Robert Bishop of the University of South Florida highlighted several issues facing academia in the wake of the crisis. These include the need for a vast expansion in remote learning and ensuring sufficient infrastructure to support fully online classes, as well as a rethinking of how universities deliver coursework given that the crisis has shown the viability of online instruction. He also discussed the financial ramifications of tuition-paying Chinese students being unable to return to American universities for the next school year due to the pandemic.

Ms. Wince-Smith brought up cyber threats in light of recent revelations of vulnerabilities in the Zoom platform for online collaboration and telework. Mr. Bates tied the emerging issue of cybersecurity in with the Council's 2018 publication *Secure*, which focused on improving cyber resiliency, and urged for the United States to develop a national cybersecurity plan. He said the current crisis is illustrating the dangers of not having a coordinated response to cyber threats. Ms. Vickie Lonker of Verizon noted that her company was identifying which elements of governance served as enablers or barriers to innovation and nimble response as a result of the crisis, which has

forced them to rapidly move capacity around networks to deal with a surge in activity due to remote work. Ms. Wince-Smith encouraged her to share Verizon's recent study on "cyber hygiene" practices because of their connection with the Commission's emphasis on resilience and infrastructure. Mr. Evans also noted that the shift to remote work has led to a rapid reorganization of work tasks and skills, and that the implications of such a shift were relevant to both the current group and the Future of Sustainable Production and Consumption, and Work group.

In discussing the COVID-19 pandemic, Ms. Choi discussed the role of intellectual property in crisis resiliency. She noted that ventilator makers were open sourcing their IP to enable faster production of necessary medical equipment. She raised the question of whether intellectual property protection should take into account the national interest during times of crisis, and whether similar rules should apply to IP withholding as apply to profiteering and other crisis behaviors.

Competition with China and Openness

Mr. Olin Wethington of Wethington International, LLC advocated for greater coordination between the government and private sector in strategic industries to combat China's attempts to secure primacy in emerging industries. He cautioned against adopting a full-fledged industrial policy or imitating the Chinese government, but urged strategic plans for sectors including biotechnology, IT and Communications, semiconductors, computing, and energy and environmental technology. Dr. Ken Poole of the Center for Regional Economic Competitiveness suggested incorporating this coordination as part of a national economic recovery response following the pandemic. Mr. Evans discussed the relevance of the Council's work with Deloitte on emerging technologies around the globe, and the strategic advantages possessed by different countries in each area. He noted that the study identified ways to improve productivity and capability in each area, and recommended incorporating it into the group's discussions on strategy.

Mr. Wethington also addressed the issue of technology transfer. He emphasized his support for an open system of data sharing and technology transfer, but urged the United States continue to fund and support organizations like the Committee on Foreign Investment in the United States (CFIUS) to prevent theft of intellectual property in critical technology areas. Ms. Wince-Smith discussed her conversations with Dr. Michael McQuade of Carnegie Mellon University, about the need to engage with allies, including the Five Eyes intelligence sharing program between the United States, Canada, Britain, Australia, and New Zealand. She compared the situation to international cooperation with allies during the Cold War and also mentioned Japan as a collaborator for sharing information and data.

Next Steps

Ms. Choi asked how the group should begin thinking about the end product of its work, including which areas to focus on, how many subtopics in each broad area, and the balance of background information for context on the problem and forward-looking solutions. Mr. Evans said that the goal was to have specific, actionable recommendations in the style of the Council's National Innovation Initiative from 2005, which contained nearly 80 detailed, implementable recommendations stemming from working group discussions. Ms. Trimble discussed the schedule and topics for upcoming calls, and said that starting next week the group will begin to engage in deep dive conversations on specific issues.

Working Group 3 Calls April 7

Setting the Stage

Ms. Kathy Trimble welcomed the group and encouraged them to use the discussion to help focus the Working Group's attention on key areas. The Honorable Deborah L. Wince-Smith introduced the kickoff speaker, Mr. Tad Lipsky, on the topic of antitrust enforcement and its interaction with intellectual property and innovation.

Kick-off Presentation

Mr. Lipsky began with a historical overview of antitrust policy in the United States, from the Sherman Antitrust Act of 1890 to the present. From the passage of the Sherman Act in 1890, U.S. regulators and courts have had significant antitrust enforcement powers, including the ability to prosecute antitrust violations as criminal, rather than civil cases. A "private attorney general" provision also enables private

citizens who believe they have been wronged by anti-competitive action to file a civil suit, with the potential to be awarded treble damages if they win their case. These provisions, particularly civil suits, have become even stronger over the years with the emergence of class action lawsuits and broader discovery rights after World War Two, resulting in exceptionally costly verdicts and settlements.

A new era in antitrust policy began during the 1940s, when courts began to find that various intellectual property protections, including patent licensing, violated antitrust provisions. During the period from roughly 1947-1972, antitrust regulators and the courts were very aggressive in challenging the actions of U.S. companies, especially pertaining to intellectual property protection. However, during the 1970s, the U.S. economy began to falter and become less competitive, and economists and scholars identified a lack of IP protection stemming

WORKING GROUP PARTICIPANTS

Dr. Robert Bishop
University of South Florida

Dr. Gerald Blazey
Northern Illinois University

Dr. Branden Brough
Lawrence Berkeley National Laboratory

Ms. Ji Mi Choi
Arizona State University

Dr. Lloyd Jacobs
University of Toledo
(Emeritus)

Mr. Tad Lipsky
Antonin Scalia Law School

Ms. Vickie Lonker
Verizon

Dr. Anthony Margida
TechGrit

Dr. Sunil Mithas
University of South Florida

Mr. Bruce Sommer
University of Illinois
Springfield

Ms. Anne Tucker
Georgia State University

Ms. Julie Meier Wright
Collaborative Economic;

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Joshua Oswald

Mr. Tim Planert

from aggressive antitrust enforcement as a major culprit. During the 1980s, courts began moving away from aggressive antitrust enforcement, and a bipartisan consensus began to emerge around a relaxed antitrust regime that recognized the importance of intellectual property in spurring innovation, and that relied on rigorous economic analysis in determining if companies were engaged in antitrust violations.

In recent years, foreign antitrust agencies, particularly in the European Union, have replaced the United States as the primary initiators of antitrust action. This newfound aggression is driven in part by concerns about patents for “standards-essential technologies”, such as those relevant to communications and internet technology standards, as well as the rise of non-practicing entities, and controversial pharmaceutical patenting practices. However, these actions are disproportionately directed at American tech firms, such as Microsoft, Apple, and Google, and while some members of Congress want the United States to adopt these aggressive policies, Mr. Lipsky warned that doing so would be dangerous, as many of these challenges are rooted in protectionism rather than genuine antitrust action.

Mr. Lipsky advocated challenging the new, aggressive antitrust policies emanating from abroad by reasserting the consensus approach in the United States of prioritizing competition and innovation. He also stressed the importance of rigorous, case- and evidence-based evaluation of antitrust claims, and of an adversarial system where firms are allowed to defend themselves before a neutral judge. He further suggested developing a new executive branch agency to challenge hostile antitrust rulings from abroad and encourage widespread adoption of American antitrust policies.

Finding a Balance in Antitrust Enforcement

Dr. Sunil Mithas of the University of South Florida agreed with Mr. Lipsky’s endorsement of evidence-based antitrust policy and the American approach of encouraging innovation and competition, but questioned whether the United States should look to bodies such as the EU for a balance between protecting firms and other stakeholders, like consumers. He noted that consumers, unlike large firms, are not well organized and have few means of making their voices heard on matters like privacy protections. He added that he agreed with Mr. Lipsky about the need to defer to experts and evidence in making antitrust decisions.

Mr. Lipsky responded that he agreed there were relevant concerns regarding privacy protection, labor standards, and other issues, but that these issues should be referred to distinct regulatory bodies, and that antitrust enforcement should focus only on competition policy. He characterized some privacy concerns as within the purview of antitrust policy, since companies deciding amongst themselves how to deal with privacy protection is as much of an anti-competitive practice as fixing prices amongst themselves. However, he urged for privacy protections as a whole to be viewed as a consumer protection issue. Mr. Lipsky argued that the strength of American antitrust policy was its explicit focus on issues of competition, avoiding politicization and conflicting or split mandates in favor of neutral economic analysis. He criticized the EU practice of invoking competition policy as a means of consumer protection. Ms. Wince-Smith agreed with this conclusion, and noted that European countries often cloak protectionist policies in the mantle of antitrust enforcement. She pointed out that nearly all antitrust enforcement actions in the European Union are aimed at American firms.

Measuring Innovation

Dr. Branden Brough of Lawrence Berkeley National Laboratory noted that current antitrust policy is focused on promoting innovation, and asked how innovation is best measured and quantified. Mr. Chad Evans discussed the work the Council has done in the past 20-25 years to identify metrics and proxies for innovation, beginning with its creation of the first global innovation index in the late 1990s. This first attempt to quantify innovation used metrics including scientific publications, patents, trade in high-tech industries, and other proxies. He also mentioned academic work around the same time period, including by current Commission Co-Chair Dr. Michael Crow of Arizona State University, on the components of national innovation systems. Mr. Evans noted that the Council's work inspired similar efforts by other groups to measure innovation, including the World Economic Forum. Mr. Evans also mentioned the Global Federation of Competitiveness Councils' Competitiveness Decoder tool, an online interactive tool that measures competitiveness around the world across 8 dimensions, including innovation. The decoder covers 200 countries over a period of 35-40 years and has 150 different metrics, from investments to policy decisions. The decoder also used AI to crawl over 40,000 government documents around the world to identify policies relevant to innovation and competition.

Antitrust Policy and Innovation

Mr. Tim Planert from the Council on Competitiveness discussed the role antitrust policy plays in either supporting or obstructing innovation. The current guidelines used by the Federal Trade Commission and the Department of Justice for prosecuting horizontal mergers as anticompetitive includes five elements. These include determining the degree of market concentration after a merger, identifying anticompetitive consequences from this concentration, identifying factors such as entry of new firms that counter these anticompetitive effects, considering whether

the merger allows the firms to innovate more effectively together than they could on their own, and whether either or both firms would have to exit the market in the absence of a merger. Mr. Planert said that the latter two considerations illustrate a way in which antitrust enforcement could reduce innovation: by preventing firms from pooling their resources and capabilities to become more competitive against other market participants, and potentially causing the number of firms in the market to shrink if one or both firms cannot afford to compete on their own. On the other hand, antitrust enforcement can boost innovation if it prevents a merger that concentrates the market without improving either firm's innovative capacity. He also mentioned academic literature and remarks from a U.S. Deputy Assistant Attorney General that echo the conclusions implied in the above guidelines: antitrust decisions are optimal when made on a case-by-case basis.

Strength of Antitrust Enforcement and Criteria for Action

Ms. Vickie Lonker of Verizon asked how powerful the federal government's antitrust enforcement mechanisms should be. Mr. Lipsky responded that the government already possesses powerful tools for antitrust enforcement, and that it overused them during the 1947-1972 period. It was scholarly consensus that this aggressive approach was hurting innovation and American competitiveness that ushered in a less aggressive regime rather than a weakening of authority. Mr. Lipsky said that while there is some push for a return to these policies, which are the norm in Europe, the American system of case-by-case evidence gathering and opportunities for firms to defend themselves is optimal. As an egregious example of overzealous antitrust enforcement, he cited the mid-20th Century Alcoa antitrust case in the United States, where the firm was punished for expanding to meet increased demand for its products. Mr. Lipsky said that EU regulators were not that

aggressive, but they still are too eager to sanction large, innovative firms, including measures like banning customer loyalty programs. He also criticized the EU practice of unilateral administrative action, rather than an adversarial trial before a neutral judge, and the slowness of EU antitrust appeals, citing the case of Intel still fighting an antitrust claim from 2001 in EU courts. He concluded by reiterating that the optimal U.S. policy is to maintain the status quo of clear economic analysis and procedural fairness. Ms. Lonker asked whether the problems in antitrust policy stemmed from statutes themselves, or from the supporting policies regulators used to enforce them, and Mr. Evans suggested this would be a good discussion topic for the group.

Maximizing the Advantages of American Antitrust Policy

Ms. Wince-Smith asked about the antitrust policies of other U.S. competitors, particularly China. Mr. Lipsky responded that China has a drastically different legal regime, but that they engage in the same protectionist behavior as Europe. He added that in China firms face the added problem of a legal system that does not regard the adversarial process or defendants' rights as important, and that China uses its antitrust policies to engage in particularly aggressive protectionism and mercantilism.

Ms. Trimble asked whether the current U.S. antitrust regime represents a competitive advantage or disadvantage. Mr. Lipsky said that the status quo in the United States is very supportive of innovation and competition, and he praised current Assistant Attorney General Makan Delrahim as the "gold standard" in applying antitrust to IP and standards-essential patents. He cited Mr. Delrahim's background in patent examination and understanding of the role of antitrust enforcement on intellectual property as sources of this strength. Mr. Lipsky advocated for the United States to continue its antitrust enforcement regime, and to focus on encourag-

ing other countries to adopt American standards, because in addition to the EU and China, countries like South Korea, South Africa, and Taiwan engage in similar patterns, and countries like France, the UK, and Germany prosecute U.S. firms through domestic antitrust agencies. He identified finding a way to spur action in foreign countries on this matter as a key policy goal. Mr. Lipsky concluded by discussing cases where foreign antitrust actions were so egregious that the U.S. president had to become involved, including President Clinton's intervention to prevent the EU antitrust enforcement body from blocking an innovation-boosting merger between two American defense contractors. He warned that having to rely on these kinds of interventions is not an optimal policy.

Working Group 3 Calls April 9

Setting the Stage

Ms. Kathy Trimble and The Honorable Deborah L. Wince-Smith welcomed the group, and introduced the kickoff speaker, Mr. Tad Lipsky of the Global Antitrust Institute at George Mason University's Antonin Scalia Law School. The session was primarily devoted to discussing antitrust policy in the United States and internationally in conjunction with and response to Mr. Lipsky's remarks

Kickoff Remarks

Mr. Lipsky provided an overview of the past, present, and future of antitrust and competition policy in the United States, and its relation to intellectual property in particular, and innovation and competitiveness in general. He began with the origins of antitrust

policy in 1890 with the passage of the Sherman Antitrust Act, which he characterized as giving the government powerful legal tools to pursue antitrust enforcement. These included the ability for the Attorney General to seek a broad array of civil and criminal remedies for anticompetitive behavior, and the prosecution of antitrust violations as criminal, rather than civil, matters. Over time, these enforcement tools have become even stronger, with some antitrust violations treated as felonies and punishable by hundreds of millions of dollars in fines and decades-long prison sentences. Numerous companies have been broken up entirely as a result of antitrust action, including Standard Oil in 1911, the United Shoe Machinery Corporation in 1968, and Bell in 1984. Mr. Lipsky noted that firms display a powerful behavioral response to antitrust laws.

WORKING GROUP PARTICIPANTS

Mr. Jim Carlisle
Bank of America

Mr. Mike Cassidy
Emory Biomedical Catalyst

Mr. Thomas Dailey
Dailey Strategic Advisors LLC

Dr. Ushma Kriplani
Argonne National Laboratory

Mr. Tad Lipsky
Antonin Scalia Law School

Dr. Cheryl Martin
Harwich Partners

Mr. Greg Pellegrino
Deloitte

Dr. Ken Poole
Center for Regional Economic Competitiveness

Dr. Irene Qualters
Los Alamos National Laboratory

The Honorable Branko Terzic
Berkeley Research Group

Dr. Rao Unnava
University of California Davis

The Honorable Olin Wethington
Wethington International LLC

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Joshua Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

The second era Mr. Lipsky discussed was the period from 1947-1972, which he characterized as the height of aggressive antitrust policy, driven by the growing use of antitrust violations to prosecute various intellectual property practices, including patent acquisition, licensing, and pooling. During this period, numerous business practices related to IP that had previously been routine were presumed to be automatically illegal, and combined with other policies hostile to intellectual property to dampen innovation. Mr. Lipsky said that by the 1970s, the U.S. economy was losing competitiveness against those of Western Europe and Japan, including economic shocks that led to wage, price, and foreign direct investment controls and the abandonment of the gold standard under President Nixon. In response, a body of academic literature began advocating for a new antitrust policy that used economic analysis of the effects of behaviors to determine if they undermined competition, rather than relying on automatic presumption. This practice, as well as the practice of allowing accused firms to defend themselves before a neutral judge, became staples of the bipartisan consensus that has emerged on antitrust policy in the post-1980 period.

In the present day, Mr. Lipsky noted that the post-1980 consensus still predominates, but that a growing number of voices in both the policy world and the antitrust community would like to see a return to the days of aggressive antitrust enforcement. He characterized this as dangerous to innovation and economic dynamism, and noted that the current consensus relies on stringent evidence for identifying practices that are actually anticompetitive. He also noted that the United States has been supplanted as the world's leader in antitrust actions by foreign actors, especially the European Union. He criticized the EU approach, which is similar to the "aggressive" approach formerly used in the United States, and which does not allow accused firms to plead their case or for adjudication by a neutral third party. He noted that the vague standards and lack of transparency in the European process prevent companies from defending themselves, and that most antitrust

actions in the EU were directed against major American technology companies like Apple, Alphabet, Intel, and Qualcomm. Mr. Lipsky warned that were the United States to adopt this antitrust regime, it would harm licensing, mergers, and acquisitions when such actions were beneficial for innovation, and would damage the relationship between companies and their suppliers and customers.

Finally, Mr. Lipsky focused on the future of antitrust regulation. He urged not only for the preservation of the American consensus domestically, but also for stronger pushback by the United States against hostile actions by foreign antitrust agencies. He argued that many of these actions are pretexts for protectionism or industrial policy, and encouraged the creation of an executive branch agency in the United States responsible for confronting foreign abuses of antitrust enforcement.

Discussion

Mr. Olin Wethington of Wethington International, LLC asked what efforts the United States has made to engage in dialogue over antitrust enforcement with other actors, especially the EU and China. He also asked what role the Council could play in spurring such dialogue, whether through seminars and public debates or through private meetings with the White House, the National Economic Council, or the U.S. Trade Representative. Mr. Lipsky noted that there have been attempts at dialogue previously, including during negotiations over the Trans-Pacific Partnership, but cautioned that trade policy is not the best way to address anticompetitive behavior. He warned against ad hoc responses, such as interventions by the President or other high-ranking officials (though he noted instances of successful interventions by Presidents Clinton and Obama in stopping antitrust enforcement by foreign powers), calling for a body that would institutionalize these actions. Mr. Lipsky also cautioned against confrontation, noting that the countries and organizations involved would become defensive. He instead advocated pursuing close ties

with countries with similar attitudes toward anti-trust, including the UK, Canada, and Singapore, and developing a common antitrust framework amongst them that becomes an alternative to the aggressive, EU-style model. Over time, the benefits of this model would become apparent and inspire emulation from other countries. Mr. Lipsky noted the success of this approach in aviation, where the United States pursued agreements with allies such as Israel and the Netherlands, and eventually succeeded in implementing its “Open Skies” principles around the world.

Ms. Wince-Smith asked if Britain’s leaving the EU opened opportunities for bilateral action on antitrust between the United States and UK, and also asked about partnerships with Canada and Australia. Mr. Lipsky replied that there has been significant movement on this front in the antitrust community, but that things were still in the brainstorming and ideation stages. Mr. Tom Dailey, formerly of Verizon, asked whether there was contention about the inclusion of non-economic damages as antitrust violations. Mr. Lipsky said this was an area of active debate, and noted that a common criticism of U.S. antitrust policy is that it is “too narrow” in its economic focus. He criticized this argument as failing to appreciate that the economic dimensions of antitrust analysis focus on competition rather than mere output or prices, and that sometimes mergers and acquisitions can enhance innovation by boosting the innovative capacity of the merged firms. He cited a court deci-

sion in Delaware announced yesterday that reached such a conclusion. Mr. Lipsky further added that user data and privacy protections are a major point of contention in antitrust law. He said that Germany is debating amending its antitrust statutes to remove the requirement of “injury” to allow the prosecution of antitrust cases on privacy grounds, following a court decision that blocked such measures. Mr. Lipsky agreed that privacy was an issue requiring regulation, but urged that it be handled by a separate body, with antitrust agencies focusing only on economic considerations.

Dr. Branko Terzic of Berkeley Research Group asked about the practice of large firms like Facebook acquiring up-and-coming firms with innovative ideas that might emerge as competitors. Mr. Lipsky agreed there was validity to concerns about such behaviors constituting anticompetitive action, but urged caution in pursuing such cases. He said that while large companies can and do engage in predatory behavior to stop competitors from entering, many of those competitors’ products and platforms become valuable because they are bought by firms with large market share. He added that many innovators count on being able to sell their startups to larger firms to make money off their innovations, and that a blanket prohibition on such acquisitions would harm the incentive for firms to innovate.

Dr. Rao Unnava of the University of California, Davis asked if the World Trade Organization could play a role in regulating global antitrust policy. Mr. Lipsky said that the WTO tried to do as much in the 1990s, but that the effort broke down because of a lack of trust and agreement among the member countries involved. He noted the WTO struggles even to prosecute price-fixing and cartel-like behavior. Instead, he suggested the creation of an international body that specializes in antitrust policy, similar to existing international organizations for white collar crime, narcotics trafficking, and securities fraud. Mr. Bill Bates asked if such an organization should be U.S.-led or predominantly international, and Dr. Unnava argued that it would need to be driven by the international community to secure buy-in.

Council Associate Carol Ann Meares asked whether platforms that make their services free to users, such as Facebook, could be prosecuted for antitrust violations. Mr. Lipsky responded that the U.S. legal system focuses on the competitive consequences of firm behavior, and that digital platforms that colluded on things like terms and conditions or privacy protections would be punished for antitrust violations even if their product was free to users, because of the negative effect on competition between platforms such actions would have. He noted that even predatory pricing cases are difficult to prosecute because the prosecutor must show that absent state intervention, the firm would have raised its prices after securing market dominance.

Mr. Dailey asked what role the EU's digital tax regime had on its antitrust actions against American tech companies like Apple. Mr. Lipsky agreed it was part of the EU's calculations, but that the EU constitution grants member states sovereignty over tax policy. As a result, it remains to be seen what the outcome of the EU's attempt to fine Apple \$14 billion for repatriating profits to Ireland will be.

Conclusion and Next Steps

Mr. Chad Evans posed a question for the group to consider during subsequent online discussion and for future calls. He asked what the detailed plans for a U.S. agency to fight antitrust abuses from other countries would look like, including budget authority, structure, and which governmental bodies it would report to. Ms. Trimble reminded the group that materials will be posted online following the call, and that next week's calls will focus on the availability of capital from startup to scale-up.

Working Group 3 Calls April 14

Introduction and Kickoff Speaker

Mr. Chad Evans welcomed the group and provided some framing thoughts for the conversation. He noted that the working group on the Future of Sustainable Production and Consumption, and Work had discussed the lack of relief for venture-backed firms in the CARES Act, and flagged it as a relevant topic for the group. He also discussed the \$1.5 trillion in reserves that venture capital sitting on, and asked how it could be productively deployed to support innovative firms during the COVID-19 crisis. Finally, he asked to what degree the government should be involved in financing and supporting innovative firms. Ms. Kathy Trimble introduced the kickoff speaker, Dr. Cheryl Martin of Harwich Partners, and former director of the Advanced Research Projects Agency-Energy (ARPA-E). Dr. Martin discussed the question of capital availability from start-up to

scale-up, and delineated three components: Sources of funding, road maps for innovation, and non-financial resources.

Capital Funding: Venture and Other Sources

Dr. Martin said that venture capital has a place in funding innovation, but that it can also chase valuations over long-term innovation, and that depending on its view of the risk-reward balance, over- or under-fund particular projects. She contrasted traditional venture capital with “Venture studios” like Macquarie Capital, which sponsors demonstration projects and is willing to provide millions of dollars of funding for pilot programs in fields such as 5G, when traditional VC would be trying to reduce the size of its investment to minimize its risk. Dr. Martin

WORKING GROUP PARTICIPANTS

Dr. Robert Bishop
University of South Florida

Dr. Gerald Blazey
Northern Illinois University

Mr. Jim Carlisle
Bank of America

Mr. Mike Cassidy
Emory Biomedical Catalyst

Dr. Lee Cheatham
Pacific Northwest National
Laboratory

Ms. Ji Mi Choi
Arizona State University

Mr. Tom Dailey
Dailey Strategic Advisors LLC

Dr. Lloyd Jacobs
University of Toledo
(Emeritus)

Ms. Vickie Lonker
Verizon

Dr. Cheryl Martin
Harwich Partners

Mr. Bruce Sommer
University of Illinois
Springfield

The Honorable Branko Terzic
Berkeley Research Group

Ms. Anne Tucker
Georgia State University

COUNCIL STAFF

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Joshua Oswalt

Mr. Tim Planert

argued that “skinnying down” VC investment in an enterprise to maximize the risk-reward ratio renders such funding useless, and praised the Manufacturing USA initiative for its ability to de-risk investments and attract substantive funding for venture capital through mechanisms like shared resources and infrastructure. However, she said some institutes were better run than others, for a variety of reasons. She also discussed her role in managing the loan program at the Department of Energy, and stressed the risks of the politicization of failure. Dr. Martin identified several shortcomings in the program, including its forbidding ARPA-E to fund pilot projects that could be converted into grants and written off if they failed. She also discussed valuable components of ARPA-E’s programs, including the funding of a site to validate prototypes for new batteries developed by firms as part of a renewable energy initiative. Firms whose batteries worked could secure additional funding. She cited this as an example of the importance of inflection points and screening mechanisms for ventures to reduce risk. Finally, Dr. Martin suggested several improvements to the Small Business Innovation Research (SBIR) program, including roadmapping to help firms figure out an appropriate focus, qualified program managers with specific expertise in helping small business working full-time for the program, and co-horting of eligible businesses with other small firms seeking funding to enable knowledge spillovers and provide more incentive for VC to investigate programs. She also suggested waiving the requirements for matching funds during the early stages of ventures, as when ARPA-E adopted this waiver, fewer firms signed risky or unrealistic agreements with VC funders in order to secure investments. She noted that this policy was not popular initially, but did a good job reducing perverse incentives.

Road Maps for Innovation

Dr. Martin stressed the importance of “Road Maps” to help funders and firms understand the implications and uses of innovations, as well as the process for scaling them and bringing them to market. She

characterized insufficient road mapping as a leading cause of loss of innovations to foreign competitors like China. Dr. Martin praised the Manufacturing USA institutes for facilitating some of this planning, but also urged them to improve in certain areas, especially the sharing of sub-maps across the different institutes and parties involved for greater coordination and collaboration. Such sharing would help the United States gain a greater understanding of its place in the global landscape and its position relative to competitors. She also encouraged the use of road maps to help identify how and when the federal government or venture capital should plug in to state and regional ecosystems.

Non-Financial Capital

Dr. Martin emphasized the importance of resources besides finance for fueling startups. She identified several ideas for improving the innovation ecosystem, including allowing SBIR participants to use funds for tech-to-market activities, and for dedicated senior technology advisers with experience developing and scaling innovations, rather than relying on volunteers for guidance. She warned that involvement by volunteers with insufficient knowledge of particular projects could do more harm than good for firms, and that programs like SBIR needed people who could “see the forest for the trees.” Dr. Martin also urged the revival of a pilot program that ended in 2018 allowing startups to use “vouchers” to gain access to national lab facilities. She said that access to facilities is crucial for startups, and that these kinds of support help innovation “go further, faster.”

Capital Facilitation at the Federal Level

Participants echoed Dr. Martin’s views on federal support of innovation. Dr. Jerry Blazey of Northern Illinois University reflected on his experiences as a program manager for SBIR, noting he was struck by the lack of direction and overarching guidance, which led to mission-driven agencies co-opting the program to further their missions rather than the

intended goal of the SBIR program. He also agreed on the need for dedicated experts with backgrounds in the commercialization of technology, and for investment in the knowledge base of program managers. Dr. Martin elaborated on the benefits ARPA-E found in “co-horting” their SBIR recipients with their other venture projects, including knowledge spillover through interactions at joint demonstration fairs, and the generation of a critical mass of promising projects to fund, mitigating the risks of any individual project failing. Dr. Blazey suggested developing guidelines directing agencies how to structure their SBIR programs to make them uniform and focused on the goals of SBIR as a whole, rather than individual agency missions. Mr. Bill Bates asked if there were ways to encourage larger initial investments from venture capital, and if there were any issues participants noticed with the lab voucher program. Dr. Martin suggested helping firms understand the needs and goals of funders, and pointed to philanthropy as a driver of larger investments. She suggested that combined investments from different philanthropic sources could exceed the dollar value of any single VC firm’s investments.

Geographic Considerations

Dr. Mike Cassidy of Emory University noted that in venture funding, the real action was often at the state level, and stressed the importance of getting capital funding, especially early stage capital, to flow outside of traditional hotspots like Boston and Silicon Valley. Dr. Branko Terzic of Berkeley Research Group

suggested an exchange that would match innovators and entrepreneurs outside of traditional hotbeds with venture capitalists, particularly in places with significant university research. He said these locations often have lots of people with innovative ideas, but that they don’t know the VC world, and the VC world does not know them. He listed biofuels and nanotechnology as areas where universities were doing groundbreaking research that could be of interest to venture capital. Ms. Ji Mi Choi of Arizona State University agreed with this idea, and drew on her experience helping ASU secure I-Corps investment to suggest a clearinghouse or database containing information on I-Corps and other grant recipients. Venture capital firms could use the database as a tool to find investment opportunities that have been “validated” by grant awards. She added that the I-Corps program expects universities to supply the administrative legwork to promote their innovations. Dr. Terzic suggested such infrastructure could ensure that investment in these ideas benefited the local economy by providing infrastructure to keep the project there, rather than “dragging” it to the location of the VC funder. Ms. Vickie Lonker of Verizon expressed concern about zeroing in too much on the geographic dimensions of funding, but expressed support for such a platform, using the example of Kickstarter as a model for connecting ideas with funding. Ms. Kathy Trimble agreed on the need for a broad focus, while also adding that it was important for all regions of the country to maximize their innovative potential.

Clearinghouses and Facilitating Structures

Ms. Choi further developed the concept of a database as a “one-stop shop” not only for venture capital firms looking for investments, but for entrepreneurs and researchers looking for funding sources for scaling their innovations. Such a platform would include information on different funding sources for innovators, as well as the terms, conditions, and eligibility requirements for each source. She noted that different projects require different levels of funding, and that “the right funding at the right time” can be the difference between success and failure for a venture. Ms. Trimble noted that such databases did not appear to exist, and that existing information on projects and funders was often piecemeal. She described the Department of Defense’s online listing of projects, which does not give details beyond the title and funding levels of the project. She cited parties fearing the release of proprietary information as the cause of this secrecy. Dr. Martin described a similar lack of coordination and cooperation that doomed an attempt by signatories of the Paris Agreement to develop new batteries for renewable energy. Countries were not forthcoming with the information needed to keep the project together and enable collaboration due to concerns about protecting their ideas. Regarding a database, she suggested that creating something to “plug into”, rather than something to “wire together” disparate existing components, was optimal.

States as Moderators and Facilitators

Dr. Lee Cheatham of the Pacific Northwest National Laboratory discussed the role states play as mediators between large, established firms and entrepreneurs. He noted that the state government of Washington has helped startups connect with giants like Boeing and Microsoft in the Seattle region, and spoke of capital access as a process or chain. Ideas are born and then transferred to various parties, and require funding at every step, especially during the period from prototyping to commercialization. He said that his lab often has the funds necessary to help firms scale the Valley of Death, but that a lack of knowledge of potential end users and use cases makes the investment not worthwhile. He concluded that capital was not only about money, but also about communication and the facilitation of relationships between entrepreneurs and potential clients.

Universities as Facilitators

There was substantial discussion of the role universities play as incubators of innovation and entrepreneurship. Ms. Anne Tucker of Georgia State University said that while academia is excellent at developing new ideas and conducting research on new technologies and processes, businesses are often better at identifying new or more efficient uses of existing resources and technologies. She also endorsed a common platform to connect innovators to funding sources, and said she had similar

experiences to Ms. Choi in relying on university back offices to promote innovations and facilitate tech transfer. Ms. Tucker added that because academic researchers face different incentives from entrepreneurs outside the university, the technology transition process is not intuitive for them, and there is insufficient institutional support for tech transfer. Ms. Trimble asked the group how universities could better support their innovators, and Ms. Tucker suggested having dedicated tech transfer experts, either working at a central institution connected with multiple universities or embedded within a university's administration, that could help innovators navigate the process. Dr. Choi saw parallels with this role in her work at Arizona State, and noted a belief among entrepreneurs that university-based startups are not "real" startups. She stressed the importance of increasing visibility and bridging the ecosystems between universities and the wider community to help both kinds of innovators learn from each other and benefit from access to each other's networks and resources. As an example, she described how ASU learned of the importance of dedicated mentors to work with startups, rather than sporadic volunteers who did not build long term relationships with firms, from this cross-pollination.

Dr. Cassidy stated that many university administrators do not believe it is their role to facilitate technology transfer, but only to license it to entrepreneurs from off-campus. However, he said that notion is changing due to changes in how venture capital

operates and new thinking from innovative university leaders. He said it was especially important for universities to lead in tech transfer and startups outside of traditional venture capital hubs like Boston and Silicon Valley. Dr. Blazey added that many universities recognize the importance of tech transfer, but lack the resources to emulate larger universities like MIT or Arizona State in doing so. Dr. Cassidy agreed and added that state governments are now facing increasing pressure on their budgets from health-care, infrastructure, and education costs, and that the federal government may increase again in importance as a facilitator of innovation. Mr. Bates noted the overlap between these issues and the problems discussed by the Council's University Leadership Forum, and that the forum had determined that joint action by university administrations in determining and adopting best practices in promotion and tenure to encourage innovation was key to its success. He also discussed the blending of STEM and the liberal arts to spur innovation, and the importance of having equality between the disciplines. Dr. Terzic noted that this re-imagining of the role of universities was bringing them full circle to the intent of the first land-grant universities in the 19th Century, which was to develop and incubate technology for use by agriculture and industry. Dr. Martin mentioned MIT's global Regional Entrepreneur Acceleration Program, which forces applicants to demonstrate collaboration across academia, industry, government, and funding sources, and said that current economic pressures increased the importance of incentivizing focus in entrepreneurs.

Working Group 3 Calls April 16

Introduction and Stage Setting

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group and introduced the kickoff speaker, Dr. Anthony Margida of TechGrit. Ms. Wince-Smith expressed interest in discussing the use of hedge funds and private equity as a source of capital for entrepreneurship as part of the discussion, and Ms. Trimble added that the priming material in the read-ahead was not meant to constrain the scope of the discussion.

Kickoff Remarks

Dr. Anthony Margida of TechGrit discussed his experiences in both developing innovations as a scientist and in bringing innovations to market through his work at TechGrit and other initiatives in

creating innovation ecosystems for the benefit of cities, communities, and corporations. He discussed in particular his experiences in Ohio, outside of the traditional hotbeds of venture capital and the geographic disparities in the allocation of investment. He noted two consequences of this disparity: some startups relocate to where venture capital firms are based and the local economy loses out on their value creation, or they never get off the ground due to insufficient investment. He argued that corporate accelerator programs have tremendous potential to reduce the risk of startup investment, but that they suffer from misconceptions and beliefs that they actually increase risk rather than mitigate it. Dr. Margida also discussed the industry disparity in venture capital, with tech companies receiving the majority of funding because the initial investment requirements are smaller, and the payoff faster, than in fields like

WORKING GROUP PARTICIPANTS

Dr. Branden Brough
Lawrence Berkeley National Laboratory

Ms. Ann Gabriel
Elsevier

Dr. Robert Kazanjian
Emory University

Dr. Ushma Kriplani
Argonne National Laboratory

Mr. Tad Lipsky
Antonin Scalia Law School

Dr. Anthony Margida
TechGrit

Dr. Cheryl Martin
Harwich Partners

Dr. Sunil Mithas
University of South Florida

Ms. Christina Orsi
University at Buffalo

Dr. Ken Poole
Center for Regional Economic Competitiveness

Mr. Bruce Sommer
University of Illinois Springfield

Dr. Rao Unnava
University of California Davis

Ms. Julie Meier Wright
Collaborative Economics

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Joshua Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

Mr. Gourang Wakade

clean energy, biotechnology, and advanced materials. He also noted that the Small Business Innovation Research (SBIR) program suffered from low success rates in commercializing technology, and that venture capital firms don't view receipt of an SBIR grant as an indicator of viability. He suggested that more could be done with the money invested in the program.

Dr. Margida elaborated on two successful initiatives in Ohio for building innovation ecosystems.

The first, the Ohio Third Frontier program made entrepreneurs-in-residence with extensive experience successfully scaling technologies available to mentor innovators, along with substantial funding for investment. The second, Innovation Fund Northeast Ohio, started at a community college and grants funding to startups at a stage where their capital requirements are too large to rely on family and friends, but not large enough or far along enough to attract the interest of venture capital or angel investors.

Dr. Margida concluded his kickoff remarks with an idea for a technology commercialization virtual marketplace, designed to help startups and small businesses in industries that are national priorities for technological progress. If startups could identify a market and a compelling technical solution to a problem in that market, they would receive both cash investment and access to and alignment with research facilities at a university or national lab. Established corporations would also partner with these startups after going through their own vetting process to ensure their commitment to putting together a package of assets for the startup. These include cash, access to an existing customer base, testing and manufacturing capabilities, and knowledge of commercialization and marketing.

The Small Business Innovation Research (SBIR) Initiative

Dr. Cheryl Martin of Harwich Partners said it was noteworthy that SBIR had a poor reputation among investors given its potential, and that changing these perceptions was a matter of will rather than funding or knowledge. She expressed interest in Dr. Margida's proposal, and asked him if there would be inflection points where investors could require signs of progress or benchmarks for continued support, and what companies would need to prove to secure this support. As an example, she discussed the Cyclotron Road program run by Lawrence Berkeley National Laboratory, which provides "exit points" along with easy origination documents to start the investment. She said that checkpoints and "swim lanes" were important to ensure accountability and focus participants on results, especially results aligned with national priorities.

Ms. Wince-Smith discussed her experience with SBIR during the period of competition with Japan in the late 1980s, and how many firms that received SBIR grants ended up being acquired by foreign companies because venture capital support for them dried up at "Phase 3." She stated the need for an organization to step in and assist these firms when their Phase 1 and Phase 2 funding dried up. Ms. Wince-Smith said it was important not to discard the entire SBIR program due to fixable flaws, especially when other countries have successfully emulated the SBIR model. Dr. Martin argued there needed to be more alignment around what Phase 3 for innovations should consist of, and that once a national consensus was reached it would be possible to direct funding at the state or regional level. Dr. Margida said there would need to be market validation for the value of an innovation at the Phase 1 and Phase 2 levels before any sort of Phase 3 funding was granted. He described how large firms have the ability to abuse their leverage in acquiring innovations from startups that desperately need cash and don't have alternatives in the form of an identified customer base.

Impact of Current Events on Financial Support for Investment Vehicles

Mr. Chad Evans said that private equity firms would likely receive assistance as part of the CARES Act or subsequent economic stimulus packages, as they do not fall under the “venture-backed” designation that was excluded from the first round of assistance. He added that private equity firms have access to the \$600 Billion Main Street Business Lending Program, and that Apollo Global Management has pushed for a \$100 Billion term asset-backed securities loan facility to purchase investment grade securities, especially in mortgage-backed or commercial real estate, to stabilize those markets. Mr. Evans also wondered about the potential for moral hazard in investment into private equity and other investment vehicles that were sitting on over \$1.5 trillion in “dry powder” unused capital. Dr. Julie Meier Wright of Collaborative Economics wondered what the return on investment was for such practices, but also discussed her work helping California’s public pension system fund investments in startups. She cautioned that most pension systems will remain underwater until the economy recovers, but that a small percentage of a very large fund can provide substantial capital to startups without endangering the pension fund investing in it. Dr. Wright also discussed the practice of “skunk works” at large corporations, which are dedicated funds for investing in innovations developed by startups. These aim to circumvent the dampening effects of bureaucracy and risk aversion on innovation at large firms. She wondered what empirical support there was for the efficacy of these ventures, and Mr. Evans linked to several studies and op-eds that demonstrated conflicting views on the practice.

The Role of States

Dr. Ken Poole of the Center for Regional Economic Competitiveness discussed the experiences of states in supporting venture capital through the State Small Business Credit Initiative that was established in response to the 2008 recession and sunset in 2017. He noted that currently, states are facing resource constraints and primarily support startups through “Phase 0” funding, but that the program showed states bring the most value in providing a supporting ecosystem for innovation. This includes public-private equity intermediaries to build innovative capacity outside of traditional startup hotbeds, and in building management and financing expertise among entrepreneurs in these regions. The primary use of public funding is to attract the attention of private capital by showcasing the opportunities for investment in “flyover country.” He also noted that intermediary bodies can draw on public funding for investment while leaving the actual investment decisions in the hands of experienced venture capital investors, who have the capacity to make sound investment decisions and lack incentives to “pick winners and losers.” Dr. Wright noted that the ongoing COVID-19 crisis means states will not be likely to spend money on new programs, and will likely cut existing ones. However, Dr. Poole suggested that future rounds of economic stimulus could include provisions for startup investment that leveraged state equity capital, even with budget cuts. He added that it is rare for states equity programs to rely on annual appropriations; they are generally given initial funding for quasi-public or public-private entities and expected to generate returns to finance continued activity. Dr. Wright emphasized that most capital is in the private sector, and that with states facing constraints due to the crisis and constitutional requirements for balanced budgets, they could leverage their resources to encourage private capital to invest in startups.

Intermediary Organizations and Connecting Ideas with Business Expertise

There was significant discussion about the construction of intermediary organizations and platforms that would connect innovators and ideas with the business expertise needed to turn those innovations into successful products and services. Ms. Christina Orsi of the University at Buffalo identified lack of business expertise as a primary driver of venture capital reluctance to fund university-based startups, and she urged the formation of intermediary bodies that would provide business expertise and mentorship to entrepreneurs while allowing universities to showcase investment opportunities for venture capital. She discussed three such initiatives. The first, the Harrington Discovery Institute, provides funding for the development of therapeutic breakthroughs by physicians and scientists, and helps them secure investment from pharmaceutical firms and venture capital to bring their innovations to scale. While Harrington operates on a national level, the Tri-Institutional Therapeutics Discovery Institute (TDI) provides the same funding and platform for innovators in the New York City area. Both of these investments are funded by philanthropy, but the recently formed Empire Discovery Institute (EDI) is a joint project of the University at Buffalo, the University of Rochester, and the Roswell Park Comprehensive Cancer Center, and received seed funding from the state of New York. In addition to providing seed funding and business expertise, the non-profit EDI is spinning off a for-profit arm that will attract venture capital to co-invest in promising discoveries that could turn into pharmaceutical treatments.

Dr. Rao Unnava of the University of California, Davis, discussed his experiences working with Ohio Third Frontier, and credited it with the emergence of Columbus as a rising center of entrepreneurship and top-ranked city for ease of doing business. He also discussed his experience with the university-startup nexus at UC Davis. He noted that senior faculty with intellectual property they don't know how to leverage,

postdocs facing uncertain academic futures, and MBA students who want to start their own companies but are in the early stages of ideation all benefit from mentoring and expertise. He described how donors funded an institute at UC Davis's graduate School of Management that educates students on the process of innovation and helps them ensure they take the necessary steps to make their ideas viable. He further explained that because donors advised the school that it did not have the resources or expertise to try and spin off startups itself, it should let private venture capital take the lead in helping student innovators bring their products to market. As a result, UC Davis started Venture Catalyst, which helps introduce student entrepreneurs to bankers, lawyers, venture capitalists, angel investors, and other figures with the expertise and financial resources to help them scale their ideas. This program is run out of the school's Office of Research. He concluded by praising similar programs at the University of California, Berkeley, and warned that concerns about nepotism and favoritism should not discourage states and universities from experimenting with ways to steer funding to promising startups.

Dr. Robert Kazanjian of Emory University described Emory's recent partnership with Atlanta-based companies and Emory Healthcare to create a problem-driven innovation center to solve pressing issues in healthcare. He said the initiative was in response to questions about where funding for innovation ecosystems should come from, and that the center creates a nexus where large companies in the healthcare space could make their needs known, and leverage university research and testing facilities to prototype solutions and attract investment. The center would also bring in startups and connect them to healthcare clients interested in investing in their innovations. Dr. Wright discussed the success of the Connect program at the University of California, San Diego, which helps connect university-based startups to the expertise and funding they need. She credited the success of the program to its strong institutional support and the experienced entrepreneur running it.

The Role of Empirical Evidence in Validating Solutions

Dr. Sunil Mithas of the University of South Florida stressed that both governments and private investors will be skeptical of ideas, including platforms and innovation intermediaries, that are not backed by empirical evidence. He noted that much of the support for programs discussed on the call seemed to be anecdotal. Dr. Ann Gabriel of Elsevier described how her company had partnered with the University-Industry Development Partnership (UIDP) in New Jersey to collect data and provide evidence-backed recommendations for investment and collaboration opportunities. She predicted such services would be especially useful to states facing budget constraints as a result of the recession as they became more deliberate about their funding of initiatives. Dr. Margida concurred with the perception of universities as idea generators, and added that the ultimate proof of concept for startups was the successful cultivation of an engaged customer base that is willing to expend efforts to see the startup succeed. He said such validation from potential end users is the ultimate evidence that a startup or idea is viable, and as such is the primary driver of investors' decisions to fund things. He emphasized that the SBIR program was held back by the inability to provide this validation, and suggested that his platform could give startups such an opportunity through partnering them with "qualified corporations."

Other Sources of Innovation Funding

Dr. Unnava asked whether pension funds, especially large public pension funds, could be a source of capital for startups. He noted that private equity firms receive investments from state pension funds, and that this approach allows states to leverage the greater expertise of private equity investors and the relative lack of bureaucracy there to generate higher returns than the pension fund managers could on

their own. He wondered if this model could extend both to venture capital firms and to funding coming directly from states, with the public investor providing funding and earning a return but not making the investment decisions themselves. He acknowledged a risk of moral hazard, but also noted that private equity investors had a strong incentive to pay attention and exercise oversight of pension funds because of their size.

Tax Policy

Dr. Poole asked what role tax policy, especially the Research and Development (R&D) Tax Credit, could play in incentivizing investment in startups. Ms. Wince-Smith also expressed interest in tax provisions, noting that many companies are not in position to make use of the R&D credit, and suggested adjustments to carried interest policies among other vehicles for encouraging investment behavior. She also noted the value countries like Australia, Brazil, and Singapore have derived from sovereign wealth funds. Dr. Wright discussed her work in California developing a tax preference at the state level for investment in "patient capital" at small firms to encourage greater investment in innovative startups. She said that while the credit had sunset, it incentivized greater investment in small firms and long-term projects, and said it was a good idea in principle to have preferential tax treatments for long-term capital investment that could yield disruptive innovation.

Conclusion and Next Steps

Ms. Wince-Smith encouraged the group to translate the discussion and ideas from the day's session into concrete and actionable recommendations, warning them not to lose an opportunity to develop novel solutions by failing to build on discussions. She expressed interest in further exploring the question of idle capital in the hands of hedge funds, pension funds, and private equity, and how it could be used to spur investment in innovation. Ms. Trimble announced that the topics for next week's discussions would be intellectual property, patents, and technology transfer.

Working Group 3 Calls April 21

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group, and Ms. Kathy Trimble introduced the two opening speakers, Dr. Lee Cheatham of Pacific Northwest National Laboratory, and Dr. Lloyd Jacobs, President Emeritus of the University of Toledo.

Framing Questions for the Future of IP and Tech Transfer

Dr. Cheatham identified three considerations for the group in developing recommendations for better IP and tech transfer policy, drawing on his experiences in academia, industry, and the national laboratories. First, there has been a significant shift toward digital technology, and even hardware has built-in software components. He identified a mismatch between

current intellectual property law and this reality, as hardware is still governed by patents, but software is governed by copyright. This discrepancy creates challenges for commercializing digital research, especially when software is developed in conjunction with government research or funding and requires government approval to obtain even copyright protections. Second, there are many stakeholders involved in the intellectual property and commercialization process, including universities, labs, industry, the government, and regulators. To expand the quality and quantity of ideas and technologies that emerge out of the innovation ecosystem, coordinated action by these groups will be essential and no single player can advance major changes. Dr. Cheatham encouraged the group to contemplate new kinds of organizations that act as intermediaries between different stakeholders and focus on transitioning ideas

WORKING GROUP PARTICIPANTS

Dr. Gerald Blazey
Northern Illinois University

Ms. Rachel Jagoda Brunette
Lemelson Foundation

Mr. Jim Carlisle
Bank of America

Dr. Russell Carrington
Lawrence Berkeley National Laboratory

Dr. Lee Cheatham
Pacific Northwest National Laboratory

Mr. William Eggers
Deloitte

Dr. Lloyd Jacobs
University of Toledo
(Emeritus)

Mr. Tad Lipsky
Antonin Scalia Law School

Ms. Vickie Lonker
Verizon

Mr. Greg Pellegrino
Deloitte

Mr. Bruce Sommer
University of Illinois
Springfield

Ms. Julie Meier Wright
Collaborative Economics

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Joshua Oswalt

Mr. Tim Planert

Ms. Carol Ann Meares

and technology from one stakeholder to another as they mature. Finally, Dr. Cheatham discussed how the nature of commerce is changing, and warned against matching technology to an outdated model of commerce. Discussing the supply chain disruption caused by the COVID-19 pandemic, as well as the emergence of new competitive threats, he called for new norms and requirements for sharing intellectual property and basic research. He also identified institutional barriers that obstruct prompt action in response to crises, like a lack of indemnification for private sector organizations with innovative responses to the pandemic that prevents them from advancing their ideas. He suggested that the group visualize the future of business and use this vision as a guide for developing new regulations and standards.

Universities and Commercialization

Dr. Jacobs emphasized the centrality of university culture and incentives to the question of technology transfer and intellectual property. He stated that universities by and large do not have commercialization or tech transfer “in their DNA” and find it incompatible with their cultural identity. However, financial stresses on universities, as well as changes in the education landscape due to the rise of online learning and the digitization of the knowledge base, will force many institutions to consider greater engagement with industry. Dr. Jacobs noted that a gulf persists between academia and corporate America, which he said has also shied away from investment in the academic world. He cited medical schools, which embed multi-billion dollar institutions within a university, as a model for university-industry interface, and discussed the challenges in encouraging a mindset shift within academia. Universities tend to be risk averse, and faculty enter academia for “the contemplative life” rather than the commercial world. Nevertheless, Dr. Jacobs called for universities to embrace globalization and digitization, while acknowledging that these transitions will be particularly difficult for older generations.

Changing Institutional Incentives

Ms. Carol Ann Meares of TechVision 21 stressed the difficulties in changing organizational cultures due to the rules, procedures, personnel practices, and incentive structures that develop in response to existing norms. These structures are linked to each other, and many institutions simply fold when confronted with significant disruption because they are unable to adapt. She asked if the country needed to fund new kinds of research and development bodies in which to instantiate these changed norms. Dr. Jerry Blazey of Northern Illinois University suggested providing funds to universities to help them change their cultures. He said cultures at academic institutions do not change by fiat because of deeply ingrained incentive structures, and suggested adopting a model successfully used by institutions to increase their student and faculty diversity for enhancing universities’ capacity to transfer technology and commercialize knowledge. This method involves funding a self-study by the university that allows it to identify the specific changes it needs to make, and providing additional funding to enable it to enact those reforms. Dr. Blazey and Ms. Wince-Smith both noted that universities currently face incentives to create new knowledge, but not to commercialize it, and Dr. Jacobs stated that successful technology transfer does not naturally “trickle down” to laboratories and academic departments and change the culture.

Mr. Bill Bates discussed the Council’s work with the University Leadership Forum, comprised of more than 40 presidents and chancellors of universities. He described university leaders’ receptiveness to changing academics’ incentives via adjusting the tenure and promotion process to encourage greater transfer of innovation rather than simply publishing research. However, he also reported a consensus that many universities would have to implement these changes at the same time to alter norms, rather than adopt a piecemeal approach.

Adjusting Patent Laws

Ms. Vickie Lonker of Verizon identified several ways to improve existing patent laws. She described industry's view of universities as being motivated to develop patent war chests and fight commercialization of their discoveries and called for the leveraging of university capabilities to help develop business. She advocated new legislation that would not grant windfalls in the form of royalties or damages to patent holders who did not advance their research into products or allow others to do so, and for Congress to reassess patent damage policy and other incentives for patent holders to "get rich quick" via lawsuits rather than through socially beneficial commercialization. Finally, she called for more flexible patent laws, noting that different industries had different time horizons from innovation to product launch. Adjusting patent length and terms by industry would encourage maximal innovation and successful commercialization over the current system that makes no distinction between products as diverse as pharmaceuticals and software.

Co-Development and Facilitating Collaboration

Dr. Cheatham touted co-development of technologies by universities, government, and industry as a promising method of accelerating knowledge commercialization. Getting input from industry helps researchers develop innovations with commercial applicability and appeal, and collaboration on goals

provides a road map for the innovation process and the deployment of resources. He also reiterated the importance of updating the IP system to account for the digital world, and better match IP laws to market and community needs. Ms. Trimble discussed the call from the Developing and Deploying at Scale Disruptive Technologies Working Group at the January Launch Conference at Arizona State for "boilerplate" technology transfer agreements. She asked if the group should further pursue this idea, which would expedite IP negotiations and facilitate more collaboration between universities and industry, accelerating the commercialization of knowledge.

Strengths of the Current IP System

Mr. Tad Lipsky of Lathan and Watkins, LLP characterized the IP challenges facing innovators as "second order" compared to the hostility antitrust regulators displayed toward intellectual property in the 1970s. He particularly praised the reforms from the 1970s through the 1990s that expanded IP protection and facilitated commercialization, including the Bayh-Dole Act, the creation of circuit courts for patents, and the criminalization of trademark theft. He also stressed the importance of regulators recognizing the mutualistic symbiosis between IP and antitrust law, and praised current Department of Justice practices in adjudicating antitrust cases. Mr. Lipsky did identify current challenges in the IP world, including the need to discourage presumption of antitrust violations when members of standards-setting bodies for technologies have interests

in licensing a technology, urging the use of contracts between innovators and standards-setting bodies to resolve disputes. He also discussed problems with antitrust settlements under the Hatch-Waxman Act, which make pharmaceutical antitrust litigation much more difficult to resolve. Dr. Cheatham agreed that the U.S. IP system was overall in good shape, but called attention to issues surrounding the IP space. He described the importance of long-term energy storage for future energy innovation, and how it would be beneficial from economic and national security standpoints to secure U.S. leadership in this area. However, most of the expertise and research on energy storage comes from abroad, which presents challenges to the development and protection of American intellectual property in this sector.

Future Cross-Pollination Opportunities and Closing Charge

Ms. Trimble discussed the potential for cross-cutting discussions on these topics involving members of Working Group 1 and Working Group 3, with a view to fleshing out ideas and turning them into recommendations. Mr. Evans discussed the Council's previous work in conjunction with IBM on intellectual property and technology transfer, and said he would make it available on the online portal. Ms. Wince-Smith issued a dual challenge to the group: to make modifications to the IP system that don't eliminate its strengths while also seeking bold transformation of the innovation landscape, in light of the Commissioners' charge to the working groups. She called for

recommendations for industry as well as academia and government, and urged them to consider the implications of the rapid reorientation of universities toward the digital world in the wake of the COVID-19 pandemic. Ms. Wince-Smith further emphasized the need to rein in firms that use intellectual property claims to dominate markets and keep out new entrants, and of secure IP rights to entice venture capital investment in innovations. She warned that the current rate, scale, and scope of innovation are insufficient to withstand challenges from U.S. competitors, especially China.

Mr. Evans asked the group to consider some additional key data related to the day's conversation. In particular, he encouraged participants to revisit some of the National Commission's early concept papers, the 2018 "Clarion Call" and primers—with a mind toward thinking how recommendations from this group might help meet some of the overarching challenges posed by the National Commissioners, like: how can the United States increase its innovation capacity ten-fold? Mr. Evans noted—reflecting on the day's WG conversation around tech transfer, better engagement/partnerships between industry and universities, etc.—that despite an improved industry-university relationship, corporations still currently invest less than 1 percent of their R&D investment into university research. Why is that? Are there factors or barriers contributing to this amenable for policy prescription?

Working Group 3 Calls April 23

Introduction

Ms. Kathy Trimble welcomed the group and framed the discussion, bringing up issues of intellectual property, patents, and technology transfer. Mr. Bill Bates emphasized the growing relevance of the Working Group's discussions to current events and the concerns of the business, academic, and policy communities. Ms. Trimble introduced the two opening speakers, Dr. Lloyd Jacobs, President Emeritus of the University of Toledo, and Dr. Lee Cheatham of Pacific Northwest National Laboratory.

Tech Transfer and University “DNA”

Dr. Jacobs characterized the central problem of university tech transfer as one of academic culture. He said universities don't have a drive to commercialize and transfer innovations as part of their “intrinsic

culture” or “DNA”, and view the “life of the mind” as taking precedence over knowledge commercialization. As a result, it is difficult to make substantive progress on technology transfer until the academic world undergoes a cultural shift. He added that fiscal pressures of universities, which have been growing for decades, have accelerated in the wake of the COVID-19 crisis, changing public attitudes about the value of higher education, and declining enrollment by American high school graduates in traditional four-year colleges. Dr. Jacobs identified technology transfer programs as especially vulnerable to budget cuts due to universities seeking to address short-term fiscal shortfall and their belief that such activities are secondary to their primary purposes. Yet another obstacle Dr. Jacobs identified was the need for both academia and industry to focus resources on repairing disruptions to supply chains, human cap-

WORKING GROUP PARTICIPANTS

Ms. Rachel Jagoda Brunette
Lemelson Foundation

Dr. Lee Cheatham
Pacific Northwest National
Laboratory

Ms. Ji Mi Choi
Arizona State University

Mr. Thomas Dailey
Dailey Strategic Advisors LLC

Ms. Ann Gabriel
Elsevier

Dr. Lloyd Jacobs
University of Toledo
(Emeritus)

Dr. Robert Kazanjian
Emory University

Dr. Anthony Margida
TechGrit

Dr. Cheryl Martin
Harwich Partners

The Honorable Branko Terzic
Berkeley Research Group

Dr. Rao Unnava
University of California
Davis

The Honorable Olin
Wethington
Wethington International LLC

COUNCIL STAFF

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Joshua Oswalt

Mr. Tim Planert

Mr. Gourang Wakade

Ms. Carol Ann Meares

ital networks, and relationships that were interrupted by the pandemic and economic crash, which he predicted would take precedence over shifting university attitudes toward commercialization.

Dr. Jacobs also talked about the road forward to greater academic embrace of tech transfer. He described academic culture as risk-averse and noted that simply setting up offices for technology transfer would not “trickle down” into the broader university culture. He identified university-affiliated hospitals as a model for academic-commercial integration, as they are highly valuable commercial entities embedded within university medical schools. He also urged action from multiple stakeholders, including government organizations, academic organizations like the APLU, individual universities, and groups like the Council, to encourage a culture change in academia. He stressed that the globalization of knowledge will make it more difficult for innovators to capture all the benefits of their ideas, and called for greater willingness on the part of industry to become involved in the academic space.

The Shifting Nature of Tech Transfer and the Global Marketplace

Dr. Cheatham identified three trends and obstacles for the group to consider regarding intellectual property and knowledge commercialization. First, he outlined the increasing importance of digital technology and the embedding of data, software, and computing in nearly all research and experimentation. However, “hardware”, or physical technology innovations, are governed by a patent system, while software is governed by copyright, and this asymmetry in IP policy makes it more difficult to usher innovations incorporating digital technology into the marketplace.

Second, Dr. Cheatham described the large number of stakeholders that are involved in different stages of knowledge commercialization, including universities, national laboratories, companies, investors, intermediary organizations, and regulators and government officials. He stressed the importance of increasing

the quality and quantity of ideas that make it from the lab to the market, and he called on stakeholders to work together to expedite this process. Dr. Cheatham suggested making “handoffs” from one stakeholder to another transparent and simple, clarifying expectations and roles, and incorporating bidirectional feedback. He also stressed the need to inform innovators, whether entrepreneurs or academics, of the market value of their ideas, to align their incentives and refine their knowledge. He suggested developing organizations that could help stakeholders coordinate these activities.

Finally, Dr. Cheatham emphasized how dramatically the economic landscape has changed in recent years, and how the current crisis has exposed weaknesses in America’s supply chains, as well as legal and regulatory barriers to innovation and resiliency. He noted the difficulty of research organizations in deploying innovations to address COVID-19 because of a lack of indemnification and a liability regime that is not well-suited to rapid response to crises. While acknowledging the importance of these protections, Dr. Cheatham called for greater flexibility, and urged the group to visualize the future of the economy before developing solutions, lest it design an obsolete set of recommendations.

Spurring Industry Investment in Universities

Mr. Chad Evans noted that companies spend at most 1 percent of the R&D budget on partnerships with or investments in universities. He asked why that was, and if this lack of involvement impacted universities’ attitudes toward tech transfer. He referenced the CRISPR gene-editing technology as an analogy for changing “institutional DNA” and making universities more enticing to industry, which could potentially affect the technology transfer experience. Dr. Rao Unnava of the University of California, Davis added that such partnership, coupled with a share in returns to investment in knowledge commercialization for industry, might dramatically alter incentives and multiply America’s global technology leadership.

Foreign Governments and Technology Transfer

Dr. Unnava discussed the problem of foreign governments, especially China, requiring innovative American companies to transfer their technology to access their markets, giving them the ability to copy American innovations and build competing firms that capture the value generated by American ideas. He suggested developing a partnership framework in which American companies agree to share their revenues with foreign governments earned in those markets rather than transferring their technology.

Ms. Trimble noted that existing technology transfer frameworks are better suited to hardware than software, and discussed the government's challenges in developing innovative tech transfer models. She suggested that different sectors might require bespoke public-private partnership models to optimize tech transfer, and added that foreign markets add complexity because of the involvement of more government actors, like the State Department. Ms. Trimble also concurred with Dr. Unnava's concern with protecting American IP even as innovations are scaled and brought to global markets.

Dr. Jacobs said that this issue was one of the most important facing the country. He said that building supply chains requires cooperation, and that the U.S. government has officials taking positions that are worrying for advocates of robust global competition. He noted the tension and tradeoffs between cooperation and competition in the international space, and said the COVID-19 crisis and economic downturn would accelerate the importance of the issue. Dr. Jacobs also praised Mr. Evans and the Council's previous initiatives in the international arena around cooperation and competition, and said they were highly relevant to the group's discussions.

International Supply Chains and International Students

The Honorable Deborah L. Wince-Smith discussed several interconnected challenges facing universities regarding international students. She noted that universities had more autonomy than national labs in developing strategic partnerships and licensing technologies, and that this resulted in a global network for education and academic research. She also underscored the importance of enabling capital to build production facilities and incorporate them into supply chains, and the manner in which the current crisis is realigning America's trusted partners for key components of its supply chains. Ms. Wince-Smith discussed the national security implications of American universities' reliance on Chinese graduate students and researchers in light of the Communist Party of China's directive to students abroad to gather intelligence during their studies, and of the growing licensure of American university technology to Chinese investors because of their willingness to provide substantive funding. She contrasted the significant Chinese graduate student population with the difficulty students in other countries, like Brazil, have in securing opportunities at American institutions, and urged universities to examine their supply chains along with corporations. Similarly, she discussed the importance of expanding access to the university innovation ecosystem across American society, both geographically and demographically, to generate inclusive prosperity. She discussed the mandate from the Commissioners to move innovation beyond "pockets" of the country.

Innovation as an Output

Dr. Jacobs argued that universities, and American society as a whole, should view innovation as a product or output with its own supply chain. He said that the innovation supply chain required an understanding of the human capital involved in creation of the product and the relationships between different

actors. He urged greater analysis of the vulnerabilities of this supply chain, and how more fine-tuned supply chains were more vulnerable to disruption. As an example, he cited the challenges faced by universities that had come to depend on foreign graduate students for tuition revenue and research capacity, a result of their attempting to economize on “inputs.” He drew further parallels between the dangers of America’s antibiotic supply chain relying on China and security threats in its innovation supply chain. He stressed the importance of keeping all of America’s innovation supply chain under American control.

University Cultural Shifts

Dr. Robert Kazanjian of Emory University agreed with Dr. Jacobs’ characterization of academic culture, but described a gradual shift in the outlook of younger faculty regarding commercialization, including an expectation that they will have outlets for bringing the products of their research to market. He said this observation had made Emory introspective about academic culture, and noted that every university possesses different strengths and opportunities for technology transfer. While Emory does not have an engineering school, it has significant innovative capabilities in healthcare, drug development, medical device development, and public health, and generates lots of intellectual property in those areas. However, the school struggles to move those innovations to market and is seeking partnerships with industry and other organizations in the Atlanta area to accelerate tech transfer. Dr. Kazanjian also discussed the disconnect between faculty who are intrinsically motivated by intellectual property and those who are not, and the need to provide greater incentives for the latter group. He said that currently patent revenues are split evenly between the university’s general budget, the researcher’s department budget, and the researcher themselves. He added that the school was working on identifying other funding sources,

both public and private, to help move its technology into the marketplace. Dr. Jacobs echoed Dr. Kazanjian’s statement about a cultural shift, noting that millennials in academia were more receptive to this new mindset than older generations.

The Importance of Industry Feedback

Dr. Branko Terzic of Berkeley Research Group discussed his personal experience with the value of industry and end-user feedback for innovators. From 1996 to 2006, he served on an advisory committee of utility and electricity company executives organized by Battelle corporation, where the company showcased technologies developed by its affiliated national laboratories and asked for feedback on industry applications. Dr. Terzic described how industry input enabled the commercialization of many of these technologies because industry members from “outside” fields saw greater potential for innovations in their sector than for the technology’s intended application. Although the program was eventually discontinued, Dr. Terzic said it accelerated the commercialization of technology, and that developing similar opportunities for feedback from potential customers could help innovators attract the investment needed to commercialize their intellectual property.

Lessons from Arizona State’s Technology Transfer

Ms. Ji Mi Choi of Arizona State University discussed the school’s success in, and lessons learned from, its technology transfer programs. She emphasized the importance of commitment from university leadership and alignment of incentives for faculty. Since faculty are traditionally motivated by teaching awards, academic publication, and research grants, incorporation of technology transfer and innovation into promotion and tenure decisions are crucial for aligning incentives, as is removing penalties for emphasizing tech

transfer over other academic and research activities. She also spoke of the importance of ASU's building bridges with the broader entrepreneurial ecosystem off campus, enabling both groups to impact each other and exchange knowledge. Such collaboration also provides far greater funding for technology scaling and commercialization efforts than the university could possibly achieve on its own. She also noted the role student desire for entrepreneurial opportunities has played in catalyzing cultural change, but cautioned that ASU still faced obstacles. These include the structure of programs like the Small Business Innovation Research (SBIR) initiative, which prevents students or faculty involved in startups spun-off from university research from being eligible for university health insurance and other benefits. Students also face pressure to obtain an immediate return on investment for their degrees rather than taking the risk of founding a startup, and professors often reach promotion and tenure milestones before an investment in knowledge commercialization has had time to pay off.

Tracking and Evaluating Technology Transfer in Academia

Dr. Kazanjian also described student demand for entrepreneurial opportunities at Emory, and noted that school provides incubators and institutional support even though students retain all the proceeds from their ideas. Ms. Choi noted that at

ASU, student-founded startups are more numerous than university-owned startups, and that there is no established metric for schools' entrepreneurial output. Existing attempts either rely on schools' reported data from degree programs, which excludes student startups in fields outside their major, or on tracking the alma maters of startup founders and investors, which includes companies founded without any institutional support from the founder's school. Dr. Kazanjian called for universities to begin comprehensively tracking the number of startups founded by students with university support, but acknowledged that different schools would likely use different metrics that complicate direct comparisons.

Concluding Thoughts

Ms. Wince-Smith thanked the participants for their discussion, and announced that next week's calls would focus on attracting patient, long-term capital to finance innovation, especially from outside the venture capital world. She noted that the United States is at a disadvantage in this arena relative to countries with sovereign wealth funds, and noted that the Export-Import Bank of the United States is unable to provide long-term financing for domestic infrastructure projects.

Working Group 3 Calls April 28

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the featured speaker, Mr. Olin Wethington of Wethington International LLC. Ms. Kathy Trimble framed the discussion, centered around U.S.-China competition, with a comparison of the strategies in the game of chess and the Chinese game of Go, which is based on encircling the opponent until they exhaust their resources. She emphasized that the U.S.-China relationship is centered around strategy and the contest for power.

Framing the Discussion

Mr. Wethington opened by noting the United States faces unprecedented challenges to the post-WWII global order it leads, surpassing even the threats from the Cold War and terrorism, as those were

primarily security threats, not challenges to American economic or soft power. He said that China has an innovation ecosystem and value system that is incompatible with those of the United States and its allies, and that it wants to export these systems around the globe, using its financial resources to write the rules for a new technology-based and infrastructure-connected order. He charged the group to design policy recommendations with China in mind and to ensure that the future of innovation remains in the United States. Mr. Wethington called the preservation of the liberal, democratic, market-based order crucial, and said that while it has advantages in population, wealth, geography, cultural power, and popularity, it lacks political willpower and strategic plans for concerted effort. He called for much greater leveraging of America's allies and channeling of influence through institutions to ensure the rules

WORKING GROUP PARTICIPANTS

Dr. Robert Bishop
University of South Florida

Ms. Rachel Jagoda Brunette
Lemelson Foundation

Mr. Jim Carlisle
Bank of America

Mr. Mike Cassidy
Emory Biomedical Catalyst

Dr. Lee Cheatham
Pacific Northwest National Laboratory

Mr. Thomas Dailey
Dailey Strategic Advisors LLC

Ms. Vickie Lonker
Verizon

Dr. Cheryl Martin
Harwich Partners

Dr. Irene Qualters
Los Alamos National Laboratory

Ms. Anne Tucker
Georgia State University

Dr. Rao Unnava
University of California Davis

The Honorable Olin Wethington
Wethington International LLC

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Joshua Oswald

Mr. Tim Planert

Ms. Carol Ann Meares

of the global economic and geopolitical order reflect American interests and values. He identified five major areas for policy recommendations regarding competition with China: infrastructure, international institutions, standards setting, trade and intellectual property, and multilateralism.

Infrastructure and Connectivity

Mr. Wethington characterized China's "Belt and Road Initiative" as a competitiveness challenge of the highest order. He said it is tied to China's tech development policies, and that China openly speaks of a "digital silk road" and a "maritime silk road." China is striving for a world of connectivity and easy money backed by Chinese investment in infrastructure abroad, and wants to shift the global economic environment away from current international norms and practices to Chinese norms. Mr. Wethington warned there was a dark side for countries that accept Chinese financing for infrastructure development, including a degrading of rules and standards, unsustainable debt, lack of transparency in financing, procurement, and regulation, and geopolitical threats. Chinese investments amount to a staggering \$500-600 billion across 130 different countries, and control of infrastructure, especially in developing countries, is central to China's geopolitical strategies.

In response, Mr. Wethington urged the United States to develop an infrastructure agenda that is framed around American strengths, values, and interests. He called for coordinating and harmonizing activities with our allies, and said such a strategy would not require large new budgetary outlays. He urged a combination of bilateral and multilateral approaches, including revitalizing multilateral development banks, and mobilizing their resources and the resources of private companies to invest in infrastructure projects around the world. In particular, he suggested the United States develop means to co-invest, de-risk, and provide technical assistance to make large infrastructure investments worthwhile to private finance. Mr. Wethington also advocated using groups like the

G7 and G20 to pursue negotiations and develop standards for international lending. He noted the United States' past success in creating new standards for international investment, and that many countries, not just the United States, are threatened by China's attempted dominance of global infrastructure.

International Institutions Impacting Competitiveness

Mr. Wethington discussed China's desire for an active role in international governance, and its desire to shape the norms and values of the UN and other international bodies. He pointed out that four out of fifteen UN organizations are led by China, and that Chinese officials occupy senior positions in other international bodies, especially those concerning innovation and competitiveness. China uses its place in these organizations to seek endorsements of its role and of the Belt and Road Initiative, and has signed more than 25 memoranda of understanding securing partnerships and coalitions to achieve its economic and geopolitical objectives. Mr. Wethington warned that the United States cannot leave a void in these institutions, and that the United States must especially increase its engagement in institutions with effects on innovation and competitiveness. He further emphasized the importance of a larger U.S. role in the standards-setting process through common action with like-minded countries, better use of existing institutions, and more effective diplomacy with respect to personnel.

Standards Setting

Mr. Wethington called for greater linkage between industry and government in the standards-setting process for new technologies. He said such proactive participation was essential to counter well-funded Chinese attempts to influence global standards, and he warned again of the dangers of a personnel vacuum in international diplomacy.

Trade and Intellectual Property Protection

Mr. Wethington stressed the United States must continue to endorse the liberal, open market order, and domestically must reinforce the bipartisan consensus emerging around the importance of reciprocity in trade policy. He said the United States must use trade policy to protect American firms from anticompetitive Chinese practices and alter China's behavior, as well as shield American interests from the impacts of some of these sanctions. Mr. Wethington urged penalties and sanctions for foreign actors engaged in theft of intellectual property, and said he expected such punitive actions, which have increased in recent years, to continue increasing.

Multilateralism

Finally, Mr. Wethington urged the United States to bring together a coalition of like-minded countries and use their collective leverage to establish new arrangements around emerging technologies. He called for an emphasis on economic statecraft, and for securing bipartisan support for defensive actions to prevent adverse technology transfer. While acknowledging that limiting the damage from Chinese technology acquisition was more feasible than stopping it, he strongly urged protections against the transfer or acquisition of critical technologies and limits on foreign acquisitions of companies possessing critical technologies. Mr. Wethington also urged the broadening of the definition of critical technologies in concert with America's allies, especially biotechnology. He said that a multilateral regime will be more effective in controlling the leakage of critical technology than a unilateral one.

De-globalization and Decoupling

Mr. Chad Evans noted that U.S. tech companies derive over \$100 billion in annual revenue from China, accounting for nearly 25 percent of their total revenue, and asked how decoupling would impact America's short-, medium-, and long-term

competitiveness given the benefits many companies reap from the status quo. Similarly, Mr. Tom Dailey, formerly of Verizon, asked about "forking" of supply chains for critical technology, such as 5G. Mr. Wethington predicted that companies would begin decoupling of their own volition due to changes in market dynamics, as the factors that impelled American firms to locate in China in the first place are shifting. He noted that China is pursuing indigenous technological development in many of the same spaces as U.S. tech companies, and that they have been decoupling and engaging in industrial policy for quite some time, a process to which American firms are now waking up. He did not think the United States would be able to seriously challenge China's growing economic strength, but that the United States could manage it through carefully crafted policies that minimize the damage to American firms stemming from changes in supply chains. Mr. Wethington particularly urged sanctions and encouragement or requirement of relocation for U.S. supply chains in cases where China engages in theft of IP or forced technology transfer. To reduce the economic damage to American firms from such sanctions, he suggested creating a transition window to give them time to identify alternative supply chains. He also warned that in many technologies China possesses significant market power to shape standards and norms, and that the United States must counter this through collaboration between government and industry.

The WTO and Other Multilateral Organizations

Ms. Wince-Smith asked what opportunities there were in revitalizing the World Trade Organization as a vehicle for advancing U.S. economic interests. Mr. Wethington noted that the WTO has thrived on other countries deciding that preserving the U.S.-led economic order is important, and said that joining with our allies to manage these institutions and establish their values is key to U.S. competitiveness. He said that while the WTO has shortcomings, the alternative is chaos and fragmentation, and stressed that

it would require hard diplomatic work to reestablish the importance of the WTO and push its multilateral capacity into new arenas.

Mr. Wethington continued, saying that the Trans-Pacific Partnership would have provided a substantial opportunity for enhancing American soft power in East Asia, and reminding the group that the United States retains significant influence around the world, including in Europe and Japan, which along with the United States dominate global financial institutions and multilateral development banks. However, with China deploying massive financial resources around the world, the lack of an American counter has created a vacuum in this space. He emphasized again that the American response would require multilateral action with our allies.

Mr. Dailey noted the U.S. retreat from international fora and its reduction in funding of the State Department, which feared left a gap in standards setting bodies that China was exploiting and using to expand its Belt and Road Initiative. Dr. Rao Unnava of the University of California, Davis noted that only a handful of countries can afford major infrastructure and technology investments, and asked if the United States should split countries into groups when it came to bilateral or multilateral agreements and protection of critical technology, as common rules would not work for everyone. He suggested that it may be beneficial to have rules encouraging greater openness to developing countries, helping them develop, and stronger scrutiny of investments from countries like China.

Academia and China

Dr. Robert Bishop of the University of South Florida asked how academia should address its interactions with Chinese academia and industry. Mr. Wethington noted that the United States has benefited from openness in its academic system, but that going forward it should define criteria for how collaboration takes place. He said there was benefit in exposing Chinese students and researchers to American thinking in the humanities and social sciences, as well as the general culture of academic independence. However, there should be limitations on access to critical technology and the basic research that undergirds it. He added that the United States must not be naïve about the Chinese government's attempts to control, influence, and direct Chinese student populations on American campuses, and that the United States must act to prevent malign activity by the Chinese government that damages academic freedom and U.S. interests. Finally, Mr. Wethington suggested establishing a pattern of reciprocity regarding Chinese access to American institutions of higher education, noting that China restricts foreign students' ability to study science and technology in China, and he called for publicizing and highlighting China's restrictions of academic freedom- domestically and abroad- to the United States and international community.

U.S. Investment in Key Technology

Mr. Evans asked about U.S. investment in key technology. He noted that for advanced microelectronics, the only manufacturers of the leading edge 7nm fabs are Samsung (in South Korea), TSMC (in Taiwan), and Intel. This is a decline from the 8 leading edge manufacturers ten years ago, and means that two of the three remaining players are within striking distance of China. He noted that loss of U.S. leadership in advanced microelectronics was an existential threat, and that the cost of a single fab facility could be more than double the annual budget of the National Science Foundation. He asked what the U.S. innovation ecosystem looked like in fields where large-scale, long-term investments were needed, and if the United States could afford to “go it alone” in these endeavors, especially those that require supplies of advanced and rare materials. Finally, he asked how to unleash the capital that is sitting in hedge funds, private equity, and other non-venture capital sources in service of these investments.

Mr. Wethington responded that capital will go where it sees returns and low risks, and said it would be important for the government to de-risk investment for technologies with key health, safety, and national security implications. He called for policy makers to be more receptive about underwriting the risks of long-term capital, and toward developing incentives and regulatory regimes that encourage this investment. Dr. Cheryl Martin of Harwich Partners said it

was important to identify how government actions in support of investments impacted firms' perception of risks, through basic research support, the creation of consortia, or other methods. She also cautioned that while some of those risks could be identified and reduced, others would remain unknown. Finally, she noted that other countries, including Japan and South Korea, were looking at the same kinds of investment decisions, and how the U.S. government addresses these challenges will interact with how other countries make decisions about underwriting risks, and vice-versa.

Concluding Thoughts

Mr. Wethington said that he hoped the group would take the ideas and policy proposals discussed today and deepen them, and Mr. Evans underscored the importance of public-private partnerships in addressing strategic challenges. He also encouraged the framing of the “societal burden” of de-risking long term investment as one of societal opportunity to secure American leadership in critical advanced technologies.

Working Group 3 Calls April 30

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the opening speaker, Mr. Olin Wethington of Wethington International, LLC. She discussed his experience in the Departments of Commerce and the Treasury, the White House, international trade law, and private business experience. Mr. Chad Evans said he was interested in hearing thoughts on the U.S.-China relationship, especially those pertaining to decoupling and supply chains, U.S. regulatory policy, and maintaining American leadership in global institutions. Ms. Kathy Trimble framed the U.S.-China relationship in the context of two popular strategy games: chess for the United States, and Go, a long-term game based on encirclement, for China.

Framing Remarks

Mr. Wethington opened by noting that the U.S.-led post-World War II international order faces unprecedented challenges from China's rise. While previous threats, including the Soviet Union and terrorism, were primarily of a military and security nature, the challenge presented by China is across the board, encompassing economics, security, values, and international leadership. He said that China has a distinctive approach that is not compatible with or hospitable to U.S. norms and values, and that it wishes to export these values around the world. Given China's desire to write the rules for new technologies and its aggressive use of infrastructure investment to further geostrategic aims, Mr. Wethington suggested policy responses in five areas: international infrastructure development, international institutions,

WORKING GROUP PARTICIPANTS

Dr. Gerald Blazey
Northern Illinois University

Dr. Branden Brough
Lawrence Berkeley National
Laboratory

Ms. Rachel Jagoda Brunette
Lemelson Foundation

Ms. Ji Mi Choi
Arizona State University

Mr. Tad Lipsky
Antonin Scalia Law School

Dr. Anthony Margida
TechGrit

Dr. Sunil Mithas
University of South Florida

Ms. Christina Orsi
University at Buffalo

Mr. Greg Pellegrino
Deloitte

Dr. Ken Poole
Center for Regional Economic
Competitiveness

The Honorable Branko Terzic
Berkeley Research Group

The Honorable Olin
Wethington
Wethington International LLC

Ms. Julie Meier Wright
Collaborative Economics

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Ms. Yasmin Hilpert

Mr. Joshua Oswalt

Mr. Tim Planert

Mr. Gourang Wakade

global standards setting, trade policy, and intellectual property protection. He stressed that the United States must act bilaterally and multilaterally with its allies to sustain the liberal, democratic, market-based international order. He further emphasized that while this order has advantages in population, geography, financing, and institutions, it lacks the will power, functioning political processes, clear priorities, and commitment to multilateral action it needs. Mr. Wethington described multilateral processes that channel U.S. influence through institutions reflecting American interests and values as crucial to efforts to maintain global leadership.

Infrastructure Investment

Mr. Wethington discussed China's Belt and Road Initiative, begun in 2013, at length. The Chinese government has invested over \$500 billion in over 140 countries, many of them developing countries, for infrastructure development. This investment is designed to create a new era of connectivity and easy money for China, part of a "digital silk road" that will give them influence on rules, standards, and norms in partnering countries, as part of a strategy to shift global norms and institutions away from American interests and toward their own. Many of these infrastructure projects violate international standards governing procurement, financing, debt sustainability, and regulatory transparency, and provide China with substantial leverage over developing countries, for whom infrastructure development is a top political and economic priority.

In response, Mr. Wethington said the United States should lead a multilateral effort rooted in American strengths and interests. He urged combining unilateral, bilateral, and multilateral actions, and noted progress on this front in recent years. The Export-Import Bank of the United States has been given authority to match China's export financing terms for projects, and the U.S. government recently created the International Development Finance Corporation. Mr. Wethington also noted that multilateral development banks are controlled by the United States and

its allies, and possess significant capital for infrastructure investment. He called for a concerted effort to mobilize these resources, along with providing technical support, to invest in infrastructure projects in developing countries. In particular, Mr. Wethington urged the clear adoption of standards around financing, procurement, and regulatory transparency that reflect the values of the United States and its allies. He also cited the actions of the G20, while chaired by Japanese Prime Minister Shinzo Abe, as a precedent for using existing platforms to reinforce current norms around financing and investment in international markets.

International Institutions

Another prong of China's strategy for influence is through the appointing of Chinese officials to lead specialized UN agencies, where four out of fifteen are led by China, and there are Chinese officials in high-ranking offices in many others. China uses personnel placement to steer international organizations and revise norms of global governance, as well as to seek endorsement for initiatives like Belt and Road. Through over two dozen memoranda of understanding with different agencies and governments, China is leveraging deft coalition building to steer the international institution system toward the promulgation of illiberal values. Mr. Wethington warned that the United States cannot cede ground to China in this space, and must prioritize magnifying its influence in international institutions. He urged the United States to engage in the same personnel placement strategy, affirmatively put forward its own interests, and insist on transparency and independent outside oversight of the decisions of all international institutions. He also suggested using America's financial leverage when appropriate to tie funding to specific policies. Mr. Wethington concluded his discussion of international institutions with two contrasting examples in recent months. On the success side, U.S. diplomacy prevented a Chinese-backed candidate from being chosen to head the World Intellectual Property Organization. On the challenge side, Chinese influence has been evident in the response of the World Health Organization to the COVID-19 pandemic.

Global Standards Setting

Related to its pursuit of influence on international organizations is China's desire to set new global standards for technologies and institutions. Among the standards setting bodies China where China has secured leadership are the International Standards Organization and the International Telecommunications Union. Mr. Wethington called for coordination between U.S. industry and the U.S. government in reasserting U.S. leadership in these bodies, and in generating support for such measures by framing them in terms of national security and military development.

Trade Policy

Mr. Wethington noted that both the United States and its allies in Europe and Asia are concerned with China's trade policies, and that this shared interest should override differing preferences for a response. He cited the Commission's work as particularly valuable in framing the national agenda in this area, and encouraged a two-pronged approach. First, the United States should endorse the growing bipartisan consensus around demanding reciprocity from China in trade policies and barriers. Second, the United States must not be afraid to incorporate leverage in negotiations when it has the ability to do so, while taking care to shield American companies from the effects of these sanctions. Here Mr. Wethington again encouraged multilateral, coordinated action and coalition-building to shape and secure the long-term rules of the international trading system. He described this "multilateral statecraft" as building economic security into institutions, arrangements, and global norms.

Intellectual Property Protection

Finally, Mr. Wethington discussed the necessity of taking defensive action to limit the damage from Chinese theft or acquisition of American intellectual property in critical technologies. He warned that the United States must not be naïve, and noted that a

bipartisan consensus is forming among U.S. lawmakers on the importance of limiting Chinese investment in critical American technology. He further urged broadening the definition of "critical" technology, warning that too many important sectors of the U.S. economy were heavily dependent on the Chinese market, with serious implications for America's long term economic and national security. While he did not advocate returning to the bloc-based arrangements the United States used during the Cold War, Mr. Wethington encouraged multilateral action to strengthen global intellectual property standards. He also argued there was room for sanctions and penalties for violators of American intellectual property, especially given clear evidence of Chinese malfeasance.

Chinese Use of Antitrust Policy as Leverage

Ms. Wince-Smith asked how the Chinese government was leveraging competition and antitrust policy to act as a non-tariff trade barrier and facilitate acquisition and control of key technological innovations. Mr. Wethington replied that while China has not yet been aggressive in this regard, it has incorporated competition considerations into its formal legal processes, and is aware of its potential for offensive action. He noted that China's competition policy differs significantly from that of the United States and Europe, favoring "national champion" firms in key sectors that enjoy special protections and support from the government at the expense of competition. Mr. Tad Lipsky of Latham & Watkins LLP and George Mason University concurred with this assessment. He noted that because the Chinese government has so many points of regulatory control, their de jure competition policy, which resembles international norms in terms of its provisions, is in practice vastly different from the United States. He characterized China as lacking a substantive legal system, with all decisions being made by senior members of the Chinese Communist Party and no judicial independence. Mr. Lipsky described how China uses its anti-monopoly laws as leverage

to attain concessions from multinational firms that benefit its interests, even when they have little to do with competition policy. As an example, he cited China's forcing two multinational companies to divest from a copper mine in Latin America as condition for allowing their merger. Similarly, China uses these powers to require the inclusion of Chinese investors in foreign direct investment projects, a practice akin to Japan's mercantilist actions in earlier decades. He noted that the lack of judicial independence in China makes true antitrust policy futile, as there is no transparency and no ability to appeal decisions made by administrators. Finally, Mr. Lipsky said that China uses its legal system to encourage the disclosure of foreign intellectual property to favored Chinese customers.

Decoupling

Ms. Trimble asked how recent tensions between the United States and China, as well as recent economic developments, would impact the process of decoupling U.S. investments and supply chains from China. Mr. Wethington responded that he believed decoupling to be a naturally occurring process, driven by a rise in the costs of producing in China and security concerns by U.S. companies. He noted that China became popular for manufacturing and assembly because of labor costs, which will increase as China becomes wealthier, and believed these would combine with security concerns to encourage U.S. companies to seek other emerging markets for new ventures, as well as redirect existing investments to those markets. He added that U.S.-China interdependence will not completely cease, especially for technologies without national security implications and where American firms are heavily dependent on the Chinese market for survival. He also said that China has been decoupling from American and other foreign investment for years, seeking to exclude foreign firms in areas where it has acquired indigenous innovation capabilities, including the recently launched Made in China 2025 effort. Finally, he warned against taking too aggressive an approach to decoupling, and suggested not thinking of investment decisions in those terms.

U.S. Economic Investment in China

Mr. Evans asked if current tensions with China would undermine the United States' long-term innovation capacity and productivity. He noted that American companies like Intel and Apple generate up to 25 percent of their revenue in the Chinese market, and wondered how this impacted America's short-, medium-, and long-term competitiveness. He also asked if American and Chinese investments in R&D were truly complementary, with America concentrating on basic research and China focusing on experimentation and application. Ms. Wince-Smith noted that America's pharmaceutical supply chain had been "hollowed out" and relocated to China, and connected this to America's punitive liability laws. She noted a similar phenomenon for medical devices and equipment, and observed that the one market segment where China still depended on American manufacture was for cancer drugs. However, she predicted that China would begin to exclude foreign drug manufacturers once they developed capabilities in this field. Revisiting the issue of reciprocity, Ms. Wince-Smith noted that the U.S. supplies cloud computing services to Chinese companies with a presence in the United States, but that China does not do the same for foreign firms invested in the Chinese market.

Dr. Ken Poole of the Center for Regional Economic Competitiveness asked how the United States could be proactive in managing supply chains currently based in China. He noted that re-shoring all production could impact the price level, and asked if there were other emerging markets, such as Vietnam or India, that the United States should prioritize. He also asked whether the federal government should incorporate national security considerations, rather than just cost, into its procurement policies. Mr. Wethington observed that the United States has regulatory processes in place to make case-by-case decisions about supply chain security. In some industries, it may not be necessary or desirable to forbid investment in China or partnership with Chinese firms like Huawei. He praised the U.S. regulatory system as offering a versatile framework for these rulings. Dr.

Poole asked if health security and economic security should be included as part of national security decisions regarding supply chains, and Mr. Wethington agreed on the need to broaden the definition of “critical technology.” In particular, he asked if bioscience and biotechnology should be included because of their implications for healthcare innovation. He also said other legal authorities could be invoked in particular circumstances to prohibit transactions that damage U.S. national interests.

The International Trade Commission

Dr. Branko Terzic of Berkeley Research Group asked if there was a role for the International Trade Commission in enforcing reciprocity with China on trade issues. Mr. Wethington replied that the ITC was primarily designed to handle countervailing duties, antidumping, Section 201, and other “conventional” international trade disputes. He said it lacked broader regulatory authority, and that the Departments of Commerce, the Treasury, and Defense would be better suited for handling these issues. Ms. Wince-Smith asked if the ITC’s authority could be broadened to give it more regulatory powers, and Mr. Wethington said this was possible, but that the process would need to be carefully thought out, as the ITC’s members operate independently from the U.S. government.

Concluding Thoughts

Ms. Wince-Smith thanked the group for their conversations, praising the emergence of concrete recommendations. She connected the group’s discussions with Working Group 1’s debate over the optimal structure of Congressional committees for leading technology development initiatives. She noted that the government rapidly reorganized itself in the wake of the September 11th attacks, creating the Department of Homeland Security, and encouraged the group to be bold in its recommendations. She added that besides the executive and legislative branches, the group should develop recommendations for the private sector and universities. Ms. Wince-Smith discussed the virtual meeting of the Council’s University Leadership Forum on Tuesday, in which university leaders discussed the reliance of many institutions on the tuition paid by Chinese students. She encouraged the conception of universities as important economic engines, and spoke of the necessity of balancing openness and the liberal research enterprise with national security concerns, even regarding basic research. Finally, she called for increasing America’s own research capacity and for partnering with our allies on the issues discussed. She said the Council has close relationships with Japan and Australia, and is seeking stronger ties with Canada, Britain, and others.

Working Group 3 Calls May 5

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the featured speaker, The Honorable Branko Terzic of Berkeley Research Group. She discussed his background working as a commissioner for the Federal Energy Regulatory Commission (FERC) and in the private sector for Deloitte, and his expertise in utilities and power generation. Mr. Chad Evans announced two changes for the working groups in the weeks following the June 16 virtual meeting of the National Commissioners. First, a fourth working group will be created to focus on questions of work and entrepreneurship, with the second working group focusing on the future of sustainable production and consumption. Second, working group calls will move to once per week and be led by co-chairs chosen by the Council. These

calls will focus on data-driven discussions and aimed at generating actionable policy recommendations. They will be preceded by a primer with background reading and policies for the group to discuss and debate.

Overview of Opening Presentation and Basics

Dr. Terzic opened his presentation with an overview of electricity generation. He distinguished between energy, defined as the capacity to do work, and power, defined as the rate at which energy is generated. He characterized electrification as the single greatest technological transformation of the 20th Century, responsible for improving the standard of living around the world. He further noted that the North American electrical grid is the most complex

WORKING GROUP PARTICIPANTS

Dr. Robert Bishop
University of South Florida

Dr. Gerald Blazey
Northern Illinois University

Ms. Rachel Jagoda Brunette
Lemelson Foundation

Mr. Jim Carlisle
Bank of America

Dr. Lee Cheatham
Pacific Northwest National
Laboratory

Dr. Thomas Dailey
Dailey Strategic Advisors LLC

Dr. Lloyd Jacobs
University of Toledo
(Emeritus)

Dr. Cheryl Martin
Harwich Partners

Ms. Christina Orsi
University at Buffalo

Mr. Greg Pellegrino
Deloitte

Dr. Irene Qualters
Los Alamos National
Laboratory

Mr. Bruce Sommer
University of Illinois
Springfield

The Honorable Branko Terzic
Berkeley Research Group

Ms. Anne Tucker
Georgia State University

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Tim Planert

Ms. Carol Ann Meares

machine ever invented. However, because of its reliance on fossil fuels, the grid is a major contributor to pollution and climate change, and because of our growing reliance on electric power, the consequences of a blackout or cyberattack on our electrical system are devastating. Dr. Terzic said that the increasing digitization of the electrical grid makes us increasingly vulnerable to such attacks.

Stakeholders in the Electricity Industry

After the introduction, Dr. Terzic described the major parties in the electric industry. He said that while previously utilities were responsible for all three phases of power generation- production, transmission, and distribution- these functions are now separate. There are approximately 3,200 utilities involved in electricity production, transmission, and distribution, with 200 shareholder-owned companies accounting for 70 percent of U.S. electricity customers. The other 3,000 are rural or tribal electricity cooperatives or municipally-owned utilities. Four major federal agencies are responsible for the construction of hydroelectric dams for flood control, irrigation, and power generation: the Tennessee Valley Authority, the Bonneville Power Authority, the Southeastern Administration, and the Southwestern Power Pool.

Utilities are run as regulated monopolies, with jurisdiction split between federal and state regulators. State regulators set retail rates and control construction, distribution, and transmission for consumer usage. They are also in charge of overseeing the construction of new generators. The Federal Energy Regulatory Commission oversees natural gas pipelines, transmission for third party access, and the wholesale electricity market. The electricity market has never undergone a full deregulation, and certificates are needed to conduct transactions in both the consumer and wholesale markets. Further, the national grid is fractured, with different regional sub-grids that use different rules and standards, including different definitions of kilowatt hours. Of note is the

Energy Regulatory Commission of Texas (ERCOT), which controls a grid covering most of the state and is not connected to the rest of the national grid. Outside of ERCOT, utilities buy and sell electricity on bilateral contracts overseen by FERC.

History of Electricity Regulation

Dr. Terzic said that in the 1980s, electric utilities in every state had vertical monopolies that owned power plants, distribution, and transmission facilities. These utilities were overseen by state commissions. However, in the 1990s a wave of restructuring occurred and 15 states (Arizona, Texas, Michigan, Illinois, and most of the Northeast and Mid-Atlantic) moved to a competitive system, alleging that monopolies had failed to properly manage the construction of new plants. In these states, utilities sold their plants and focused on distribution, and consumers could buy electricity on FERC-regulated, competitive wholesale markets. The federal government retained the ability to intervene in these markets, including requiring refunds and setting price floors and ceilings. In California, the competitive electricity market failed in 2001-02 and was repossessed by the state. However, Dr. Terzic said this stemmed from a poorly designed market, rather than moving to a competitive system per se.

Dr. Terzic also discussed the beginnings of electricity regulation. Much like telephone service and natural gas, electricity was initially considered a luxury, with the financier JP Morgan becoming the first customer of home electric power. However, just as regulated monopolies emerged when railroads became essential for the 80 percent of the population that lived on farms in the late 19th century, by the time electricity became seen as a need, a regulatory framework emerged. Early regulation was influenced by the "Wisconsin idea" championed by politicians like President Theodore Roosevelt and Wisconsin Governor Robert LaFollette, and rested on the belief that experts acting without political pressure could objectively and scientifically determine the cost of service for monopoly producers in the absence of markets.

Cost Elements and Innovation Barriers Facing Utilities

Dr. Terzic identified four cost components facing utilities, which he said mirrored every other industry. The first, operations and maintenance, includes R&D expenditures. The second, depreciation, includes capital recovery over the economic life of equipment. The other elements are taxes and return, the latter of which is defined as a base rate investment multiplied by the rate of return.

Dr. Terzic connected many of the barriers facing utilities seeking to innovate to these four components. Capital investment is very difficult for utilities because of the lengthy approval process required for “first mover” investments in untested technology. Firms want to see another utility go first rather than assume the high initial investment costs themselves. Regulators also face pressure from consumer advocates not to approve R&D activities, as these are chiefly financed by raising rates. There is also a prevailing mindset that utilities are retailers and thus have no need for R&D. Finally, existing depreciation policy does not allow for timely recognition of obsolete technologies, with consumers again resisting attempts by utilities to raise rates in order to pay off the costs of upgrading their depreciated equipment. All of these factors act as obstacles that discourage utilities from innovating.

In response to these concerns, Dr. Terzic discussed an article he wrote for a trade periodical describing how these policies combined to delay the adoption of digital telecommunications infrastructure for a decade, as companies like AT&T could not get permission to write off mechanical switches. Due to the sluggishness of municipal regulators, small towns leapfrogged larger municipalities in their telecom infrastructure, going from 1920s era technology to digital infrastructure while larger cities remained on 1970s era technology. Dr. Terzic also emphasized that retail corporations do engage in research, citing Wal-Mart’s opening a research facility in India. Finally, he noted that various mechanisms, including state commissions and FERC surcharges on interstate pipeline tariffs, were used to fund research

on new methods of electricity generation and distribution. However, regulators increasingly found the approval process unwieldy, and most of these mechanisms disappeared with the advent of unbundling after 1992. Dr. Terzic observed that FERC still retains the power to collect surcharges on gas pipelines, but has chosen not to reinstate this policy.

The Importance of Lateral Transfer

A major theme of Dr. Terzic’s presentation was the importance of lateral transfer, or the adoption of an innovation in one industry for use in another, for the electricity industry. He noted that many great discoveries and inventions, from Kepler’s laws of planetary motion to Gutenberg’s printing press and Darwin’s Theory of Evolution, were inspired by similar processes. In the electric industry, Dr. Terzic cited nuclear reactors, initially developed for use on submarines, jet turbines, which have been adopted from aircraft to generate energy by power plants, and lithium ion batteries, developed initially for phones but then adopted by cars and from there utilities. In every case, utilities saw an application for the technology that addressed an unmet need, and modified for use in the electrical grid. Dr. Terzic noted that lithium ion batteries will likely become obsolete, as the next wave of batteries will need to be cheap and capable of quick transmission of energy.

The Future of Electricity and the Internet of Things

Next, Dr. Terzic shared projections for the future of the electric grid. With the advent of sensing technology and the Internet of Things, Dr. Terzic predicted that houses would be able to generate their own energy and buy and sell it through the grid. Devices would use AI to automatically make decisions about energy use, storage, and sale based on inputs from individual consumers. He noted, however, that there could be cost allocation challenges, as some components of this new grid, like electric vehicles and smart buildings, would be owned by consumers, while some, like smart meters and electric vehicle

charging stations, would be owned by utilities. Dr. Terzic noted that the assets currently held by utilities need not remain their exclusive jurisdiction, and identified situations in which challenges might arise, like neighbors' devices interfering with each other or a failure of a privately owned part of the grid spilling over to shared sections.

Dr. Terzic also discussed the role of federal programs in innovation, particularly the Advanced Research Projects Agency-Energy (ARPA-E). He praised the agency's investment in entirely new technologies for electricity generation that were too early state for private investment, but stressed the need to effectively transition these inventions to the marketplace. He also discussed the difference between short-term and long-term innovations. Some innovations, like solar energy, are older but did not find a market use until the emergence of climate change as a threat. Others, like nuclear power, solve immediate needs but were implemented before the long-term impacts were fully understood.

Incentivizing Innovation

Dr. Terzic concluded his presentation with a discussion of policies necessary to incentivize innovation. He called for tax incentives and regulatory changes to encourage greater capital investment by utilities, along with more federal partnerships for joint investment. He also called for extending these tax and regulatory incentives to cover R&D by utilities, along with a formal recognition that R&D is an essential component of all businesses, including retailers. Finally, he called for new depreciation rules that allows utilities to more quickly replace assets that have become obsolete. Dr. Terzic observed that current policies actually incentivize utilities to take on debt, as doing so minimizes their capital costs.

The Role of Self-Regulation

Mr. Greg Pellegrino of Deloitte was struck by the role voluntary standards-setting and self-regulation had played in the evolution of the electricity industry. He mentioned the example of insurance companies

and appliance makers developing safety standards that led to a vast improvement in product safety in the late 19th Century, and cited cars as an example of damage in the form of safety hazards stemming from an unwillingness of industry to self-regulate for decades. Dr. Terzic discussed the emergence of Hartford Boiler as a certifier of safety for boilers, which were prone to exploding and killed thousands of Americans every year in the 1890s. In addition to combining with insurers to fund the development of safer technologies and standards, the company invested in inspectors who would certify boiler makers, which became a precondition for insuring them. Because of consumer demand for boilers that met safety standards and could be insured, this self-regulation drastically improved their safety.

Dr. Terzic described a similar process that occurred during FERC's restructuring of the natural gas industry. Rather than writing a new, complicated set of standards as power generators joined distributors in relying on natural gas, FERC allowed industry to put together a committee of experts to suggest regulations for the agency to review. Although FERC retained final decision making power, the experts convened by the North American Energy Standards Board developed most of the regulations and standards around natural gas pipelines.

Current Vulnerabilities and Threats

Dr. Lloyd Jacobs, President Emeritus of the University of Toledo, asked if the grid was keeping pace with the country's current demand for energy, and how vulnerable the U.S. grid was to disruption. Dr. Terzic said that prior to the COVID-19 crisis, the grid had more than enough capacity to satisfy domestic energy needs, and that he advocated having as much excess capacity as possible, as the costs of storing it paled in comparison to the cost of blackouts triggered by cyberattacks or "Black Swan" events. Dr. Terzic added that digitization and sophistication increase cyber vulnerability, and argued for the incorporation of analog redundancy into the grid. He noted that when Russia launched attacks on Ukraine's electricity system, field crews were able

to turn switches back on manually, but a fully digital grid cannot be turned on except through software. He discussed technologies that allow people to start cars remotely and Amazon Alexa, and warned that those systems could be co-opted by hostile actors for eavesdropping and remote manipulation of vehicles and other devices plugged in to the Internet of Things. He further warned that during the COVID-19 crisis, attacks on America's cyber infrastructure have increased fourfold.

Opportunities for Action and Future Developments

Ms. Wince-Smith asked how the United States could turn the COVID-19 crisis into an opportunity to improve the resiliency of the grid. Dr. Terzic said the increase in cyberattacks came with potentially devastating consequences, such as an attack shutting off power to essential facilities like hospitals. Dr. Terzic encouraged the U.S. government to treat cyberattacks from foreign powers as tantamount to military strikes or terrorist attacks. He emphasized that many federal agencies, as well as utilities themselves, have devoted significant resources to preparing for these threats and developing responses. He also noted continued federal support for nuclear programs, carbon capture, and carbon sequestration, although he characterized the results of the latter two initiatives as mixed.

Dr. Cheryl Martin of Harwich Partners, formerly of the Advanced Research Projects Agency-Energy (ARPA-E) discussed an ongoing initiative that allows prior ARPA-E funding recipients to come in with new partners for demonstration projects. This initiative is aimed at scaling up promising technologies, and she said that the agency is broadly focused on developing means of identifying candidates for scaling earlier in the development cycle. Dr. Martin also reported that ARPA-E continues to receive federal funding and a gradual budget increase, and continues to have a broad research portfolio.

Dr. Terzic identified modular nuclear reactors as a potential arena for development and investment in the near future. He describe the existing Nuclear Regulatory Commission safety review process for new nuclear plants as unconscionably long, and expressed hope that smaller, modular reactors would partially obviate this. He also highlighted hydrogen as a storage mechanism for energy. By using hydrogen technology to run fuel cells, jet turbines in power plants, and internal combustion engines, energy producers and consumers could drastically reduce greenhouse gas emissions, and major cities like New York could become large scale buyers of hydrogen technology due to a reluctance to expand the natural gas distribution infrastructure. Dr. Terzic touted the potential of hydrogen for storing energy until it was needed.

Concluding Thoughts

Ms. Wince-Smith said the conversation had yielded many potential policy recommendations. She also expressed hope that the country could use the recognition of the need for regulatory reform prompted by the COVID-19 crisis as a starting point for other important regulatory reforms.

Working Group 3 Calls May 7

Introduction

The Honorable Deborah L. Wince-Smith welcomed the group and introduced the featured speaker, The Honorable Branko Terzic of Berkeley Research Group. Mr. Chad Evans announced two important changes to the work of the Commission following the June 16 virtual meeting of the National Commissioners. First, a fourth working group focusing on the future of entrepreneurship and work will be created, with the second working group focusing on the future of sustainable production and consumption. Second, beginning the week of June 22, Working Group co-chairs as nominated by the Council will be leading once-weekly discussions focused on generating actionable policy recommendations from the discussions of the groups. Each session will be

accompanied by a primer containing background information and specific policies for consideration and debate.

Basics of Electric Utilities

Dr. Terzic began with an overview of the structure and history of the electricity distribution system in the United States, drawing from his experience managing utilities and serving as a commissioner at both the state and federal levels. He differentiated between energy, or the capacity to do work, and power, or the rate at which energy is generated for use. Dr. Terzic cited the Federal Reserve Bank of St. Louis, which characterized electrification as the most important technological development of the 20th Century, in underscoring the importance of electricity

WORKING GROUP PARTICIPANTS

Dr. Branden Brough
Lawrence Berkeley National Laboratory

Ms. Ji Mi Choi
Arizona State University

Mr. William Eggers
Deloitte

Ms. Ann Gabriel
Elsevier

Dr. Anthony Margida
TechGrit

Dr. Lloyd Jacobs
University of Toledo
(Emeritus)

Mr. Tad Lipsky
Antonin Scalia Law School

Dr. Ushma Kriplani
Argonne National Laboratory

Dr. Ken Poole
Center for Regional Economic Competitiveness

The Honorable Branko Terzic
Berkeley Research Group

Dr. Rao Unnava
University of California
Davis

The Honorable Olin Wethington
Wethington International LLC

Ms. Julie Meier Wright
Collaborative Economics

COUNCIL STAFF

The Honorable Deborah L. Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Ms. Yasmin Hilpert

Mr. Josh Oswald

Mr. Tim Planert

Ms. Carol Ann Meares

to the economy, and emphasized that this importance will grow as more and more devices become connected to the grid. He attributed the unprecedented prosperity of the modern age to electricity, pointing out that 20 kilowatts of electric power, the minimum household capacity in the U.S. building code, provides as much energy as 260 human laborers. He added that the North American grid is the largest, most complex machine ever invented by humans, and noted that it has been a significant contributor to climate change given its reliance on fossil fuels for energy generation. Further, Dr. Terzic warned that our increasing reliance on the grid makes the United States increasingly vulnerable to cyberattacks.

A History of the Electric Industry

Dr. Terzic explained that the electricity industry has four components: power generation, transmission, distribution, and marketing to consumers. Prior to the late 1980s, the electricity industry in every state was vertically integrated, with utilities having monopoly power over all components of the production and distribution process. Since that time, however, these functions have separated, and it is possible for different companies to control power production, transmission, distribution, and marketing, a model that has taken hold in many states.

Regulating Electricity

Dr. Terzic delineated the roles played by state and federal regulators in managing electricity distribution. Retail electricity is overseen by state public service commissions, including the building of plants and transmission lines, the quality of service, connection and disconnection, and approving investments by utilities. The wholesale market, governing sales between utilities, is regulated by the Federal Energy Regulatory Commission (FERC). Unlike most industries, the wholesale electricity market has not undergone deregulation since it was established in the 1930s. Unlike in the competitive financial, real estate, or commodity markets, FERC regulators can set prices, order refunds, and otherwise intervene

in or overrule market transactions and dynamics. Wholesale markets are regional, with the largest ones covering California, New York, the Mid-Atlantic, the Northeast, and the Midwest, respectively. The Texas grid, run by the Electricity Regulatory Commission of Texas (ERCOT) is not connected to the rest of the North American grid, and as such is regulated by the Texas Public Service Commission rather than FERC. Further, some regions, like the Southeast and Northwest, do not have regional wholesale markets at all.

Beginning in the late 1980s, fifteen states began creating competitive retail markets, as a result of technological advances and a growing belief that utilities were being inefficient in their construction of power plants and exceeding costs in developing nuclear facilities. This move transferred retail market regulation from the state to the federal level, but did not result in deregulation. Under this system, utilities had to sell off their generation facilities and focus on production and distribution. They now could deliver power to customers for a regulated fee, and power generators competed for the right to sell wholesale to utilities.

Dr. Terzic described the roots of utility regulation, which stem from the “Wisconsin Idea” championed by Wisconsin Governor Robert LaFollette in 1912. The Wisconsin Idea held that in the absence of market signals, independent experts free of political pressure could scientifically determine the fair value of a service provided by a monopoly. Originally designed to deal with monopolized railroads in an era where 80 percent of the population were farmers who relied on railroads to ship their crops, this model was extended to telephone service, electricity, and natural gas during the 20th Century.

Dr. Terzic then discussed the process by which regulators manage utilities. He characterized utilities as having the same four cost categories as any other enterprise. The first, operations and maintenance, includes research and development spending. The others are depreciation, taxes, and returns on investment, the last of which is defined as the

initial level of investment multiplied by the weighted average cost of capital. Dr. Terzic highlighted that R&D spending, depreciation of obsolete equipment, and overall investment are all relevant to innovation. However, he noted that regulators generally do not consider R&D to be a normal expense for utilities.

Barriers to Innovation by Utilities

Dr. Terzic identified three barriers facing utilities that discourage innovation. The first is the requirement that all R&D be approved by regulators. Because any investment requires risk due to the possibility of the new technology not working, firms need the possibility of greater market share and higher revenue as a reward for their investment decision. However, because utilities' rates are regulated, they are unable to capture any additional revenue from their investments, and in fact their competitors benefit from adopting new technologies that result from this investment without spending on research.

A second barrier to innovation is the requirement of regulator approval for general operation and maintenance spending. Because of the mistaken belief that retailers do not invest in R&D, regulators are reluctant to allow utilities to raise their rates to cover R&D expenses, especially in light of pressure from consumer advocates. In this vein, Dr. Terzic cited Wal-Mart's opening of a research facility in India in 2011 as evidence that retailers do conduct R&D research.

The third barrier Dr. Terzic identified is regulators' reluctance to allow for quick depreciation of technology that becomes obsolete, again because the costs of replacing equipment must be recouped in the form of higher rates. He discussed his academic paper, "Innovation Requires Capital Recovery Recognition," in which he argues that the unwillingness of regulators in large cities to recognize the obsolescence of third-generation telecommunications infrastructure led to them receiving digital telephone service a decade after rural areas and small towns did. Utilities in these areas, which were still on first-generation technology, had their investment requests approved because the obsolescence of their technology was more obvious to regulators.

In spite of these obstacles, Dr. Terzic noted that some states provide support for research in electricity generation. However, he said this funding pales in comparison to the support that was formerly provided by federal and state governments for such research from the 1970s to the 1990s. State regulators formerly approved funding for the Electric Power Research Institute, and the federal government used a surcharge on the transmission of natural gas through pipelines to fund the Gas Research Institute. However, with the move to competitive markets for wholesale electricity and natural gas, both institutes were dismantled as power generators claimed the funding for these projects was eroding their revenues. Dr. Terzic disagreed with this contention, and noted that there is nothing stopping either FERC or state public service commissions from reestablishing these policies.

Lateral Transfer and Innovation

Dr. Terzic discussed the importance of lateral transfer, identified by the author Arthur Koestler as the process by which innovations in one area are adopted by another sector that sees uses for technology beyond its original purpose. He gave examples of such transfer throughout history, including Darwin's Theory of Evolution, Gutenberg's printing press, and Johannes Kepler's synthesizing physics and astronomy to develop a theory of orbit trajectories that resolved major issues in astronomy. These came from combining two earlier theories, the wine press, and the theological conception of the trinity, respectively. Dr. Terzic then provided three examples of lateral transfer in electricity technology, one of which was ambiguous in its impact and two of which were positive.

The first example of lateral transfer in electricity generation was the adaptation of nuclear reactors on submarines for terrestrial power generation. Here, Dr. Terzic noted that while reactors on submarines had to be small, compact, and light, the main concerns for nuclear power plants simplicity, cost, and reliabil-

ity. He speculated that the nuclear industry would have fewer problems than at present if they had designed purpose-built reactors from scratch rather than trying to adopt naval technology.

On the positive side of the ledger, Dr. Terzic discussed how utilities realized that jet engines from aircraft were a highly efficient source of power generation. Although initially only used to support peak usage, gas-fired jet turbines eventually became the predominant means of generating power at fossil-fuel based plants due to their superior energy efficiency. Finally, lithium ion batteries, developed for telephones, formed the basis of electric vehicles, including Tesla, which aggregated thousands of light, energy-dense, and portable batteries to produce electric motors for its cars. This innovation was then used to spur research on batteries that can store intermittently generated renewable energy, like solar and wind energy. Dr. Terzic observed that for electricity generation, concerns about weight, energy density, and portability were secondary to cost, reliability, and non-toxicity.

The Next Grid and Questions of Ownership

Dr. Terzic outlined the future of the electric grid, which he said would be characterized by far more devices requiring access and by two-way flow, as households will be able to generate their own energy that could flow into the grid. He mentioned that many cities have declared moratoriums on new natural-gas powered homes, and warned that significant improvements in AI and rebuilding of infrastructure were necessary to safely manage this new reality. He also raised the question of ownership of the infrastructure for this new grid, and whether utilities should own all the components or if private individuals should own some of them. He cited the FCC's refusal to allow local phone companies to install cable lines as a reason for the delayed introduction of cable television, following pressure from Hollywood.

Issues in Technology Development

Related to the future of energy are the stakeholders in the development of new technology. Dr. Terzic praised the Advanced Research Projects Agency-Energy (ARPA-E) for its work funding revolutionary ideas in energy generation, transmission, and storage that are too early to attract private investment. He also emphasized the importance of the national laboratory system in developing new energy technologies. Dr. Terzic added that while he supported nuclear energy, there are serious concerns about the long-term impact of nuclear waste and the cost of building new nuclear plants that must be addressed.

Incentivizing Investment

Dr. Terzic closed his remarks by identifying policy levers for encouraging innovation by utilities. These include tax and regulatory incentives to make capital investments and official recognition that R&D expenses are a legitimate cost of service for utilities, allowing them to recoup them through higher rates. He even suggested requiring utilities to include R&D spending as part of their operations and maintenance expenses, and also suggested federal partnerships for research as a means of spurring innovation. Finally, he called for better recognition of obsolete technology by regulators, to allow utilities to depreciate outdated equipment more effectively. Mr. Bill Bates noted that Dr. Terzic's recommendations on legitimizing R&D rate increases and depreciation were previously supported by the Council in Accelerate (2018), but that they remained relevant for the group's consideration. Dr. Rao Unnava of the University of California, Davis asked if marketing and social cause contributions by utilities were considered part of the utility's returns or if they came out of maintenance and operations. Dr. Terzic said that regulators allow utilities to include these expenses as part of operations and maintenance when they are aimed at consumer research to improve reliability or customer service, but not for boosting sales or other purposes.

Policy Changes and Pushback

Mr. Bates asked what the political obstacles were to implementing the recommendations Dr. Terzic outlined. He responded that because utilities are the only service providers whose ability to raise prices is affected by public testimony, people blame utilities for adding to increased costs of living that are primarily the fault of other sectors raising their prices. He said it was crucial to illustrate for the public how investments by utilities in replacing depreciated equipment and conducting R&D would lead to improvements in energy generation and transmission that would benefit them in the long run. He noted that the “Wisconsin Idea” included the right of regulators to raise rates if they felt it was in the public interest.

Ms. Julie Meier Wright of Collaborative Economics discussed the issues of Consumer Choice Aggregators (CCAs), which act as intermediaries for buyers of electricity by making purchasing decisions on the behalf of consumers. She noted that these entities compel participation from customers and do not produce any energy themselves, making them a likely target for public resentment if they implement unpopular policies, like purchasing more expensive renewables and raising rates. Dr. Terzic agreed that involuntary membership in CCAs was an issue, and characterized them as a “solution looking for a problem.” He noted that individual buyers already have the right to purchase energy from particular sources if they want to, and that CCAs justify their decisions as being based on optimal long-term public policy.

Mr. Bates asked if the federal government could intervene to supercede patchwork state responses to utility R&D, and Dr. Unnava asked if it was necessary to develop an entirely new management framework instead of shoring up the old system. Dr. Terzic said there was precedent for federal intervention in the Public Utility Regulatory Policies Act (PURPA) and Fuel Use Act, both in 1978. Intended to prevent the exhaustion of natural gas and oil supplies, these acts forbade the use of natural gas for any purposes other than home heating and cooking, required states to build power plants with nontraditional fuel sources, and began introducing competition to power markets. They also required states to investigate inverted or flat utility rates, real time pricing, and other energy management policies.

Broadband Infrastructure

Dr. Ken Poole of the Center for Regional Economic Competitiveness asked why there was insufficient political will to provide universal broadband access in a similar fashion to previous efforts at rural electrification. He wanted to know if there were restrictions preventing broadband companies from using the same infrastructure that was used for the transmission and distribution of electricity to install fiber optic lines. Dr. Terzic said that while a majority of the 3200 utilities in the United States are rural cooperatives financed by specialized federal agencies or municipal corporations, the 200 investor-owned utilities supply 70 percent of America’s electricity market. He

compared this to the situation in the telecommunications industry prior to the breakup of AT&T, in which most of the 2600 telephone companies were locally owned and operated, resulting in a federal program to install “last mile” telephone service in rural areas. He suggested a similar program for broadband access, and doubted that the capacity of the existing infrastructure to handle fiber optic cables was an issue. He noted that the COVID-19 pandemic had laid bare the problems with widespread internet access in the United States, and that questions remained about what speed of broadband transmission was needed.

Cyber Vulnerability and Government Responses

Ms. Wince-Smith asked about the United States’ increasing vulnerability to cyberattacks, and Dr. Branden Brough of Lawrence Berkeley National Laboratory asked what role ARPA-E and the national lab system had in maintaining and securing America’s electric grid. Dr. Terzic said that as more devices come to rely on the electric grid, an attack disabling it would have increasingly dire consequences. He warned that new digital grid technology could not be manually restarted following a cyberattack, further increasing vulnerability to actions by nations such as Russia, China, Iran, and North Korea. He cited the example of Russia planting software in the Ukrainian grid that it used to remotely trigger a grid shutdown in December of 2017 as an example of the kinds of enemy actions that could paralyze the United

States, and noted that during the COVID-19 pandemic cyberattacks had increased fourfold. Dr. Terzic praised the concerns of both utilities and government agencies, including the Departments of Defense and Homeland Security, ARPA-E, and the National Laboratories, for their investments in combating these problems. He said that the most important step for the United States to take was to make it clear that cyberattacks aimed at our financial system, water supply, grid, or other critical infrastructure will be interpreted as acts of war, and responded to in the same fashion as a missile strike. Ms. Ann Gabriel of Elsevier said that academic publishers are increasingly turning their attention to cyber vulnerabilities on platforms like SciHub.

Concluding Thoughts

Ms. Wince-Smith thanked the participants for their discussions, and Mr. Evans reminded the group again about forthcoming changes to the Working Group discussion process. Ms. Trimble reminded the group that next week’s calls will feature presentations from Dr. Ken Poole of the Center for Regional Economic Competitiveness. Ms. Wince-Smith also asked how the country could use the opportunity for reform in the wake of the COVID-19 crisis to accelerated the development of a national integrated, self-healing smart grid.

Working Group 3 Calls May 12

Introduction

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group. Ms. Wince-Smith noted that the Council was affiliated with several experts in regional innovation, and that it was crucial to develop a strategy for regional diversity and inclusive growth going forward. Mr. Chad Evans also expressed interest in the day's discussion topic, adding that it was a passion of the Council and that he also wanted to discuss investment and infrastructure needs at the regional level. Ms. Trimble then introduced the featured speaker, Dr. Ken Poole of the Center for Regional Economic Competitiveness.

Overview and Framing of Regional Innovation Challenges

Dr. Poole opened his remarks by discussing the importance of recognizing that the U.S. economy is comprised of hundreds of regional economies, something he said was illustrated in the widely differing effects of the COVID-19 pandemic and the resulting economic crisis around the country. He said that while universities, the private sector, and nonprofits all play a role in building regional innovation ecosystems, state and local governments play an especially important role. While some of this is through their regulatory regime and business environment the principal impact they have is in their efforts to

WORKING GROUP PARTICIPANTS

Dr. Robert Bishop
University of South Florida

Dr. Gerald Blazey
Northern Illinois University

Dr. Branden Brough
Lawrence Berkeley National
Laboratory

Mr. Thomas Dailey
Dailey Strategic Advisors LLC

Mr. William Eggers
Deloitte

Dr. Lloyd Jacobs
University of Toledo
(Emeritus)

Mr. Tad Lipsky
Antonin Scalia Law School

Ms. Vickie Lonker
Verizon

Ms. Christina Orsi
University at Buffalo

Mr. Greg Pellegrino
Deloitte

Dr. Ken Poole
Center for Regional Economic
Competitiveness

The Honorable Branko Terzic
Berkeley Research Group

Ms. Anne Tucker
Georgia State University

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Chad Evans

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Mr. Chris Reigelsperger

Mr. Tim Planert

develop and support new technology and transition it into the marketplace. He characterized the roles state governments play along six broad categories: investment in applied research, technical workforce development, infrastructure, technology diffusion, equity capital markets, and equity of access.

Investment in Applied Research

Dr. Poole discussed the ways in which states and regions help to commercialize technology and facilitate its adoption within the regional economy. He noted that universities were an important part of this process, and also cited state-level initiatives like Pennsylvania's Ben Franklin Partnership and Ohio's Third Frontier. He said many of these initiatives are cluster-focused and concentrate on developing technology important to a sector that is already established in the region, like the Water Council in Milwaukee, Wisconsin that draws on the city's proximity to the Great Lakes. Dr. Poole also identified New York's 28 regional Centers of Excellence around individual technologies, the BioStL initiative in Missouri, and the Oregon Innovation Council as state-based technology efforts. These projects generally start as government-funded initiatives but grow to include private financing as part of a public-private partnership model.

Technical Workforce Development

Addressing the skills gap and improving technical curriculum is a major challenge area for states. Dr. Poole cited curriculum that lags technological advances, siloing of nontraditional students and traditional curriculum from technological advances, insufficient engagement with industry, inadequate digital literacy, and a lack of response to the growing need for skill hybridization as contributors to workforce development challenges. He emphasized the importance of the K-12 system and of regional colleges and universities to fostering technical skills, and said the system was suffering from a "missing middle." However, Dr. Poole said that states were in

the process of modernizing their curriculum, developing models to give credit for experience and reduce classroom time, and secure greater input from the technology sector in overhauling their curriculum.

Related to these issues, Mr. Evans discussed the Council's membership in Science Is Us, a coalition of over a dozen national organizations working to highlight the importance of investment in and promotion of STEM in the educational system. He noted that STEM fields account for \$2.3 trillion in annual federal tax revenue, 69 percent of U.S. GDP, and nearly two thirds of all jobs. Further, 59 percent of STEM workers don't have bachelor's degrees, illustrating the outsized role that technical education plays in the U.S. economy.

Infrastructure

Dr. Poole highlighted three major infrastructure challenges to innovation: energy, broadband internet, and air transportation. He said that states were already investing heavily in clean energy technology, contributing \$700 million in direct investment in 2019 and \$900 million in 2020. States are investing in a variety of technologies in order to establish regional advantages in particular sectors and target funding to areas that would not otherwise attract private capital. Dr. Poole also stressed the importance of smart grids to innovation.

Broadband access has proved a major challenge for regional development, especially in rural areas, and Dr. Poole warned that because of data collection flaws, the problem is likely worse than is currently reported. He said that the FCC considers an area to have access based on proximity to regional broadband infrastructure, rather than verifying whether or not residents can access the system. This is further exacerbated by the lack of competition in many areas that do have broadband access, with only one provider whose costs and quality do not induce high adoption rates.

Another infrastructure challenge is air transportation. Dr. Poole said that many areas are not near airports with flights to a wide variety of areas, and that air service concentration leads to over-congestion in certain areas and lack of access to investment opportunities for others. He warned that venture capital and outside investors are not interested in regions they must take multiple flights to reach, and without in-person networking and knowledge transfer, innovation and investment are stifled.

Technology Diffusion

Dr. Poole discussed two large initiatives in regional technology diffusion. The Manufacturing Extension Partnership, which includes 1400 field agents in all 50 states and has been in operation for more than three decades, provides valuable assistance in helping manufacturers adopt new technology. However, Dr. Poole said the program's \$140 million budget is not sufficient, and noted that the Obama administration tried to double the program's funding but could only secure a small increase. The Manufacturing Extension Partnership embeds staff into regional centers to identify new technology that is particularly relevant to smaller companies. Another program is the National Manufacturing Innovation Institutes, which are currently a patchwork of regional initiatives. Dr. Poole said the goal for this program is to scale up to the national level.

Equity Capital Markets

The concentration of venture capital into a handful of markets in recent years has been a driver of regional divergence in economic growth. From 1995 to 2015, the share of venture capital investment in Boston, New York, Silicon Valley, and Los Angeles went from 51.4 percent to 77.8 percent. Dr. Poole characterized this shift as stemming from the venture capital's desire to find quick, high returns, and lack of interest in "patient" capital. He outlined several different junctures for state intervention from early stage seed funding up to commercialization, but

said there were several "valleys" in the development process, all of which revolved around scaling. Dr. Poole described several policies states use to attract investment, including tax credits for R&D and angel investing, product development grants, and ecosystem support, including funds to increase capital and programs designed to mentor in-state talent to invest in and manage equity capital. He also discussed the provisions for state support of venture capital in the 2010 federal stimulus bill, which provided \$1.3 billion to states before its provisions expired.

Equity of Access to Innovation

Finally, Dr. Poole outlined the ways in which states seek to increase access to innovation networks and ecosystems. States engage in initiatives to encourage new entrepreneurs through programs to recognize talent in underrepresented populations and through the creation of maker spaces and accelerators. They also use pitch competitions, reverse-pitch problem solving contests, innovation vouchers, and expedited prototyping programs to promote technology adoption and product ideation. Finally, states provide business management and technical assistance to help develop the expertise and experience necessary in the local population to fuel an innovation ecosystem.

Dr. Poole concluded his presentation by discussing the challenges he experienced in getting state and local governments to fund and support innovation initiatives, due to the perception that innovation only benefits metropolitan centers at the expense of other areas. Mr. Evans discussed the Manufacturing USA institutes, and the role they play in creating a "tapestry of capabilities", as well as a shared national innovation infrastructure that plays a key role in the development and application of products. He discussed a suggestion from a Working Group 1 discussion that the government pivot to funding technologies in the "valley of death", adding that even a small investment there could have a substantial impact.

The Importance of In-Person Networking for Innovation

Dr. Branden Brough of Lawrence Berkeley National Laboratory wondered if the COVID-19 pandemic would change the value of in-person interactions to innovation. He observed that technology meant that entrepreneurs could pitch their ideas remotely rather than in-person, and added that while physical meetings were still preferable, using remote meetings as a complement could reduce the need for travel. Mr. Evans responded that the question was an interesting one, but noted that research as found that unplanned, “water-cooler” meetings are as important to innovation as planned encounters. He said he would be interested in seeing any evidence that emerges on the value of virtual interactions.

Dr. Poole said that it was likely the role of virtual meetings with investors was going to grow even prior to the COVID-19 crisis, and added that while stakeholders should open to incorporating this technology, it would not completely replace the serendipitous interactions that are key to forming connections and building the trust necessary to encourage investment of money. He said that one reason venture capital investors want their firms to relocate is so they can have more face-to-face interactions, and that this relocation of talent is the biggest drive of venture capital concentration. Mr. William Eggers of Deloitte said that virtual reality technology, including online avatars, would soon make it possible to recreate the experience of physical meetings remotely.

Air Service and Transportation

The Honorable Branko Terzic identified the deregulation of the airline industry as the driver of air service concentration, noting that when airlines were no longer required to serve small areas to operate in larger areas, they eliminated most direct flights to those locations. Dr. Poole said that while some subsidy programs for air service still existed, the current “hub and spoke” model produced dual problems of congestion in some places and under-service in others, and said policy makers needed to think strategically

about where to subsidize air service and the appropriate distance between major aviation hubs. Dr. Terzic also mentioned the potential of electric airplanes, which require less maintenance and fuel. Dr. Poole said these vehicles could serve as the basis for “air taxis” that would fly passengers to customized routes, similar to services like Uber or Lyft.

Mr. Eggers noted that Deloitte had done studies on passenger drones and flying cars, and Ms. Wince-Smith discussed the Council’s engagement with Skyworks Global, which is working on similar technologies. Dr. Brough expected high quality embedded reality technology, like MagicLeap, would mature and scale before flying cars, but Mr. Eggers predicted flying cars and drones would start scaling within the decade, and even be accelerated by the COVID-19 crisis. Mr. Evans noted that many VR, AR, and XR companies were already joining to form a trade association.

The Effects of Recession on State Innovation Investments

Mr. Eggers asked what effects cuts to state budgets in light of the economic crisis would have on state and local programs to boost innovation. Dr. Poole predicted that these programs would be among the most severely affected, and that those that remained would primarily rely on fiscal policy, including tax incentives. He characterized this trend as ineffective since people are not motivated by tax breaks in the future during times of immediate economic distress. He also praised the State Small Business Credit Initiative from the previous economic downturn, as it re-energized technological investment and helped create new infrastructure in states that normally would not invest in it. Dr. Poole further cautioned that direct state investment in technologies carries concerns of “corporate welfare”, and that elected officials prefer to invest in projects that have returns within an election cycle, rather than long-term efforts that could take a decade or more to bear fruit.

Developing Supporting Infrastructure

Ms. Wince-Smith asked Dr. Poole where he would invest if he could triple the Economic Development Agency's investment budget. Dr. Poole said that while there has been some discussion around picking a handful of locations for intensive investment, he would prefer to support the organizational infrastructure that brings together companies and technologies and allows for pre-competitive investment and development. He said that the agency has historically invested a lot in entrepreneurship and management training, but not in technology, and that providing support for cluster initiatives and infrastructure around convening and developing new technology would be the most valuable use of resources because these are areas regional governments struggle with.

Regional Innovation Initiatives

Ms. Christina Orsi of the University at Buffalo cited a Brookings Institution proposal to identify secondary markets with significant innovation indicators and directing intensive federal investment toward building up their regional ecosystems. She asked if this was an initiative the group should investigate or support. Dr. Poole said that he would not want federal officials picking the regions to invest in because so much of the necessary structures for successful regional innovation projects are outside of their control. He said any such program would

need to identify regions that had already established the capacity and commitment to making an initiative work in specific technology sectors. Ms. Orsi said such programs could include funding requirements and other signs of commitment and infrastructure, and Dr. Poole noted that while states like New York, Pennsylvania, and Ohio have made serious investments in innovation, other states have talked about it but have not put up the resources. He said there was growing pushback against programs that did not provide proof of results, and urged the development of metrics and objectives to meet before proceeding with any projects.

Broadband Access

Ms. Vickie Lonker of Verizon discussed challenges in extending broadband access. She said that Verizon had had surprising success in providing wireless service for remote work and education, and urged against treating broadband like a utility. She said that competition was essential to ensuring continued innovation in broadband technology, and cited the improvements made in satellite, fiber, 5G, and other technologies in competitive broadband markets. Ms. Lonker discussed the challenge of securing long-term regional support for a public-private partnerships to develop broadband infrastructure, noting that new administrations led to changes in support or objectives.

Mr. Thomas Dailey of Dailey Strategic Advisors LLC and formerly of Verizon mentioned the challenges his clients have had in getting support from the FCC in organizing a joint bid with other small firms to put together a broadband system in rural areas. He said many small companies often have parts of the needed infrastructure and could connect all the components by partnering with each other, but they lack the platform to do so. He added that part of the challenge is in figuring out ways to make broadband access economically viable, noting that all potential broadband technologies, including satellite technology, have limitations. Mr. Dailey said that other regulatory requirements also get in the way of technology deployment.

Dr. Poole said that his organization has worked with clients in Appalachian who are unable to work from home during the crisis because of insufficient broadband infrastructure. He again warned that inadequate FCC data was painting a misleading picture of broadband access and making it impossible for these regions to secure assistance because they are incorrectly deemed to already have access. He urged investment not only in “last mile” broadband infrastructure, but also “middle mile” infrastructure, and said that if the United States was able to put electricity in every household, it should be able to do the same for broadband. He concluded by observing that many stakeholders are frustrated by the lack of a clear path forward under the current regime of federal program execution.

Concluding Thoughts

Ms. Wince-Smith closed the discussion with a description of the heavy-handed approach China took to economic development in Shenzhen, near Hong Kong. Due to heavy subsidy and a long tax-free period for manufacturing investments, the region went from empty fields to a metropolis home to nearly every major multinational company and boasting high tech manufacturing and supercomputing facilities. She said that while the approach the Chinese government adopted clashes with American values and culture, it was important for the United States to be similarly bold in generating inclusive economic transformation, rather than making incremental improvements. She noted that there were trillions of dollars sitting in hedge funds and private equity that could be deployed to revitalize growth across the country, allowing the United States to leapfrog into the future. While agreeing that universal broadband was key to regional development, she noted that the Economic Development Administration also had money and functioned as a signal to the market with its investment decisions. Finally, she challenged the group to come up with bold ideas to discuss at the next session on Thursday.

Working Group 3 Calls May 14

Introduction

Mr. Bill Bates and Ms. Kathy Trimble welcomed the group to the call, and introduced the feature speaker, Dr. Ken Poole of the Center for Regional and Economic Competitiveness. Mr. Bates noted that the issue of regional innovation was of particular importance and interest to the Council, and that he looked forward to hearing Dr. Poole's policy recommendations for developing regional innovation ecosystems.

Framing Remarks

Dr. Poole said that because the national innovation ecosystem is so vast and complex, it would be like "boiling the ocean" to address it in totality, and emphasized the important role that different states and regions play in fostering their local innovation ecosystems. He noted that while most of his remarks were centered on states, the private sector, nonprof-

its, laboratories, and universities also played a role in regional innovation policies. Dr. Poole said that while states exert some influence on innovation through their regulatory regimes, they primarily impact innovation ecosystems through focused investment in developing components of those ecosystems that are targeted to local or regional interests. He grouped this issues facing states and other sub-national governments into six broad areas: investment in applied research, the skilled technical workforce, knowledge sharing infrastructure, technology diffusion, capital concentration, and equity in capital access.

Investment in Applied Research

Dr. Poole said that states focused on commercializing research and in generating and disseminating new ideas in areas of economic need. He gave the example of university research centers of excellence,

WORKING GROUP PARTICIPANTS

Ms. Ji Mi Choi
Arizona State University

Ms. Ann Gabriel
Elsevier

Ms. Rachel Jagoda Brunette
Lemelson Foundation

Dr. Cheryl Martin
Harwich Partners

Dr. Ken Poole
Center for Regional Economic Competitiveness

The Honorable Olin Wethington
Wethington International

Mr. Bruce Sommer
University of Illinois Springfield

Dr. Roland Stephen
SRI International

The Honorable Branko Terzic
Berkeley Research Group

Dr. Rao Unnava
University of California-Davis

Ms. Julie Meier Wright
Collaborative Economics

COUNCIL STAFF

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Mr. Tim Planert

Ms. Carol Ann Meares

which are guided by both federal and industry priorities, and which direct investment into locally relevant research. He also discussed state and regional technology partnerships, including Pennsylvania's Ben Franklin initiative and Ohio's Third Frontier program. Dr. Poole then discussed state and regional cluster initiatives, which are pre-competitive alliances in industry to research solutions to common challenges and means of aggregating markets and product demand. Examples of these specialized initiatives include the BioStL program in Missouri, the Oregon Innovation Council, and New York's 28 centers of excellence spread throughout the state.

The Skills Gap and Technical Education

Dr. Poole discussed several problems with existing technical education programs, and emphasized that middle-skill positions were at least as important to the technical workforce as PhDs and entrepreneurs. Among the challenges he cited were curriculum that lags technological advances, a lack of response to the demand for hybrid skill sets, the siloing of non-traditional students and traditional curriculum from technological advances, insufficient digital literacy, insufficient engagement with industry, and workforce development boards that are not responsive to the needs of industry. Dr. Poole said that regional colleges and the community college system are crucial to the technical education pipeline, and that states are currently undertaking many initiatives to overhaul the technical education system. These include changing the governing structure of workforce boards to make them responsive and accountable to industry, improving and emphasizing STEM curriculum, increasing the amount of technology in the classroom, overhauling curriculum with industry input, and recognizing experiential learning and competency with credentials that allow students to accelerate their degree programs.

Knowledge Sharing Infrastructure

The three major infrastructure challenges Dr. Poole discussed were those of energy, the internet, and air service. He said that clean technology and smart grids have affected which technologies society prioritizes and revolutionized how companies are delivering and accessing energy. He highlighted the massive urban/rural divide in broadband access, and said that existing data understated the extent of the crisis because of poor data collection methods used by the FCC that overestimate broadband connectivity. He further added that areas with broadband service often have no competition between providers, and that high costs and lack of perceived need lead to low adoption rates in many parts of the country. Air service is highly concentrated in metropolitan centers, which makes the in-person interactions and knowledge exchange that are crucial for sparking innovation and providing the networking with funders that entrepreneurs need much more difficult for people living in rural areas. While technology can help connect people outside of the major venture capital hubs, it will never replace physical meetings, and before the COVID-19 pandemic large airline hubs were congested while regional air infrastructure was underutilized.

Technology Diffusion

Dr. Poole said states spend significant resources on diffusing existing innovations to markets, and highlighted two programs in particular. The Manufacturing Extension Partnership, a project of the National Institute for Standards and Technology (NIST) consists of 51 centers in all 50 states and Puerto Rico, with 1400 experts working with local manufacturers to help them adopt new technology and smart business practices. The Manufacturing USA institutes consist of 14 industry-based centers that develop technology and connect smaller companies with innovations. There has been some connection between these two programs, with Manufacturing

Extension Partnership field agents embedding in Manufacturing USA centers, but overall there is no unified strategy for deploying these resources, resulting in a “scattershot” approach across agencies.

Capital Concentration

Another major challenge for states is attracting venture capital funding outside of hotbeds like Silicon Valley, New York, Los Angeles, and Boston. Dr. Poole noted that between 1995 and 2015, these four regions went from attracting 51.2 percent of all venture capital investment to 77.8 percent of all venture capital investment. He said this was driven by venture capital’s search for fast, high returns, which are more common in software than in the long-term, patient investment opportunities found in other regions of the country. Dr. Poole said states have multiple potential points for intervention, and that there were multiple bottlenecks where venture capital concentrated, including in the later stages of product development. In response, states are increasingly funding early-stage research and development, but struggle with scaling issues because the small investments they make do not attract high levels of venture capital. Those projects that do get funded often face pressure to relocate to be nearer their funders. Of note, Dr. Poole said the most common tool for states to attract capital is fiscal policy, which is challenging during an economic downturn when the tax base is dwindling. However, he also praised state efforts to build management capacity and keep talent home, in order to develop venture capital ecosystems locally. These efforts attempt to use, develop, and keep equity funding within particular communities.

Equity in Capital Access

Dr. Poole discussed state efforts to broaden the demographics of entrepreneurship. States are developing maker spaces and accelerators, along with networking programs, designed to find and foster entrepreneurial talent from underrepresented communities. Other initiatives include pitch competitions,

innovation vouchers, and other programs designed to promote technology adoption and product ideation. States are also investing in providing business management and technical assistance, to help members of underrepresented groups turn their ideas into business propositions, attract funding, and effectively manage startups. These initiatives also include cyber awareness and preparedness training.

Ten Recommendations for Addressing Regional Competitiveness

Following a charge from Tuesday’s session, Dr. Poole listed ten recommendations to bolster regional competitiveness. First, he advocated making regional innovation a high priority on the national innovation agenda, and urged the development of good metrics to demonstrate the value of widely distributed innovation. In this vein, he also advocated significantly expanding the Economic Development Administration (EDA)’s Build Regional Innovation Systems to Scale program, and tied it into a proposal by the Information Technology and Innovation Foundation and the Brookings Institution to invest significant capital in “second tier” metropolitan areas to turn them into innovation hubs. Dr. Poole suggested modifying this proposal to one of matching funds for emerging cluster networks with partners in the state or metropolitan area, and to spread funding to as many areas as possible. Third, Dr. Poole advocated expanding federal and state investment in boosting technical development and deployment capacity among small firms. This would also require a massive expansion of scouting, rapid prototyping, and technological problem solving for manufacturers. Fourth, he suggested expanding the SBIR program, with a particular focus on Minority/Women-Owned Business Enterprises (MWBES). A fifth recommendation was the creation of a new federal equity capital bank, modeled after the State Small Business Credit Initiative created in 2010 that phased out in 2017. This program would include \$10 billion in funding over 10 years to leverage state partnerships with the private sector to invest in underserved regions.

Dr. Poole's sixth recommendation was creating a federal broadband authority that leverages state programs and public-private partnerships to achieve universal broadband access. He said that if the government was able to electrify every household in the United States, it should be able to implement broadband in every household. He said rural areas in particular needed stable broadband, and that wireless was not doing an adequate job, while 5G was likely to pose geographic challenges. Dr. Poole also called for better distributing air service to second-tier metropolitan areas, and for better ground connectivity between second tier areas and major airline hubs. As part of this, he recommended turning local airports into logistics centers. To boost workforce development, Dr. Poole called for \$500 million in funding for competency-based technical education. He noted that most companies, especially for middle-skill positions, care more about particular skill sets than they do credentials. Relatedly, Dr. Poole's ninth recommendation was to create a fast-track student loan forgiveness program for students willing to teach in-demand STEM skills to underrepresented regions at the K-12 and community college levels. Finally, Dr. Poole called for place-based immigration visas to generate a flow of talent and economic activity to rural areas and small towns, revitalizing areas in demographic decline.

Causes of Startup Failure and Stagnation

Dr. Rao Unnava of the University of California, Davis asked how many startups that failed in the "Valley of Death" simply didn't have marketable ideas, and how many died because of insufficient access to working capital or network connectors. Dr. Poole said that often companies, don't die, but their ideas stagnate and never turn into products because they cannot get audiences with the funders who could help them realize their ideas. Dr. Roland Stephen of SRI International said there were multiple bottlenecks facing startups, including early and later on in the process. He stressed the importance of business talent to successful startups, noting that a great idea isn't the same thing as a great product. He also listed funding gaps as a major obstacle for startups. Dr. Ste-

phen also observed that the regions of the country outside of venture capital hotspots are often better suited to actually scale products than those hubs are themselves. These regions have factory facilities and skilled workforces, but most startups produce overseas. He encouraged forging connections between these regions of the country, and said the shock to supply chains from the COVID-19 crisis may provide an opportunity to jumpstart that process.

Barriers to Entrepreneurship for Women and People of Color

Ms. Rachel Jagoda Brunette of the Lemelson Foundation said that many women and people of color report the lack of an adequate safety net for entrepreneurs as the biggest obstacle to their starting a business. She noted that leaving an employer to found a startup means giving up benefits like healthcare or childcare, and asked how providing more of those resources could mitigate risk in an innovation ecosystem, and if there were regions that could serve as models for these programs. Dr. Poole said childcare was an especially important issue, due to the undersupply of quality childcare at affordable prices, and he said subsidization would likely be required. He also observed that the increased unemployment benefits during the COVID-19 pandemic would be sufficient to allow people to become entrepreneurs rather than immediately look for a job, and expressed interest in watching whether the economy sees a surge in entrepreneurship after the crisis ends. He also agreed healthcare was a major obstacle to entrepreneurs leaving their existing jobs, but said he wasn't sure exactly what policies would best address these issues. Dr. Stephen said that healthcare needed to be decoupled from employment, and Dr. Poole agreed while adding that transportation issues for lower-income people were also a concern. He said that there are quite a few people from lower socioeconomic strata who have ideas but do not have the financial security to turn them into businesses. Ms. Jagoda Brunette said she was glad the group was discussing these issues, because regulatory issues that affect people's ability to mit-

igate risk have significant downstream effects on entrepreneurship, even when they don't appear to be directly connected.

Fiscal Constraints and the Need for Prioritization

Ms. Meier Wright said that due to the fiscal stresses to both states, which have to balance their budgets each year, and the federal government, it was not going to be possible to implement all of Dr. Poole's recommendations in the short term. She encouraged the group to think of ways to prioritize them, as well as turn their focus to state-level initiatives, as she did not see the political will or interest in innovation policy at the federal level right now. Dr. Poole agreed on the need to prioritize, but noted that the government is currently spending large amounts of money without an overarching strategy or careful consideration. He said many initiatives could be funded by redirecting existing spending to more considered ends. Ms. Choi added that many rules and regulations with a profound impact on the innovation landscape do not cost anything to change, such as altering the eligibility rules for SBIR/STTR grant recipients. She said that current bylaws force university employees who spend a majority of their time working for startups that spin out of university research to lose their eligibility for university employer benefits, discouraging researchers from becoming entrepreneurs. Dr. Stephen said this was emblematic of the federal government's tendency to err on the side of overregulation

to keep people from taking advantage of federal funding. He said he would rather see a system that was more open ended, even if it led to more abuse, because it would not throttle entrepreneurship and innovation with a "thicket" of regulations.

The Credibility and Messaging Challenge

Dr. Poole said that one of the biggest challenges in getting support for innovation initiatives at the state level was that previous initiatives did not result in the benefits, especially new jobs, that politicians were promised. He discussed Utah, which shut down its innovation initiative after its promoters failed to provide evidence of new jobs created, which he characterized as a misrepresentation of the real benefit of innovation investments. He urged the group to improve upon current messaging around the economic outcomes of innovation investment, including training the workforce of the future and extending capital to small businesses. He noted the political pressure to enact policies with immediate effects, and offered these metrics, as well as greater broadband access, as relevant innovation initiatives with the time horizons necessary to interest office holders. Ms. Meier Wright agreed that the proponents of innovation have created credibility problems by "promising things in the wrong way," as Dr. Poole put it. She described California's ongoing \$3 billion stem cell initiative that touted results within six years, even though it normally takes a decade or more for life sciences investments to come to fruition.

Broadband Access

Ms. Meier Wright said that the challenges in transitioning to remote work and education during the COVID-19 pandemic were highlighting the need for better broadband connectivity. She said it should be very high on the group's list of priorities, and warned that the "last mile" on infrastructure installation was currently not economically feasible for the private sector. Dr. Poole said he was facing similar challenges working with Appalachia, and emphasized the role connectivity plays in connecting talented people outside major urban centers to the tools they need to realize their potential. Ms. Choi added that the United States could not achieve an inclusive, technology-driven economy without equitable broadband access. Mr. Bates observed the juxtaposition in the discussion between the need for greater broadband access and the need for more air service. He discussed the challenges facing airlines, including discontinuations of service and layoffs, which he said could exacerbate air service challenges in smaller areas while also making broadband access even more important.

Concluding Thoughts: Framing Recommendations

Mr. Bates said that the idea behind this phase of Working Group calls was to generate a broad universe of potential recommendations, and then whittle down specific priorities after receiving feedback from the Commissioners and transitioning to a model of

co-chair led discussions. He added that the Commissioners' mandate was for impactful, bold ideas, but said the group needed to include both short-term and long-term solutions. Dr. Poole said that in his recommendations he had opted not to incorporate fiscal constraints, but instead focused on what scale new and existing programs would need to reach to make a measurable impact. He cited the Economic Development Agency's Build Regional Innovation Systems to Scale program as an example of a program that was too underfunded to make a difference at just \$20 million annually. He further added that several other agencies had similar programs that were scattered and underfunded. Ms. Meier Wright suggested framing the report as a response to a charge for big ideas, prioritized according to the immediate conditions created by the COVID-19 pandemic. She also urged including details on how to build accountability into and guarantee returns on investment for new programs. Ms. Choi said the group should be clear about the current funding needs and desired future funding levels programs, especially those administered by the states, will require. Dr. Poole observed that as large as the numbers being discussed were, the U.S. economy is \$20 trillion annually, and that it wasn't possible to steer something so large with lightly funded programs. He added that by better leveraging metrics, the group can best illustrate the positive impacts of programs and build support for them. Ms. Trimble said that these themes were emerging in the discussions of the other working groups as well, but from different angles.

Working Group 3 Calls May 19

Introduction

The Honorable Deborah L. Wince-Smith and Ms. Kathy Trimble welcomed the group, and Ms. Wince-Smith introduced the featured speaker, Ms. Julie Meier Wright of Collaborative Economics. Ms. Wince-Smith discussed Ms. Meier Wright's extensive experience in the field of innovation-led economic growth, including her service as Secretary of Trade in the administration of former California Governor Pete Wilson, where she had a substantial impact on the business environment for high-value investment and job creation. Ms. Meier Wright also served in economic development agency, of the city of San Diego, which has long been a leader in fostering a regional innovation ecosystem, and was studied by the Council in 1999 as part of its initiative on regional innovation.

Featured Remarks

Ms. Meier Wright opened her presentation by emphasizing the importance of the Council's work in encouraging national competitiveness, and noted that this imperative resonates with both political parties at all levels of government. She reminded the group that competition is global, and that competitiveness challenges require sustained effort to solve. However, she also urged action in areas like immigration reform, where policy changes could yield an immediate competitiveness impact. Ms. Meier Wright warned against complacency, noting that Britain had dominated the 19th Century as an unquestioned economic and political leader just as the United States had done for the 20th Century, but eventually ceded its global leadership. With China seeking to dominate the 21st century in a similar fashion, the United States cannot assume it will escape relative

WORKING GROUP PARTICIPANTS

Dr. Gerald Blazey
Northern Illinois University

Mr. Thomas Dailey
Dailey Strategic Advisors LLC

Dr. Lloyd Jacobs
University of Toledo
(Emeritus)

Ms. Rachel Jagoda Brunette
Lemelson Foundation

Ms. Vickie Lonker
Verizon

Ms. Christina Orsi
University at Buffalo

Mr. Greg Pellegrino
Deloitte

Mr. Bruce Sommer
University of Illinois
Springfield

The Honorable Branko Terzic
Berkeley Research Group

Ms. Anne Tucker
Georgia State University

Ms. Julie Meier Wright
Collaborative Economics

COUNCIL STAFF

The Honorable Deborah L.
Wince-Smith

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Mr. Tim Planert

decline if it does not take steps to ensure its own competitive standing. She also cautioned that competitiveness cannot be based on wishful thinking, lest regions waste millions of dollars on futile initiatives. She said she hoped to build her presentation on the remarks of Dr. Ken Poole of the Center for Regional Economic Competitiveness, who presented last week.

Ms. Meier Wright said that avoiding wishful thinking required an inclusive convening process featuring the right people and leaders, using good data and metrics, and focused on what is real, sustainable, and fundable. She emphasized the importance of location, even arguing that “the place is the product” and warning that a flawed regional ecosystem means a loss of market share or economic failure. She added that currently just 1 percent of U.S. counties account for 30 percent of all economic growth. To build regional innovation ecosystems, stakeholders should use SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, and clearly define the boundaries of their economic region and assess its assets. These include universities and companies located in the region, the supplier base, the existing workforce, and the physical infrastructure. Ms. Meier Wright said that adhering to this process builds the ownership and sustainability necessary for a strong business development plan.

Ms. Meier Wright discussed best practices in regional innovation, drawing on her work with the California Economic Strategy Panel, the Center for the New Economy, the Center for the Global Economy, the California Economic Summit, and the Cali Baja Bi-National Mega Region initiative. Commonalities in these successful endeavors included a data-driven understanding of regional economies, building on regional assets and strengths, and working across political boundaries and jurisdictions. She also stressed the long time-frame necessary to develop a robust innovation environment, tracing San Diego’s development from the early 1900s to the present decade. Similarly, the North Carolina Research Triangle was the product of decades of

sustained vision and commitment that lasted longer than any political term of office, and took decades to bear fruit. Over the years, however, North Carolina evolved from a tobacco and textile producer to a high tech hub with a robust innovation economy. Ms. Meier Wright said the required timeframe was not well understood by most observers. She also discussed the specific innovation ecosystem in San Diego, which has a massive cluster of 50-70 elite research institutions centered around the University of California, San Diego (UCSD). She said the Torrey Pines Mesa area is among the densest concentrations of research enterprises in the world, and generates \$14 billion annually in economic product and sustains 100,000 jobs.

Ms. Meier Wright concluded her remarks with an overview of common characteristics of successful regions. Successful innovators have a welcoming attitude, nurture entrepreneurs of all kinds, and promote seamless interaction between industry, labor, government, research labs, and academia. These regions also align workforce development programs with economic development goals and remain on the cutting edge of scientific research. She closed with a reminder that other nations covet what the United States has and are rapidly making up ground, again emphasizing the danger of complacency.

Maintaining Innovation in San Diego

Ms. Wince-Smith asked what concerns the San Diego region faces as it seeks to leapfrog into the next generation of innovative industries. Ms. Meier Wright noted that the area’s strengths in life sciences and wireless communication had positioned it well for the future of telemedicine and personalized medicine, especially following the COVID-19 pandemic. She did observe that companies in the region were concerned about maintaining the quality of the workforce, a lack of affordable housing that forces frontline responders to COVID-19 to commute long distances into the city, and ongoing infrastructure challenges that include roads quality, secure water supplies, and an airport with only one runway. Ms.

Meier Wright expressed optimism regarding an innovative university-industry partnership UCSD to address workforce development, and also recalled successful initiatives that arose from stakeholders sharing concerns at the California Economic Strategy Panel's meetings, including the creation of a world-class business school at UCSD. She also noted that addressing challenges is a continuous process with no finish line, and said it was important for stakeholders to be on the lookout for new issues that arise.

Sustaining Long-Term Investment

The Honorable Branko Terzic asked how regions without existing innovation ecosystems could ensure sustained commitment to economic development initiatives, given the challenges of coordination multiple political jurisdictions and the turnover in elected officials. Ms. Meier Wright said the process varied from region to region, but that bringing together public sector, private sector, and academic voices and giving them input from the beginning was key. She said the private sector plays an especially important role because they have a vested interest stemming from their investments in the region. She noted that UCSD's business school was established with the support of the founder of GenPro, who had committed \$250 million to the San Diego area. She added that there is often a need for training and economic base analysis in areas without robust innovation ecosystems, and that during this exploratory period it is critical to establish a collaborative process encompassing all stakeholders and developing passionate champions who are willing to see the project through.

The Importance of Collaboration

Ms. Vickie Lonker of Verizon said the infrastructure concerns facing San Diego provided an important perspective, and Ms. Meier Wright said that the region's topography constrains the number of major roads. Objections by one city to allowing an inter-

state to pass through it can negatively impact the entire region's transportation infrastructure. Building on this theme of cooperation, Ms. Meier Wright discussed the success of the Baja Cali Bi-National Mega Region project. Because the two counties involved did not allow the national border to become a barrier and collaborated on common challenges, they were able to come up with strong policy recommendations and secure funding from Asia, Europe, and the North American Development Bank.

Ms. Christina Orsi of the University at Buffalo discussed an initiative in the State of New York that tied economic development funding to regional strategic plans. These initiatives were successful because they pulled in cross-sections of the economy and brought together industry, academia, government, and the nonprofit sector to collaborate. The initiative in the Buffalo area was co-chaired by the University at Buffalo's President and a local business leader. Ms. Orsi added that having a long-term focus and a data-driven approach were also important factors. She discussed how the group adopted a smart growth strategy after new data showed that Buffalo was becoming more sprawling despite a shrinking population. Ms. Meier Wright praised the scope and funding of the New York initiative, and added that organizations she had worked with made use of "best practices" trips, where stakeholders visited regions with similar challenges and learned how they addressed them. She said these trips to cities like Orlando, San Jose, Portland, Seattle, Vancouver, and Austin both helped the group bond and gave members new creative ideas and wide-ranging professional contacts.

The Role of Place-based Service Providers

Dr. Lloyd Jacobs, President Emeritus of the University of Toledo, noted the contrast between the long-term vision required to transform a regional economy and the short tenures of elected officials and even university presidents. Ms. Meier Wright stressed the

importance of place-based service providers, like utilities and banks, that are unlikely to relocate and have a strong stake in the region's economic development, as anchors for initiatives. She added that academia and industry had less overall turnover than the public sector, especially when extending beyond the top executive levels to include thought leadership more generally. She noted that San Diego was able to thrive despite hosting just two Fortune 100 companies because of its strong startup ecosystem and a large number of organizations that have commitments to economic development beyond the office of any one individual. Dr. Terzic added that utilities have an especially strong interest in economic development because the nature of their industry means they cannot be wealthier than the region they serve. He discussed how utilities in Wisconsin have pooled their resources to form economic development arms, and the role utilities played in funding Pittsburgh's economic transformation from a steel town into a financial and medical center. Ms. Meier Wright agreed and added that San Diego strives to include representatives from different industries and sectors, as well from organizations dedicated to building up entrepreneurial communities, on its economic development boards. She said that Dr. Michael Porter, when working for the Council on its regional innovation initiative in the late 1990s, singled out collaboration as the key to San Diego's success, and added that the Council could play a role in fostering that collaboration in other locations.

Geographically Inclusive Growth

Ms. Wince-Smith praised the discussion's focus on geographically inclusive growth, as it was a major point of emphasis from the National Commissioners in their August 2019 meeting. She added that while programs like the National Science Foundation's S-Corps program have done a good job fostering inclusive growth, there remains a vast disparity in venture capital investment across the United States, with most firms investing only on the coasts. Ms. Wince-Smith also discussed a recent Wall Street Journal editorial highlighting the disparity in COVID-

19 lockdown compliance between people who are able to work from home and financially comfortable and those who are not. Ms. Meier Wright described a visit to Johannesburg, South Africa, during which she witnessed extreme poverty just outside the city, and the challenges these areas faced in attracting investment. She said similar dynamics were at play in the United States, and gave the example of neighboring Imperial County, which was struggling to attract the investment that San Diego County received. Ms. Meier Wright discussed the importance of creating an environment and workforce that attracts firms, and how the Economic Development Agency helped Imperial County develop its workforce during the Baja Cali Bi-National Mega Region project. These investments in workforce training, combined with the area's weather and a state commitment to renewable energy, led to San Diego Gas & Electric investing in a renewable energy pipeline in Imperial County. She said this example highlighted both the opportunity of regional development and the patience necessary to execute it.

Reopening After COVID-19

Dr. Jacobs asked what the process of reopening after the COVID-19 pandemic would look like, and Ms. Meier Wright said that while she understood the public's anxiety and resentment, failure to comply with data-informed lockdown policies will lead to the healthcare system being overwhelmed. She said the only way to responsibly reopen will be to use data as a guide for reopening regions, and for when to shut them down again in the face of resurgences. Because the pandemic did not hit the whole country at the same time, it will not end at the same time everywhere either. Ms. Wince-Smith discussed the challenges of data integrity, noting debate over the validity of social distancing recommendations within the scientific community, and the emerging view that the disease may be one of the vascular system rather than a respiratory illness, which has implications for the use of invasive ventilators.

The Post-COVID-19 Normal

Ms. Orsi discussed pre-COVID-19 trends of young people moving to dense urban areas, and how the pandemic could lead to a migration out of denser cities toward less dense cities, especially as working from home becomes more common and viable. She noted that Buffalo had the physical infrastructure of a city twice as large due to population loss, which might make it attractive for people looking for more space. Ms. Meier Wright asked how the Council would shape its recommendations for the “new normal” and noted an opportunity to investigate which cities could thrive in a world where people seek lower density living and the ability to work remotely. Ms. Wince-Smith said the Council would build on emerging recommendations for the near term about reopening the economy safely and securely, and that it was essential to take advantage of the opportunity to make needed reforms. She said the crisis had highlighted the impediments in the nation’s energy and broadband infrastructures, and how investment in universal broadband would have dramatic implications for the urban-rural relationship and associated class divide. Dr. Terzic concurred on the socioeconomic implications, noting that in wealthy Northern Virginia the virus was simply an inconvenience while it was devastating elsewhere, and how younger people were leaving densely populated areas like New York City as the combination of costs and crowding outweighed the benefits of living there. He predicted the country would be rethinking quality of life and that a new normal would emerge. Ms. Meier Wright added there could be implications for mass transit as people fear density, and that some industries might not come back from the crisis.

Leveraging San Diego’s Veteran Population

Mr. Greg Pellegrino of Deloitte discussed San Diego’s large veteran population, and how it impacts the region’s competitiveness. He noted that in contrast to Michigan, where many college graduates leave the region, veterans who come to San Diego tend to stay, which provides a substantial asset for companies like Deloitte. Ms. Meier Wright said that many jobs benefit from the skills veterans bring, but that even officers leave the service without experience applying for civilian jobs, preparing resumes, and translating their skills into the private sector. She discussed an innovative program in San Diego that aims to help veterans develop these skills. Ms. Trimble noted that studies indicated that those transitioning out of the military differ socioeconomically from other workforce entrants because they receive retirement pay and robust medical support. She said that San Diego provides very attractive incubating infrastructure to veterans than induces them to stay. Ms. Meier Wright added that veterans have experience in “soft skills” like discipline and working in teams that are valuable in the corporate world.

Concluding Thoughts

Ms. Wince-Smith thanked the group for its discussion and said there would be one more session this week, followed by a hiatus. During this hiatus the Council will focus on synthesizing the recommendations emerging from the Working Group sessions and preparing for the second phase of Working Group discussions, which will begin the week of June 22.

Working Group 3 Calls May 21

Introduction

Ms. Kathy Trimble welcomed the group and introduced the featured speaker, Ms. Julie Meier Wright. She noted Ms. Meier Wright's long affiliation with the Council and her expertise in state and regional economic development through innovation. She also reminded the group that the weekly calls would go on hiatus until the week of June 22, when once-weekly calls will resume as part of Phase II of the Working Group sessions.

Featured Remarks

Ms. Meier Wright opened her remarks by expressing support for the Council's work, characterizing it as critically important and as having the potential to transcend partisan divisions with its focus on facts and data. She also warned that the United States faces increasingly stiff global competition, and that

China and India have massive demographic advantages over the United States. She stressed the importance of ensuring policies keep up with surrounding world events, and that the United States needed to begin acting now to address many competitiveness challenges that require long-term action to address. She also discussed areas, like immigration, where unfavorable policies could and should be reformed quickly.

Ms. Meier Wright used the decline of Britain from its 19th Century status as the leading innovator, economic powerhouse, and political leader, as well as examples of historic empires and civilizations from Greece and Rome to France and Spain, to illustrate the dangers of complacency. She said that while the United States was the unquestioned hegemonic power of the second half of the 20th Century, it cannot take for granted that it will escape the fate of

WORKING GROUP PARTICIPANTS

Dr. Branden Brough
Lawrence Berkeley National
Laboratory

Mr. Mike Cassidy
Emory Biomedical Catalyst

Dr. Lee Cheatham
Pacific Northwest National
Laboratory

Ms. Ji Mi Choi
Arizona State University

Dr. Peter Dorhout
Kansas State University

Ms. Ann Gabriel
Elsevier

Ms. Rachel Jagoda Brunette
Lemelson Foundation

Mr. Tad Lipsky
Antonin Scalia Law School
George Mason University

Dr. Anthony Margida
TechGrit

Dr. Cheryl Martin
Harwich Partners

Dr. Ken Poole
Center for Regional Economic
Competitiveness

The Honorable Branko Terzic
Berkeley Research Group

Dr. Rao Unnava
University of California-Davis

COUNCIL STAFF

Mr. Bill Bates

Ms. Kathy Trimble

Mr. Gourang Wakade

Mr. Tim Planert

these other nations if it fails to address crucial issues. She added that China has been very clear in its plans to become the hegemon of the 21st century.

Referencing Dr. Ken Poole of the Center for Regional and Economic Competitiveness's presentations from the previous week, Ms. Meier Wright expressed a desire to build upon their themes and recommendations by focusing on turning them into actionable policies. She warned against wishful thinking by regions, and said that many state and local governments have wasted millions of dollars on development strategies with no chance for success. She identified the keys to successful development as an inclusive convening process with input from across sectors and stakeholders, strong and committed leadership, quality measurements and data, and a focus on policies that are "real, sustainable and fundable."

Ms. Meier Wright said that for regional development, "the place is the product," not political jurisdictions. She warned that if the product is flawed, a region will lose market share or fail altogether, and she emphasized that sound data is key to a successful development strategy. In particular, she recommended SWOT (strengths, weaknesses, opportunities, threats) analysis of a region's economic base and a frank comparison with the competition. To illustrate the importance of developing regional innovation clusters, she referenced the fact that just 1 percent of U.S. counties account for 30 percent of all economic growth.

Drawing on her service as California Secretary of Trade and her work as part of several different regional development organizations in California, Ms. Meier Wright discussed best practices in building regional innovation ecosystems. An overarching key is bringing together the right leaders and stakeholders and building ownership and sustainability into the development plan. She said that regions need to examine and leverage research institutions, the existing workforce, workforce training capabilities, local companies and supplier networks, and physical infrastructure to develop or expand an industry clus-

ter. She also urged cooperation across jurisdictional boundaries, discussing her work on the Cali-Baja Bi-National Mega Region project. In this endeavor, San Diego and Imperial Counties in California collaborated with the government of Baja California in Mexico to address shared infrastructure challenges and attract investment that benefitted both sides of the border. Ms. Meier Wright said this example illustrated how political boundaries need not be obstacles for regional development.

Another element that Ms. Meier Wright identified as crucial is long-term commitment. She discussed San Diego's innovation ecosystem, which has evolved over 120 years continuously since the founding of the Scripps Oceanographic Institute in 1900. She also cited the example of North Carolina's Research Triangle Park, where it took decades of state support and investment from three large universities to attract the workforce and companies needed to develop an innovation cluster. While these efforts last far longer than any elected official's term in office, they can have dramatic long-term results, as evidenced by the Research Triangle Park's transformation of North Carolina from a tobacco and textile producer into an innovative technology hub. Building upon the concept of hubs, Ms. Meier Wright discussed how San Diego uses GIS mapping to visually illustrate the clustering of industries. She noted that the hub around the University of California, San Diego (UCSD) is compact enough to be walkable but contains one of the highest concentrations of research institutions in the world. In 2015, this cluster contributed \$14 billion and 100,000 jobs to the regional economy.

Ms. Meier Wright also discussed general characteristics of the most successful innovation regions. They maintain welcoming attitudes and a commitment to fostering entrepreneurship of all kinds, and they facilitate seamless interaction among academia, research facilities, labor, industry and government. These regions also align their workforce development and economic development strategies, and remain on the cutting edge of new technology. She discussed the possibility that these ecosystems might be impacted

by COVID-19, but noted that similar predictions following the September 11 attacks did not materialize. She closed her presentation with another warning that the United States cannot be complacent. She said other nations covet what the United States has and are investing heavily to get there. Ms. Meier Wright urged stakeholders from across the country to come together and help regions that have been left behind find effective ways to innovate.

What and How to Measure Innovation

Dr. Ken Poole of the Center for Regional Economic Competitiveness discussed the capacity of different regions to develop innovation plans. He said that larger metropolitan areas had the necessary industry clusters and technology councils to form the organizational backbone for such efforts, but that many smaller regions had nascent or limited ecosystems. He discussed the proposal by the Brookings Institution and the Information Technology and Innovation Foundation to pick ten “second-tier” metropolitan areas and invest heavily in them, and how this proposal furthered the idea that innovation is inherently concentrated. He characterized Ms. Meier Wright’s work as a “roadmap” for all the other regions that would not benefit from the second-tier hubs proposal, and asked how to ensure that these regions had the ecosystem in place to support economic development. Ms. Meier Wright said that the Council needs to help lead a national effort to change the conversation from one of ideology to one of ideas and data. Dr. Poole added that it is difficult to measure innovation directly, and that proxies like academic publications and patents don’t always capture the true nature of innovation, which is impact on people’s lives. Ms. Meier Wright said it was crucial to study a region’s economic base and communicate that information to local policy makers, who often learn things about their region they did not know before. She said that her organization, Collaborative Economics, provides economic base analysis for regions that prepares the groundwork for in-depth investigations of industries where a region has a competitive edge. She added that many regions have

at least some competitive advantages, but that without identifying them through data they risk going on “wild goose chases” after the wrong things.

Successes and Failures in De Novo Innovation Ecosystems

Dr. Poole agreed with the importance of building on existing strengths, while discussing exceptions where regions were able to build innovation ecosystems out of nothing. He discussed growing up in the Research Triangle area and seeing the dramatic transformation of the area into a technology hub, as well as Upstate South Carolina, where concerted state efforts to court BMW led to the development of an automotive manufacturing cluster. He said that commitment to the innovation process from a whole community can allow for the successful development of an innovation ecosystem from scratch, albeit at very high cost and risk. Ms. Meier Wright added two examples of similar attempts, one successful and one not successful. Rio Rancho, New Mexico spent enormous amounts of money and took on lots of debt to invest in attracting an Intel wafer fab facility, but even after thousands of employees flocked to the facility, the city was unable to generate the economic activity needed to repay its debts. Conversely, Alabama’s state government invested heavily in attracting Mercedes-Benz to the state, and despite taking an enormous financial risk were able to establish an industry cluster, as Mercedes began investing more heavily and other car makers were attracted to the region.

COVID-19, Virtualization and Opportunities for Regions

Ms. Ann Gabriel of Elsevier asked if the COVID-19 crisis and its associated acceleration of the move to virtual work would provide opportunities for the democratization of innovation away from traditional technology clusters. Ms. Meier Wright said that this transition would be easier for companies that are already used to using technology and dealing with remote work, and that regions with good qualities of

life will benefit the most, as workers can now live in regions with lower costs of living and entertainment and cultural amenities while working in cutting edge industries. She discussed the example of Qualcomm establishing a remote workforce in Colorado because skilled employees preferred to live there, and how Intel based its investment decisions on the quality of life that regions would provide for employees.

Ms. Trimble noted that many midwestern cities are looking to attract high tech workers, but noted that with lower salaries these cities would need to identify other amenities to attract that talent. Ms. Meier Wright noted that many of these places have lower costs of living, and Ms. Ji Mi Choi of Arizona State University expressed the hope that future industry clusters would form around communities based on quality of life factors, rather than proximity to a research university or corporate headquarters. She identified a dual benefit from this potential development, as people and organizations invested in quality-of-life relevant assets like K-12 schools and cultural institutions and virtual work enabled the democratization of innovation and a wider distribution of its benefits. She added that Arizona had already experienced many of these benefits as its lower cost of living attracts workers from California. Ms. Meier Wright said that regions did not need to achieve the success of Silicon Valley or even San Diego to be successful, and said that she hoped younger business tycoons became invested in philanthropy. She discussed the high volume of potential philanthropists in Silicon Valley, and said that it was important for them to give back to the communities that enabled their success by contributing to educational and cultural institutions.

Different Ways to Benefit from Innovation

Dr. Poole noted that regions did not need to be conducting cutting edge research and development in order to leverage innovation to drive productivity. He said that while it is not feasible to recreate the success of research universities like Stanford or MIT, or to develop the research clusters of Boston and

Silicon Valley, there are many opportunities to create value by bringing ideas developed in those regions to the commercial market. He discussed the medical device clusters in Phoenix and the Twin Cities, and how both of them played important regional and national roles in scaling certain kinds of innovative ideas and technologies for the market. Dr. Poole said that deliberately focusing on this scaling role could be a viable means of improving productivity and quality of life in many regions.

Building Innovation Capacity Across Industries and Regions

Ms. Meier Wright asked participants how to create economic opportunity in other industries, noting the significant disparity between the importance of frontline workers in the COVID-19 crisis and their compensation. Dr. Anthony Margida of TechGrit said that the crisis has led to not only the emergence of virtual tools, but a growing familiarity with them among the general public. He said that many second-tier regions could become self-sufficient based on the removal of geographic limitations, with small towns being able to anchor an innovation ecosystem in a broader region, contingent on a high quality of life and leveraging unique regional capabilities, institutions, and infrastructure. He added that these assets will not come together organically, and that there are tremendous opportunities in the intentional study of regional strengths and capabilities and using this research to inform regional ecosystem architectures. Ms. Meier Wright said that geographic boundaries are not disintegrating, but that they are fluid. She added that many metropolitan areas are thinking differently about their regional boundaries, and extending assistance and collaboration to neighboring regions. She discussed San Diego's working with Imperial County, long plagued by high unemployment, to identify workforce needs for biofuel farming. Using Economic Development Agency grant money, they were able to establish the infrastructure and workforce training necessary to establish biofuel pipelines in Imperial County to supply San Diego with clean energy.

Balancing National and Regional Priorities and Leveraging Regional Strengths

Dr. Branden Brough of Lawrence Berkeley National Laboratory said that while on a regional level every region should strive to be competitive, it is not realistic for every part of the country to build an elite innovation ecosystem. He asked where the balance should be between equal opportunity for innovation and targeted priority investments. Dr. Rao Unnava of the University of California, Davis echoed this sentiment, and asked if committing to at least one investment project in every state to start a cluster based on regional strengths would split this divide effectively. Ms. Meier Wright said that in addition to overcoming opposition to the idea of prioritizing investment sectors in some quarters, it was important to focus on targeting investment to struggling regions. She said, for example, that Imperial County needs investment in innovation more than San Diego does, and suggested a model where there is support at the national level for initiatives that are planned at the regional level.

Ms. Trimble said it was important to think about core competencies in a region, and use an overarching national policy to optimize regional development by ensuring a match between investment activity and region's indigenous or constructed strengths. Dr. Poole said that having cutting edge, state-of-the-art innovation throughout the country was vital to national strategy, but that a vibrant national economy depends on specialized regional clusters in different industries. He noted the importance of partnership, and the challenges caused by the erosion of the U.S. manufacturing base. Dr. Poole also suggested determining the focus of regions locally while adopting a national strategy that recognizes the importance of successful regional ecosystems. Ms. Meier Wright discussed a National Science Foundation initiative that gathers data on innovation while dividing the country into four broad regions. She said this initiative has encouraged innovation-rich areas to form

partnerships with research universities in their wider "region" to address critical challenges like transportation infrastructure. She said the COVID-19 pandemic had shown the vulnerability of America's food supply chain, and asked if there was a way to shore it up by leveraging the agricultural capabilities of the Midwest.

Reviving or Retooling Historic Industries

The Honorable Branko Terzic of Berkeley Research Group discussed the ways in which regions can revive or retool historic industries to revitalize their economies. He noted that nearly every city has a historical economic base, and was often settled because of its strategic location for a particular industry, but that technological changes and failures to adapt obviated these advantages. However, he noted that it was possible to leverage existing capabilities for new ends, giving the example of the French company Hermes. Originally a buggy whip manufacturer, as buggy whips became obsolete the company, conceiving of itself a leather maker, not a buggy whip maker, turned to making expensive belts and purses and became a dominant player in the fashion world. Dr. Terzic said that engineering these turnarounds will require a multi-pronged approach, including private equity and venture capital. He added that harnessing technology is essential to continue prospering. Rochester lost its place in the film and copier industries despite being the home of Kodak and Xerox because those firms did not pursue digital video and photography technology. Ms. Meier Wright said rich collaboration among different levels of society was important for a region's long-term prosperity, as was understanding that the world economy is always changing and a region must constantly be adapting and building up capacity to thrive as industries change.

Concluding Thoughts: Equipping Regions to Develop Innovation Capacity

Dr. Poole referenced his suggestion from the previous week's discussions of leveraging the Economic Development Agency to invest in at least one innovation cluster in each metropolitan area, and to support the organizational infrastructure necessary to further develop those clusters. Ms. Meier Wright said there was a real opportunity for the Council to make an impact in second-tier counties, not by solving their problems for them, but by helping them acquire the tools necessary to solve those problems themselves. She added that this would require those regions to rethink their identity and boundaries and move forward with an aggressive development strategy. Ms. Trimble reminded the group that the Working Group is adding new members for Phase II, and encouraged participants to refer or recommend colleagues whose perspectives and expertise would help the Council explore new topics.

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Deputy Laboratory Director for Science
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Idaho National Laboratory

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Innovation & Economic Impact
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Interim Vice President for Economic
Development and Innovation
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Argonne National Laboratory

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University of Illinois System

Working Group 1

Developing and Deploying at Scale Disruptive Technologies

(as of May 22, 2020)

Mr. Edward Agne

President
Communications Strategy Group Inc.

Dr. Ramprasad Balasubramanian

Associate Provost for Decision Support
& Strategic Initiatives
University of Massachusetts Dartmouth

Mr. Bill Briggs

U.S. & Global Chief Technology Officer
Deloitte

Ms. Margaret Brooks

Sr. Manager, Enterprise Innovation
& 5G Solutions
Verizon

Dr. Thomas Campbell

Founder and CEO
FutureGrasp, LLC

Mr. Dave Copps

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Ms. Candace Culhane

Program/Project Director
Los Alamos National Laboratory

Dr. Jennifer Curtis

Dean of the College of Engineering
University of California, Davis

Mr. Eric Cylwik

Virtual Construction Engineer, Sr.
Sundt Construction

Mr. Robert Dixon

Former Global Chief Information Officer
and Senior Vice President
PepsiCo

Mr. Andre Doumitt

Director, Innovation Development
The Aerospace Corporation

Dr. Gloria Gonzalez-Rivera

Professor of Economics
University of California, Riverside

Mr. Jon Greaves

Chief Technology Officer
QTS Data Centers

Ms. Leah Guzowski

Director for Industry Engagement
Idaho National Laboratory

Mr. Ryan Haines

Virtual Construction Application
Developer
Sundt Construction

Ms. Maggie Hallbach

Vice President—State, Local & Education
Markets
Verizon Business Group

Dr. Alan Hevner

Distinguished University Professor and
Eminent Scholar; and
Citigroup/Hidden River Chair of
Distributed Technology
University of South Florida

Dr. Nathan Hillson

Computational Staff Scientist and
Department Head of Biodesign
Lawrence Berkeley National Laboratory

Dr. Paul Hommert

Former Director
Sandia National Laboratories

Mr. Gerardo Interiano

Head of Government Relations
Aurora Innovation

Dr. Anne Marie Knott

Robert and Barbara Frick Professor of
Business, Olin Business School
Washington University in St. Louis

Mr. Derek Koecher

Vice President, Strategy & Planning
Verizon

Mr. Raaj Kurapati

Executive Vice President and Chief
Financial Officer
University of Memphis

Ms. Sara Lawrence

Program Director, Innovation Led
Economic Growth
RTI International

Dr. Kelvin Lee

Gore Professor of Chemical and
Biomolecular Engineering
University of Delaware; and
Institute Director
National Institute for Innovation in
Manufacturing Biopharmaceuticals

Dr. Edlyn Levine

Lead Physicist,
Emerging Technologies Group
The MITRE Corporation; and
Research Associate, Department
of Physics
Harvard University

Dr. Laurie Locascio

Vice President for Research
University of Maryland

Dr. Sasikanth Maniapatruni

Chief Technology Officer
Kepler Computing

Dr. Fred Mannering

Associate Dean for Research, College of
Engineering; and
Professor of Civil and Environmental
Engineering
University of South Florida

Dr. Theresa Mayer

Executive Vice President for Research
and Partnerships; and
Professor of Electrical and Computer
Engineering
Purdue University

Dr. Carolyn Meltzer

William P. Timmie Professor and Chair,
Department of Radiology, School of
Medicine; and
Executive Associate Dean of Faculty
Academic Advancement, Leadership and
Inclusion, School of Medicine
Emory University

Mr. Mark Minevich

Principal Founder
Going Global Ventures

Mr. Gregory Morin

Director of Strategy
Argonne National Laboratory

Dr. David Norton

Vice President for Research
University of Florida

Mr. Marcus Owenby

AVP Innovation and Customer
Experience
AT&T

Dr. Sethuraman Panchanathan

Executive Vice President, ASU
Knowledge Enterprise Development and
Chief Research and Innovation Officer
Arizona State University

Lieutenant Colonel Stewart Parker

Senior Military Fellow
Center for a New American Security

Dr. William Pike

Division Director, Computing and
Analytics
Pacific Northwest National Laboratory

Dr. Albert Pisano

Dean and Walter J. Zable Distinguished
Professor, Jacobs School of Engineering
University of California, San Diego

Dr. Ravi Prasher

Associate Laboratory Director, Energy
Technologies Area and Division Director,
Energy Storage and Distributed
Resources Division
Lawrence Berkeley National Laboratory

Dr. Gary Pratt

Chief Information Officer
Kansas State University

Dr. Arun Rai

Regents' Professor, J. Mack Robinson
College of Business; and
Director, Center for Digital Innovation
Georgia State University

Dr. Charles Riordan

Vice President, Research, Scholarship
and Innovation and Professor of
Chemistry & Biochemistry
University of Delaware

Dr. Gene Robinson

Director, Carl R. Woese Institute for
Geonomic Biology
University of Illinois at Urbana—
Champaign

Dr. Robie Samanta Roy

VP Technology, Government Affairs
Lockheed Martin

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Dean, College of Engineering; and
Professor, Electrical and Computer
Engineering
Carnegie Mellon University

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Defense Analytics

Dr. Roland Stephen
Director, Center for Innovation Strategy
and Policy
SRI International

Dr. Anthony Tether
Former Director
Defense Advanced Research Projects
Agency

Dr. Neil Thompson
Research Scientist,
MIT Computer Science and Artificial
Intelligence Lab &
MIT Initiative on the Digital Economy
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Vice President for Research and
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Auburn University

Dr. Neal Woodbury
Professor and Director, School of
Molecular
Sciences and Chief Science Officer,
Knowledge Enterprise
Arizona State University

Working Group 2

Exploring the Future of Sustainable Production and Consumption

(as of May 22, 2020)

Ms. Charlotte Alexander

WomenLead/Connie D. McDaniel Chair and Associate Professor of Law and Analytics, J. Mack Robinson College of Business
Georgia State University

Dr. Carlotta Arthur

Director, The Clare Boothe Luce Program for Women in STEM
Henry Luce Foundation

Dr. T.J. Augustine

Vice Chancellor for Innovation
University of Illinois at Chicago

Mr. Leslie Boney

Vice Provost and Director, Institute for Emerging Issues
North Carolina State University

Dr. Marcelle Chauvet

Professor of Economics
University of California, Riverside

Dr. Sue Clark

Chief Science and Technology Officer, Energy and Environmental Directorate
Pacific Northwest National Laboratory

Dr. Carol Dahl

Executive Director
The Lemelson Foundation

Dr. James Davis

Vice Provost, Information Technology & Chief Academic Technology Officer
University of California, Los Angeles

Ms. Tiffany Davis

Human Resources Director
Southern Company Gas

Dr. Jasbir Dhaliwal

Executive Vice President for Research and Innovation
University of Memphis

Dr. Helene Dillard

Dean of the College of Agricultural and Environmental Sciences
University of California, Davis

Ms. Ellen Donaldson

Community Advocate and Philanthropist
Former Executive, Healthcare Communications and Pharmaceutical Industries

Dr. Ricardo Ernst

Baratta Chair in Global Business and Co-Director, Global Logistics Research Program
Georgetown University

Mr. Frank Frontiera

Director Global Supply Chain
Verizon

Dr. Thomas Gardner

Chief Technology Officer, HP Federal
HP Inc.

Dr. Michael Goodman

Professor of Public Policy and Executive Director, Public Policy Center
University of Massachusetts Dartmouth

Ms. Erin Guthrie

Director
Illinois Department of Commerce and Economic Opportunity

Dr. Jerry Haar

Professor and Executive Director for the Americas,
College of Business
Florida International University

Dr. Gary Henry

Dean of the College of Education and Human Development and Professor, School of Education and the Joseph R. Biden, Jr. School of Public Policy & Administration
University of Delaware

Ms. Ciannat Howett

Associate Vice President
Resilience, Sustainability, and Economic Inclusion
Emory University

Mr. Bill Johansen

Senior Advisor to the Deputy Laboratory Director for Research
Lawrence Berkeley National Laboratory

Mr. Noel Kinder

Chief Sustainability Officer
Nike

Mr. Jonathan King

Assistant to Executive Vice President and Chief Administrative Officer
Southern Company Gas

Dr. Chauncy Lennon

Vice President for the Future of Learning and Work
Lumina Foundation

Ms. Amy Lientz

Director for Energy Industry Supply Chain
Idaho National Laboratory

Ms. Stacy Lippa

Former Group Vice President, Food Supply Chain
Target

Dr. Kathleen Merrigan

Executive Director, Swette Center for Sustainable Food Systems
Arizona State University

Dr. Eric Rasmussen

CEO
Infinitum Humanitarian Systems

Mr. Jason Smith

President & CEO
Manhattan Area Chamber of Commerce

Dr. James Stock

Distinguished University Professor and Frank Harvey Endowed Professor of Marketing; and
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University of South Florida

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Arizona State University

Dr. Maya Trotz

Professor, Environmental Engineering, College of Engineering; and
Faculty Fellow, Kiran C. Patel Center for Global Solutions
University of South Florida

Ms. Erica Volini

Global Human Capital Leader
Deloitte

Dr. Paul Wolpe

Raymond F. Schinazi Distinguished Research Chair in Jewish Bioethics; and
Director, Center for Ethics
Emory University

Dr. Mohammad Zaidi

Strategic Advisory Board Member
Braemar Energy Ventures

Working Group 3

Optimizing the Environment for the National Innovation System

(as of May 22, 2020)

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CIO, Consumer & Small Business & Wealth Technology
Bank of America

Dr. Robert Bishop

Professor and Dean, College of Engineering
University of South Florida

Dr. Gerald Blazey

Vice President for Research and Innovation Partnerships
Northern Illinois University

Dr. Branden Brough

Deputy Director, The Molecular Foundry
Lawrence Berkeley National Laboratory

Ms. Rachel Jagoda Brunette

Program Officer
The Lemelson Foundation

Mr. Jim Carlisle

Senior Vice President,
Federal Government Relations
Bank of America

Dr. Russell Carrington

Chief Technology Transfer Officer
Lawrence Berkeley National Laboratory

Dr. Lee Cheatham

Director, Technology Deployment and Outreach
Pacific Northwest National Laboratory

Ms. Ji Mi Choi

Associate Vice President,
Entrepreneurship and Innovation, Office of Knowledge Enterprise Development
Arizona State University

Mr. Thomas Dailey

Founder
Dailey Strategic Advisors LLC

Dr. Peter Dorhout

Vice President for Research
Kansas State University

Mr. William Eggers

Executive Director,
Center for Government Insights
Deloitte

Ms. Laure Bachich Ergin

Vice President and General Counsel
University of Delaware

Dr. Aaron Friedberg

Professor of Politics and International Affairs
Princeton University

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While the players may have changed since its founding in 1986, the mission remains as vital as ever—to enhance U.S. productivity and raise the standard of living for all Americans.

The members of the Council—CEOs, university presidents, labor leaders and national lab directors—represent a powerful, nonpartisan voice that sets aside politics and seeks results. By providing real-world perspective to Washington policymakers, the Council's private sector network makes an impact on decision-making across a broad spectrum of issues from the cutting-edge of science and technology, to the democratization of innovation, to the shift from energy weakness to strength that supports the growing renaissance in U.S. manufacturing.

The Council's leadership group firmly believes that with the right policies, the strengths and potential of the U.S. economy far outweigh the current challenges the nation faces on the path to higher growth and greater opportunity for all Americans.

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900 17th Street, NW
Suite 700
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+1 (202) 682-4292
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