

IMPLEMENTING SUPPLY CHAIN RESILIENCY

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED SEVENTEENTH CONGRESS

FIRST SESSION

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JULY 15, 2021
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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED SEVENTEENTH CONGRESS

FIRST SESSION

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IMPLEMENTING SUPPLY CHAIN RESILIENCY

THURSDAY, JULY 15, 2021

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 10:32 a.m., in room SR-253, Russell Senate Office Building, Hon. Maria Cantwell, Chair of the Committee, presiding.

Present: Senators Cantwell [presiding], Klobuchar, Blumenthal, Peters, Tester, Sinema, Rosen, Hickenlooper, Wicker, Thune, Fischer, Sullivan, Blackburn, Young, and Scott.

OPENING STATEMENT OF HON. MARIA CANTWELL, U.S. SENATOR FROM WASHINGTON

The CHAIR. The U.S. Committee on Commerce, Science, and Transportation will come to order. Thank you all for being here. We have a distinguished group of witnesses today to talk about a very important issue to us in the United States of America, that is the state of competitiveness of our supply chain and its resiliency for the future.

Each one of our witnesses, the distinguished Dr. Gary Gereffi, Dr. James Lewis, Mr. Rich Aboulafia, Dr. Dario Gil, Mr. William Lex, I am sorry, Taylor, thank you, and Mr. John Miller all offer a variety of perspectives on the importance of this issue. I can say for me, in the state of Washington, the aviation supply chain is something we are very proud of. More than 150,000 people work in that supply chain that continue to innovate and create new products that, as Mr. Aboulafia says in his testimony, that is where the innovation is happening in the supply chain.

That is why we just recently passed the now called U.S. Innovation and Competition Act, USICA, that we are trying to negotiate with our House colleagues because we believe in making an increased investment in the supply chain. So I am sure we are going to hear today also about the challenges we face in the semiconductor sector, an aspect of our supply chain in which we saw great shifts over the last several decades and the consequence is obviously less jobs in the United States of America.

So needless to say, I think Congress has caught on that the supply chain is key to our economic strategy and that a robust supply chain in the United States of America means we are going to continue to have robust employment in the United States of America. Without the resiliency of the supply chain, it could be complicated as to, given the experience of the COVID-19 pandemic, whether products can be delivered in a timely fashion, whether our services

and security could be impacted, and just how important it is that we have a strategy for a global economy in which a variety of products and services can be delivered in a much more competitive fashion than in the past.

That means the investments that the Department of Commerce should make are important. USICA took several steps to contribute to the resiliency of the supply chain, and incentivize domestic semiconductor manufacturing, establish a supply chain resiliency and response office within the Department of Commerce. It makes tremendous investment in the Department of Commerce National Science Foundation, and Department of Energy to support R&D in translating inventions into products, creating regional technology hubs, and expanding the workforce and our innovation economy.

And these important facilities like our Pacific Northwest National Laboratory, can help with spinoffs of new technology that become critical parts of our R&D and domestic supply chain. Also, our NIST funded manufacturing extension programs can help in working with developing resiliency and supply chain strategies so that we continue to have not just potential customers and supply chain connectors, but understand, again, how we can best innovate and stay competitive. So I look forward to hearing the testimony from our witnesses today.

I feel very excited to have this distinguished group in front of us, and I hope our colleagues will all learn from the information here. Senator Wicker, I am not sure 20 years ago that we would have had the same hearing. I see our colleague, Senator Young here, the key sponsor behind what was then the Endless Frontier Act.

I am not sure we would have been having the same conversation. But the world has changed. Supply chains have changed and are changing and I look forward to how the United States stays very competitive here. Thank you.

**STATEMENT OF HON. ROGER WICKER,
U.S. SENATOR FROM MISSISSIPPI**

Senator WICKER. Thank you, Madam Chair, and good to be here with you today and to be with this distinguished panel. What do we mean when we say supply chain? It is the process that starts with raw materials and ends with sale or consumption. Along the way, there are various steps, materials, refinement, manufacturing and distribution.

Resilient supply chains can withstand and quickly recover from disruptions, and we have had disruptions, but they also include, in addition to infectious disease outbreaks, severe weather, international conflict, things like that. In recent decades, our manufacturing capacity has declined significantly. Between 2000 and 2010, manufacturing jobs were cut by one-third, with small businesses heavily impacted. And as we all know, that is where we create the jobs in the United States of America, small business.

As global competition has increased, control over our supply chains has fallen into the hands of fewer and fewer countries, most notably China. Such geographic concentration of supply chains has left many U.S. companies vulnerable to disruption, something we are now acutely experiencing. Helping U.S. companies identify, and

address areas of vulnerability will require strong partnerships and international partners.

The Federal Government can also help by investing in R&D and workforce development to make sure new innovations are conceived and developed here in the United States. Taylor Machine Works in Mississippi is one great example of a U.S. company conducting R&D in the materials handling industry and whose innovations are today being replicated around the world.

This committee took important steps, as the distinguished chair mentioned, in passing the Endless Frontier Act, now known as the United States Innovation and Competition Act, or USICA. I don't like that as well. This bill, authored by Senator Young, passed the Senate by a vote of 68 to 32. The legislation would create a new supply chain resiliency program within the Department of Commerce to monitor key industry supply chains and develop ways to address vulnerabilities.

The bill also includes emergency appropriations to support semiconductor manufacturing and R&D. This is a much needed response to the semiconductor shortages that have disrupted manufacturing across the nation, including my home State of Mississippi. And undoubtedly we will hear about that from our distinguished panel. The legislation also includes important contribution from the Finance committee to combat China's manufacturing imbalances and threats to free and fair trade.

Today's hearing is an opportunity for witnesses to discuss how the United States Innovation and Competition Act can make our supply chains more resilient. Our witnesses may want to share their thoughts on how the Department of Commerce might implement the various provisions of this bill. The House passed its reauthorization of the National Science Foundation, but it still needs to take action on the broad range of topics covered by our legislation. The president recently issued a 100 day supply chain review that identifies some important supply chain vulnerabilities. We perhaps will hear about that today.

I am honored that among our panel is my good friend and fellow Mississippian Lex Taylor, the Chairman and CEO of the Taylor Group. It is a leading manufacturer in Mississippi. Taylor builds forklifts and a wide variety of material handling machines for both industry and defense purposes.

Mr. Taylor has firsthand experience with the topics we will cover. And I know he and other members of the panel will make a valuable contribution to this discussion. Thank you, ma'am.

The CHAIRMAN. Thank you, Senator Wicker. We are leading off with you, Dr. Gereffi. Thank you so much for being here. We are honored to have you before the Committee and hear your expertise in this area. So please proceed.

**STATEMENT OF GARY GEREFFI, Ph.D.,
EMERITUS PROFESSOR AND FOUNDING DIRECTOR,
GLOBAL VALUE CHAINS CENTER, DUKE UNIVERSITY**

Mr. GEREFFI. Thank you very much. Madam Chair Cantwell, Ranking Member Wicker, members of the Senate Commerce committee, it is a pleasure and an honor to be invited to testify before you today. My name is Gary Gereffi. I have been a Professor at

Duke University for many years, and I direct the Global Value Chains Center there.

And I have spent a number of decades studying global supply chains. And this is the first time that I think my neighbors and friends want to talk about that topic, not necessarily for good reasons the last couple of years. As we know, COVID-19, the pandemic has introduced many disruptions and shortages of products so supply chains have come to the public consciousness, oftentimes through these shortages. But I think as the White House report that was released last month on building resilient supply chains has emphasized, supply chains have been a critical part of globalization and the U.S. economy for the last five decades.

And it is really important that we be aware of disruptions not just for products like personal protective equipment or the other issues that have come up with COVID-19, but as a matter of long term competitiveness. So what I wanted to do is just highlight a couple of points that I make in my written testimony, one about the nature of supply chain research, two, about the concept of resilience, and then I want to give a kind of a bottom up perspective of supply chains and conclude with a couple recommendations. Supply chain research is surprisingly recent in the university context. Businesses deal with supply chains all the time. It is a matter of logistics. But from a researcher point of view, it is a challenging field for two reasons.

One reason is the boundary problem. We are aware of industry studies, but supply chains are bigger and different than industries. Supply chains have multiple tiers of companies that stretch up and down that supply chain. So we might be aware of the end product makers. We are not aware so much of the first tier, second tier, third tier suppliers. That is critical. But supply chains also have an important breadth. They have backward linkages and forward linkages. So in many ways, supply chains are much bigger and more complicated than our traditional sense of industries.

So it has been hard to create those boundaries and that raises a measurement problem. The data that we have on other kinds of economic analysis like trade and investment data are easier to find if we are dealing with traditional industries. But when we are dealing with supply chains, many of those supply chain linkages are confidential. They are not the kind of things that you can just go and find easily. So the researchers working in different industries have had to try to recreate what those supply chains are. Resilience, I agree, as a critical concept, but I think we need to look at it at several levels.

There is resilience from the level of the firm, but from a firm perspective, they are thinking of resilience in terms of operational efficiency and how do they risk—how do they deal with risk management if supply chains are disrupted? There is a second level of supply chains, resilience viewed at the level of supply chains themselves, which are bigger than firms. They are the industry systems that have organizational and geographic characteristics.

And finally, there are supply chains, resilience in terms of countries and what we care about. Part of that is National Security. And that was a key emphasis in the White House report last month. But also from a country point of view, supply chains relate

to jobs. They relate to infrastructure. They relate to different kinds of economic, social, and environmental concerns. So I think when we are talking about resilience, it will be helpful to link resilience for whom? For firms, for the industries themselves, or for countries? In my written comment, I talk about supply chains from top down or bottom up.

In these short remarks, we just mentioned the bottom up perspective. How do we look at supply chains from a U.S. vantage point? And one of the projects we had done at Duke too was something called the North Carolina and the Global Economy Project, where we looked at seven key industries in North Carolina, natural resource industries like tobacco and hog farming, traditional manufacturing like furniture or textiles, but also high tech industries like biotechnology or information technology or banks and finance.

Every state in the country has critical industries that they care about. So I think if we start looking at supply chains from the bottom up, and each state says, here is the industries we care about, there are things we can learn from supply chain research about how to do that kind of mapping, and I gave some examples in the written testimony. Final point on some of the recommendations I noticed. What is important to me is how universities get tied in to the initiatives that this committee and this legislation is talking about.

I think in the USICA, the Information and Competitiveness Act, there is a critical emphasis on an NSF technology directorate as a way to perhaps focus some of these efforts. I would applaud that. I think that is going to add applied research to the kind of basic research that NSF does. But NSF also tries to get universities involved in this research. And so one thing I would just recommend is that if we think about a technology directorate, we think about it as more than just engineering. Engineering is embedded in a lot of these other social areas that we care about, jobs and the like.

So I think that that part of what we can do with the technology directorate is figure out how do you link universities in different parts of the country that are dealing with common industry issues. So I think the kind of initiatives that have been proposed are really going to be important. But some of the advice you might be getting from private sector, university folks, and others could help us knit together these proposals in a really strong, robust way. Thank you very much.

[The prepared statement of Mr. Gereffi follows:]

PREPARED STATEMENT OF GARY GEREFFI, PH.D., EMERITUS PROFESSOR AND
FOUNDING DIRECTOR, GLOBAL VALUE CHAINS CENTER, DUKE UNIVERSITY

I. Introduction

Madam Chair Cantwell, Ranking Member Wicker, and Members of the Committee, I am honored to appear before you today to offer testimony on the hearing topic, "Implementing Supply Chain Resiliency." My name is Gary Gereffi, and I am the Founding Director of the Global Value Chains Center at Duke University. I have spent much of my academic career looking at the structure and dynamics of global industries, and how and why U.S. companies decided to set up international production and sourcing networks. This research has involved extensive fieldwork in a wide variety of industries and countries around the world, including in-depth interviews with the companies, business and labor groups, policymakers, and other industry stakeholders in each setting.

In light of this experience, I am very gratified to see the excellent White House report on “Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth” released in June 2021 that outlines steps to strengthen critical U.S. supply chains. In my remarks today, I draw upon my background as both a researcher and a policy adviser. I will organize my remarks around three main themes: (1) a brief review of the rise of global supply chains as a research field; (2) a short list of building blocks of resilient supply chains that derive from this research; and (3) a few recommendations for actions that the U.S. Federal government can take to implement supply chain resiliency.

Recent disruptions associated with the COVID-19 pandemic have brought both the significance and risks of supply chains to the American consciousness as never before. COVID-19 has been a unique and terrifying event because of its swift global spread and its devastating and lingering impact on the health and security of the American people and the global community. It has resulted in unprecedented supply shortages and demand fluctuations that have affected virtually all U.S. industries, from medical supplies to food products and toilet paper, and from the transportation and service sectors to critical intermediate goods like semiconductors, active pharmaceutical ingredients, and rare-earth minerals. These dislocations can provide important lessons for the future.

Supply-chain disruptions are a recurrent risk for many businesses. They can be caused by natural events, such as tropical storms, earthquakes, or extended droughts, as well as cyclical fluctuations like business cycles or financial crises (*e.g.*, the 2008–09 global recession). Government policies can also disrupt supply chains, such as trade restrictions that impede the cross-border flows of imports and exports or local-content requirements that mandate the domestic procurement of goods and services. While COVID-19 disruptions were a different order of magnitude because of their speed and global impact, a supply-chain perspective that links firm strategies, industry dynamics and government policies can help address short-term supply-chain discontinuities in the U.S. economy, and inform plans for long-term resilience as a basis for dynamic, inclusive and sustainable economic growth.

II. Supply Chain Research: A Recent Field

Although supply chains may sound like a rather arcane or technical topic, supply-chain research has flourished in recent decades, especially as supply chains have gone global. In contrast to the more familiar field of industry studies or intriguing case histories of well-known products (such as Barbie dolls or iPhones), supply-chain research encompasses the full structure of an industry, including its *pre-production* (R&D and design) phases, the often complex *production* process (raw and processed materials, manufactured components and other inputs, and the assembly, testing and packaging of final products), and *post-production* stages (*e.g.*, distribution and logistics, marketing, and in some cases recycling).

During the origins of American big business (19th and early 20th centuries), most supply-chain activities were carried out inside large vertically integrated corporations where the “visible hand” of management replaced Adam Smith’s famous invisible hand of the market.¹ However, in the post-World War II era, as businesses became more specialized and global through the twin processes of “outsourcing” (obtaining goods or services from outside suppliers) and “offshoring” (moving portions of the production process to overseas locations), the *global factory model* became more common where the assembly of goods and later the full range of production activities were spread across multiple countries for a combination of cost, capability and market reasons.² Thus, a growing proportion of international trade was made up of intermediate goods rather than finished products. As this globalization process gained momentum from the mid-1960s through the 1990s, American manufacturing especially of relatively labor-intensive consumer goods moved offshore, imports accounted for a growing portion of consumer items sold in the United States, and the number of companies and employees in the U.S. manufacturing sector fell precipitously.

Supply chain studies to analyze this globalization process and its impact on the U.S. economy were promoted by various U.S. foundations. The Alfred P. Sloan Foundation in New York launched an Industry Studies program (1990–2010) to foster a closer interaction between academia and industry, which grew to include around two dozen centers at U.S. universities. The Rockefeller Foundation supported a Global Value Chains Initiative (2000–2008) that funded an international network of

¹ Alfred D. Chandler, Jr., *The Visible Hand: The Managerial Revolution in American Business* (Belknap Press, 1977).

² Joseph Grunwald and Kenneth Flamm, *The Global Factory: Foreign Assembly in International Trade* (Washington, DC: Brookings Institution, 1985).

scholars with the goal of creating a paradigm linking global, national, and local levels of analysis to address both the knowledge gaps and policy gaps created by globalization. What the global value chain (GVC) framework added to earlier supply chain studies was an explicit effort to understand and measure how and where value is created and captured along global supply chains, as well as the main trajectories of economic, social and environmental upgrading (or downgrading) associated with these changes at the global, national, regional and community levels.³

Supply-chain researchers are very interdisciplinary and their work is featured at a variety of annual conferences, such as Industry Studies Association (ISA), Regional Studies Association (RSA), Society for the Advancement of Socio-Economics (SASE), and Academy of International Business (AIB). Traditionally, the supply-chain literature has relied heavily on industry case studies and cross-industry comparisons, but the Organisation for Economic Co-operation and Development (OECD) in conjunction with the World Trade Organization has created a Trade in Value Added database that permits a detailed trade mapping of how countries participate in GVCs by calculating the value-added of exports (domestic content minus imported inputs), which permits modeling of how domestic manufacturing contributes to economic growth. The World Bank, in collaboration with other multilateral development agencies, created the World Integrated Trade Solution software package that allows users to download detailed trade information on commodities and over 170 partner countries to assist policymakers and practitioners involved in the international trading system.

Academic researchers also build their own unique databases to measure supply-chain relationships. For example, a study of the aerospace industry collected data on buyer-supplier and partnership linkages among more than 2,800 firms across 52 aerospace clusters in North America and Europe during 2002–2014,⁴ and another study utilized a dataset of over 57,000 sourcing transactions of automotive parts manufacturers in Europe and North America between 1993 and 2012 to test propositions derived from GVC governance theories.⁵ Thus, mixed methodologies continue to characterize the field.

International organizations have increasingly adopted the GVC framework as a way to understand how countries at different levels of development participate in the global economy, and what kinds of policy advice could promote dynamic, inclusive and sustainable economic growth.⁶ This was the focus of a Duke GVC Summit in October, 2014 that invited representatives from 30 international organizations, national development agencies, non-governmental organizations (NGOs) and universities as well as leading supply-chain researchers to discuss how and why they use the GVC approach, and to provide suggestions on how it can be improved. This type of policy impact is very unusual for most academic research paradigms, and it is a significant catalyst for ongoing work in the field.⁷

III. Building Blocks of Resilient Supply Chains

Drawing from recent research on global supply chains, I will outline six broad themes that intersect with the goals and recommendations of the White House’s “Building Resilient Supply Chains” report,⁸ and also address the Department of Commerce’s concerns to identify concrete steps it can adopt to ensure the resiliency of the Nation’s critical supply chains. These central concepts, findings and trends

³Gary Gereffi, *Global Value Chains and Development: Redefining the Contours of 21st Century Capitalism* (Cambridge University Press, 2018); Stefano Ponte, Gary Gereffi and Gal Raj-Reichert (eds.), *Handbook on Global Value Chains* (Edward Elgar Publishing, 2019); World Bank, *Trading for Development in the Age of Global Value Chains*, World Development Report 2020 (World Bank Group, 2020).

⁴Ekaterina Turkina, Ari Van Assche and Raja Koli, “Structure and evolution of global cluster networks: Evidence from the aerospace industry,” *Journal of Economic Geography* 16 (2016): 1211–1234.

⁵Johannes Van Biesebroeck and Alexander Schmitt, “Testing predictions on supplier governance from the global value chains literature,” *Industrial and Corporate Change* (2021), <https://doi.org/10.1093/icc/dtab034>.

⁶Olivier Cattaneo, Gary Gereffi and Cornelia Staritz (eds.), *Global Value Chains in a Postcrisis World: A Development Perspective* (World Bank, 2010); UNCTAD, *World Investment Report 2013—Global Value Chains: Investment and Trade for Development* (United Nations Conference on Trade and Development, 2013); UNIDO, *Global Value Chains and Development: UNIDO’s Support towards Inclusive and Sustainable Industrial Development* (United Nations Industrial Development Organization, 2015).

⁷Gary Gereffi, “Global value chains and international development policy: Bringing firms, networks and policy-engaged scholarship back in,” *Journal of International Business Policy* 2(3) (2019): 195–210.

⁸The White House, “Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Economic Growth,” 100-Day Reviews Under Executive Order 14017, June 2021.

reflect work on supply chains that cuts across the global, national, regional and local levels, and they inform my recommendations for U.S. supply chain initiatives such as those carried out by the Department of Commerce to advance a broad-based, inclusive and sustainable economic agenda.

1) Resilience for Whom? Firms, Supply Chains and Countries

In the aftermath of the disruptions caused by COVID-19, there has been an intense debate on whether U.S. supply chains are too rigid and dependent on a small number of offshore locations in pursuit of cost-based global efficiency.⁹ The notion of “resilience” is often proposed as an alternative principle to guide recovery from recurrent disruptions. However, resilience has different meanings for companies, supply chains, and countries:

- For *companies*, resilience refers to the ability to adjust and respond to disruptions in their supply chains through strategies and capabilities that balance operational efficiency and flexibility via appropriate forms of risk management and redundancy.
- For *supply chains* that extend beyond individual firms, resilience entails adaptation via modes of governance established by lead firms that maximize system-level efficiencies and cushion against vulnerabilities, taking into account the organizational and geographic configurations of each supply chain.
- At the *country* level, building resilience in the face of supply-chain disruptions involves proposals for reshoring, country and supplier diversification, near-shoring, and reliance on trusted partners, as well as the buildup and maintenance of national stockpiles and strategic reserves that will be driven by national security considerations as well as broader economic and social goals related to jobs, investment, trade, sustainability, and innovation.

Understanding resilience as a multidimensional concept means that coordination and tradeoffs are inevitable to develop robust and comprehensive supply chain policies. Resilience strategies may not easily align across these different levels, but awareness of the interdependencies is a necessary step to ameliorate disruptions in a more effective way.

2) Supply Chains Have Multiple Governance Structures

A core finding and premise of the GVC framework is that global supply chains have *governance structures* that are established by the lead firms that set up and orchestrate the activities of the multi-tiered suppliers in the chain. An initial seminal distinction was between producer-driven and buyer-driven supply chains: (a) the lead firms in *producer-driven chains* were integrated manufacturers that typically controlled the capital and technology used to establish new industries (e.g., automobiles, aircraft, computers, pharmaceuticals); and (b) conversely, in *buyer-driven chains* the lead firms were large retailers (e.g., Walmart, JC Penney, Costco, Tesco) and brand-name firms (e.g., Nike, Adidas, Liz Claiborne, Disney) that orchestrated but did not own vast networks of global suppliers in consumer-goods industries, such as apparel, footwear, sporting goods, toys, and food products. Whether led from the supply side or the demand side, lead firms tend to set the rules of the game in terms of price, quality, product standards and delivery schedules for other firms in the chain.¹⁰ Subsequent governance typologies were introduced that cover a wider range of structures, such as hierarchical, captive, relational, modular, and market forms of governance.¹¹

Within key industries like semiconductors, multiple governance structures may be set up by lead firms that adopt distinct production models. For example, the integrated device manufacturers (IDMs), such as U.S.-based Intel and Texas Instruments and South Korea-based Samsung, do the entire production process for finished chips themselves, whereas in the alternative “fabless” or foundry model, the three broad steps for making finished semiconductors—design, manufacturing, and assembly, testing and packaging (ATP)—are carried out by specialized companies. While U.S. firms are dominant IDM players, accounting for over half of global IDM

⁹Lizzy O’Leary, “The modern supply chain is snapping,” *The Atlantic*, March 19, 2020; Willy C. Shih, “Bringing manufacturing back to the U.S. is easier said than done,” *Harvard Business Review*, April 15, 2020; Aaron Friedberg, “The United States needs to reshape global supply chains,” *Foreign Policy*, May 8, 2020; Robert E. Lighthizer, “The era of offshoring U.S. jobs is over,” *New York Times*, May 11, 2020.

¹⁰Gary Gereffi, “The organization of buyer-driven global commodity chains: How U.S. retailers shape overseas production networks,” in Gary Gereffi and Miguel Korzeniewicz (eds.), *Commodity Chains and Global Capitalism* (Praeger, 1994), pp. 95–122.

¹¹Gary Gereffi, John Humphrey and Timothy Sturgeon, “The governance of global value chains,” *Review of International Political Economy* 12(1) (2005): 78–104

revenues in 2020, the fabless/foundry model relies very heavily on chip output from Taiwanese-based TSMC (Taiwan Semiconductor Manufacturing Company), which accounts for 53 percent of the contract foundry market, including the most technologically advanced chips.¹²

3) Supply Chains Have Shifting Geographies

The geographic footprint of most supply chains evolves quite significantly over time. The apparel industry, which epitomized the fragmented and globally dispersed production networks associated with buyer-driven GVCs, became much more consolidated when quotas allowed by the Multi-Fiber Arrangement were eliminated by the World Trade Organization (WTO) in 1995. Today, just three countries—China, Bangladesh and Vietnam—account for nearly half of world apparel exports. In other industries, supply chains are more regionally based, such as the North American automotive industry, the European aerospace sector, and East Asia’s ecosystem of consumer electronics suppliers. Regional chains are often a by-product of regional trade pacts, such as the North American Free Trade Agreement (NAFTA) and the European Union (EU).¹³

Supply chains can also be examined at the national level, but measurement and boundaries raise difficult challenges. National statistics typically use standard industry classifications. If we take the U.S. semiconductor industry, for example, which is analyzed in the recent White House supply-chain report, we can define the size of the industry using various metrics: annual sales (\$208 billion in 2020, which is nearly half of the world market); value added (\$35 billion in 2019, 1.4 percent of U.S. manufacturing value added); employment (207,400 workers in 2019, 1.6 percent of U.S. manufacturing employment); number of firms (733 companies in semiconductor device manufacturing and 140 semiconductor equipment manufacturers); and the breadth of activities across the country (18 U.S. states have major semiconductor manufacturing operations).¹⁴

However, these industry figures fall far short of indicating the true size and scope of the semiconductor supply chain in the United States, which would include the multitude of suppliers (domestic and international) to U.S. semiconductor firms. In addition, since semiconductors are a critical intermediate component used in many industries, the semiconductor supply chain would also extend to the main sectors that use these chips, which include (based on worldwide demand in 2019): mobile phones (26 percent), information and communication infrastructure (24 percent); computers (19 percent); industrial (12 percent); automotive (10 percent); and consumer electronics (10 percent).¹⁵

4) Asia Is a Pre-eminent Global Production Hub, and China Is Its Epicenter

In the last couple of decades, Asia has emerged as a dominant production hub for many global supply chains. Asia offers a unique combination of low-cost production, economies of scale, and a broad array of technologically sophisticated and specialized suppliers that serve both global and increasingly Asian consumer markets. The cost advantages associated with Asia-based sourcing are attractive not only to the lead firms in global supply chains, but also to cost-conscious institutional clients like U.S. hospital systems and medical agencies that wish to couple just-in-time (JIT) purchasing of medical supplies with the JIT low-inventory model favored by industry leaders.

China has become the world’s top exporter (\$2.6 trillion in 2020), well ahead of the United States and Germany (each around \$1.4 trillion).¹⁶ However, given rising wages in China and growing shortages of factory workers in many parts of the country, other relatively low-wage economies within Asia, such as Vietnam, Bangladesh, India, Indonesia and the Philippines, are becoming prominent exporters from the region. The most technologically advanced Asian economies, such as Japan, South Korea, Singapore and Taiwan, provide specialized components and equipment, which combine to make Asia a formidable global production and export hub.

As an economic power, China is a significant adversary. It has supplemented its export-oriented development strategy from the 1990s and 2000s with a technology-driven and domestic-economy-oriented approach since the early 2010s, as typified by its Made in China 2025 and indigenous innovation programs. China is also poised

¹² White House (2021), op. cit., pp. 34–35.

¹³ Gary Gereffi, Hyun-Chin Lim and Joonkoo Lee, “Trade policies, firm strategies, and adaptive reconfigurations of global value chains,” *Journal of International Business Policy* (2021), <https://link.springer.com/article/10.1057%2Fs42214-021-00102-z>.

¹⁴ White House (2021), op. cit., p. 24.

¹⁵ *Ibid.*, pp. 24–25.

¹⁶ World’s Top Export Countries, <https://www.worldstopexports.com/worlds-top-export-countries/>, accessed on July 6, 2021.

to expand its regional influence through its massive Belt and Road Initiative that will increase its external investments and trade in Central and Southern Asia, sub-Saharan Africa, and South America. Although still lagging in key technologies like semiconductors, China has placed an emphasis on forward-looking industries like electric cars, high-speed rail, artificial intelligence, automation, and e-commerce services like mobile banking and digital platform-based factory networks.

There are many valid concerns about China's troubling policies and practices involving state control of the economy, intellectual property theft, human rights abuses, and political repression at home and abroad, among other issues. New U.S. supply chain initiatives are needed to meet the technological and economic challenges posed by China. However, in pursuing its agenda, the United States would do well to align its efforts to address the threats posed by China with U.S. strategic partners and allies who share many of our concerns and objectives. A rapid decoupling from China poses many practical difficulties and it could reduce U.S. leverage in terms of broader geopolitical and economic interests.

5) *Building Resilient Supply Chains in the United States*

While much work on supply chains tends to highlight the international dimension and looks at global industries from the "top down," it is equally important to view supply chains from the "bottom up" by emphasizing their potential contributions to national and local growth. A good illustration of this bottom-up approach is the project on "North Carolina in the Global Economy," which was launched at Duke University to understand how globalization affected seven of the state's principal industries: tobacco, textiles and apparel, furniture, hog farming, information technology, biotechnology, and banks and finance.¹⁷ Like many U.S. states, North Carolina's key industries reflect a mix of resource-based, manufacturing and service sectors, and it faces a range of investment, employment, skills training, small business development, and innovation challenges. The NC-Global Economy website was built using publicly available state-level and national economic statistics for a 20-year period (1992–2012), supplemented by online data searches at the company and industry levels, to provide a longitudinal portrait of how North Carolina's industries and companies have fared in an era of globalization, and what policies and strategies at the state and local levels might foster resilient growth.

Among the insights gleaned from the NC-Global Economy project is that traditional industries like textiles and furniture have adapted in striking ways to recent political, economic and technological shifts. While North Carolina's textile firms accommodated NAFTA by continuing to supply apparel customers that moved to Mexico and Central America, the industry also embraced technological change via the growth of nonwoven and "technical" textiles in the state's output and exports. These new products shifted the industry's end markets from its traditional apparel, home furnishing and automotive customers to sectors like aerospace, medical, marine, military and geotextiles.¹⁸ North Carolina's furniture industry also showed resilience in adapting to change, as local manufacturers were hit by export slowdowns and rapidly rising furniture imports from Asia and Mexico. However, the annual High Point, NC furniture market served as a lifeline to keep wholesale buyers coming to the state as local manufacturers slowly recovered.¹⁹

A supply-chain methodology can also prove very useful in tracking opportunities created by new high-tech sectors in the United States. For example, following a study on the U.S. smart grid (the "energy internet") that assessed the potential of 125 leading smart grid firms to create clean energy-related jobs, the Research Triangle Region of North Carolina emerged as one of the U.S. "hot spots" for future growth.²⁰ A separate study was commissioned by a local development agency to assess how this North Carolina cluster of smart grid firms could build on its competencies and expand its opportunities to invent, make and sell their products in the U.S. as well as abroad.²¹ A main objective of both studies was to "map" the

¹⁷ See the North Carolina in the Global Economy website at <http://ncglobaleconomy.com>.

¹⁸ <http://www.ncglobaleconomy.com/textiles/overview.shtml>

¹⁹ Bill Lester and Lukas Brun, "The economic impact of the High Point market," Duke Center on Globalization, Governance & Competitiveness (CGGC), Durham, N.C., October 2013, available at https://gvcc.duke.edu/wp-content/uploads/2013-09-30High_PointMarket-economic-impact-analysis-1.pdf.

²⁰ Marcy Lowe, Hua Fan and Gary Gereffi, "U.S. smart grid: Finding new ways to cut carbon and create jobs," Duke CGGC, Durham, N.C., April 19, 2011, available at https://gvcc.duke.edu/wp-content/uploads/Lowe_US_Smart_Grid_CGCG_04-19-2011.pdf.

²¹ Marcy Lowe, Hua Fan and Gary Gereffi, "Smart grid: Core firms in the Research Triangle Region, NC," Duke CGGC, Durham, N.C., May 11, 2011, available at https://gvcc.duke.edu/wp-content/uploads/Lowe_Research-Triangle-Smart-Grid_CGCG_05-24-2011.pdf.

smart grid value chain to show more clearly the technological synergies linking the national and state-level economies.

Value-chain studies have proven particularly useful to show the connections between so-called “clean technologies” and U.S. jobs. One of the initial clients of the Duke GVC Center was the Environmental Defense Fund (EDF), which commissioned a series of product-level studies to show how the transition to a low-carbon economy positively impacted the U.S. manufacturing sector. The initial report focused on five carbon-reducing products—LED lighting, high-performance windows, auxiliary power units for trucks, concentrated solar power, and a “super soil” system for hog-waste management—and value chain maps for each product helped to show how and where manufacturing jobs were being produced in the United States.²² Subsequently, EDF commissioned over a dozen additional product and company case studies to illustrate the tangible connections between the green economy and U.S. blue-collar jobs.²³ A similar supply-chain methodology was employed in a new study focusing on expanding utility-scale, lithium-ion battery-storage capacity in North Carolina as a foundation for all forms of clean energy, thus enhancing North Carolina’s potential to be a national leader in clean energy.²⁴

This “bottom up” approach to building supply-chain resiliency focusing on particular states and products is broadly applicable across the entire U.S. economy. Virtually all U.S. states rely on a handful of key industries linked to national and global markets that account for the bulk of their investment, output and employment. The tools of value-chain analysis, as exemplified in the NC-Global Economy and EDF projects highlighted above, are suitable for various monitoring, planning and innovation objectives that could be spearheaded by the Department of Commerce, including:

- tracking how both large and smaller companies in a state’s key industries are performing over time, and how the state compares to its main U.S. competitors in relevant industries
- attracting investors to supplement or fill critical supply-chain needs, especially as multiple U.S. states seek to lure top firms and talent in similar industries
- supporting university, community college and corporate research and training capabilities
- assisting local workforce development efforts to identify and add critical skills needed by priority sectors

Similar dynamics are unfolding in major U.S. cities. A number of American cities stand out as hubs or centers of excellence in key U.S. industries, such as Seattle (aerospace, software and digital economy, with Boeing, Microsoft and Amazon), Houston (oil and gas; medical), Phoenix (semiconductors), Pittsburgh (steel and biomedical), and Boston (high-tech; defense), to name just a few. Cities like these are production and innovation nodes in critical U.S. and global supply chains. To enhance their resiliency, U.S. supply-chain initiatives should strengthen and deepen the supporting activities (infrastructure, hardware, software and services) these urban hubs rely on, and facilitate their connections to other regions and smaller cities that are part of the same value chain.

As U.S. technology giants like Google, Apple and Amazon make major investments in machine learning, artificial intelligence, software engineering, and quantum and cloud computing in mid-sized cities like those in North Carolina²⁵ and elsewhere across the country, it is clear that vibrant U.S. supply chains rely on urban knowledge and production networks that can create and retain value and spread benefits to surrounding communities.

²²Gary Gereffi, Kristen Dubay and Marcy Lowe, “Manufacturing climate solutions: Carbon-reducing technologies and U.S. jobs,” Duke CGGC, Durham, N.C., November 2008, available at https://gvcc.duke.edu/wp-content/uploads/greeneconomy_Full_report.pdf.

²³https://gvcc.duke.edu/search-our-work/?fup_cggc_search=environmental%20defense%20fund.

²⁴Lukas Brun and Gary Gereffi, “Battery storage: North Carolina’s footprint in the global value chain,” report commissioned by Audubon North Carolina, February 1, 2021, available at <https://mercury.postlight.com/amp?url=https://nc.audubon.org/press-release/report-finds-north-carolina-well-positioned-battery-storage-growth>.

²⁵David Sebastien, “Apple to build new campus in North Carolina: Move would create at least 3,000 jobs in machine learning, AI, software engineering and other fields, company says,” *Wall Street Journal*, April 26, 2021, available at <https://www.wsj.com/articles/apple-to-build-new-campus-in-north-carolina-11619441000>; Rick Smith, “Google picks Durham for engineering hub, aims to create 1,000 jobs,” March 18, 2021, available at <https://www.researchtriangle.org/news/google-picks-durham-for-engineering-hub-aims-to-create-1000-jobs/>.

6) *The Role of Universities in Supply-Chain Research*

Somewhat surprisingly, perhaps, universities play a very uneven role in supply-chain research. U.S. foundations have been an important source of financial support, but even in the most positive cases, assistance has been temporary. The Sloan Foundation's Industry Studies program set up industry-specific centers in 26 U.S. universities, but the program was terminated in 2010. A by-product of the Sloan program was the formation of the Industry Studies Association in 2009, which has annual conferences but offers no funding for industry research or university-based industry centers. The Rockefeller Foundation, which helped to launch the Global Value Chain Initiative with an international group of scholars,²⁶ encouraged the formation of the Duke GVC Center (previously the Center on Globalization, Governance & Competitiveness) in 2005 to provide a university base to facilitate the future networking of GVC scholars, but research support was guaranteed by neither Rockefeller nor Duke University. Project funding was client driven and therefore highly uncertain.

This situation reflects the business model of most U.S. research universities. Their core mission is to foster high-quality independent research by faculty that secure long-term funding (primarily from large U.S. government agencies like the National Science Foundation (NSF) or National Institutes of Health) and publish in prestigious peer-reviewed academic journals. Supply-chain research is not an ideal fit for U.S. universities because industry-oriented researchers are both interdisciplinary and international, and acquiring industry-specific knowledge does not necessarily lend itself to academic publications, which tend to privilege theoretical and methodological rigor, and in the social sciences this often translates into quantitative (rather than case-based) analysis.

Given the significant real-world impact of good supply-chain research, a growing number of universities support programs linked to supply chains and economic development (*not* including supply-chain management programs in many business schools). In the United States, along with the Duke GVC Center, the Massachusetts Institute of Technology's Industrial Performance Center is a highly regarded and relatively well-funded unit. Many overseas universities have research groups in GVC analysis or related fields like global production networks, including the University of Manchester (UK) and Oxford Business School (UK), Copenhagen Business School (Denmark), University of Padova (Italy), the National University of Singapore, and the University of International Business and Economics (Beijing, China).

IV. Implementing Supply-Chain Resiliency: A Few Recommendations

Based on this overview of various concepts, findings and trends in recent supply-chain research, I will highlight several final topics that may be relevant in the Department of Commerce's efforts to design and implement projects to strengthen supply-chain resiliency.

Supply Chains Are Product-Specific

Although it is tempting to think of supply chains in broad industry categories, such as automotive, aerospace or semiconductors, in fact supply chains are often quite product-specific and we overgeneralize at our peril. For example, during the COVID-19 pandemic, it was common to analyze disruptions in COVID-19-related medical supplies as though they fit a standard pattern. Particular concern was given to shortages of personal protective equipment (PPE) such as sterile rubber gloves and face masks to limit the spread of the novel coronavirus in the general population, as well as ventilators used by medical personnel to treat seriously ill patients. But recent supply-chain research shows that PPE shortages required different solutions, depending on how the supply chains were organized:

- *Rubber gloves:* Production was concentrated in Southeast Asia, and Malaysia is the dominant supplier with two-thirds of global exports. Although some shortages persist, the U.S. resolved its main supply shortfalls via increased imports of sterile gloves from Malaysia and Thailand.²⁷
- *Face masks:* China accounted for about 60 percent of U.S. face mask imports prior to the pandemic, but China suspended its exports of face masks worldwide as it dealt with its own outbreak of COVID-19 cases in early 2020. In late March 2020, the U.S. government began to encourage large U.S. face mask producers like 3M and Honeywell along with smaller domestic suppliers to ramp

²⁶The GVC Initiative agenda and members are discussed in Gary Gereffi and Raphael Kaplinsky (eds.), "The value of value chains: Spreading the gains from globalization," special issue of *IDS Bulletin* 32(3), July (2001).

²⁷Gary Gereffi, "Increasing resilience of medical supply chains during the COVID-19 pandemic," *Industrial Analytics Platform*, June 24, 2021, available at <https://iap.unido.org/articles/increasing-resilience-medical-supply-chains-during-covid-19-pandemic>.

up production, but it took several months before the supply gap was substantially narrowed by late August.²⁸

- *Ventilators*: The United States confronted acute shortages of ventilators in late March and April, 2020, a life-saving device for many COVID-19 patients treated in the intensive-care units (ICU) of hospitals. Ventilators were much more complex than other PPE items, and the Defense Production Act was invoked to facilitate production partnerships between U.S. auto companies like General Motors and Ford with much smaller medical equipment firms. Although U.S. ventilator output dramatically increased, domestic supply soon exceeded demand. The number of ventilators in the U.S. strategic stockpile surged from 10,000 in April to over 95,000 by mid-August 2020, but only a very small number of these machines were actually used to treat COVID-19 patients. With improved hospital care, far fewer patients were sent to ICUs, demand for ventilators plummeted, and the U.S. ventilator shortage became a glut.²⁹

Lessons the Department of Commerce can take away from these COVID-19 product case studies include:

- (1) Related products with different supply-chain structures may require distinct policy solutions (*e.g.*, reliance on trade ties for rubber gloves; use of the Defense Production Act in both face masks and ventilators to increase domestic production; anticipate the risks in overbuilding strategic stockpiles).
- (2) An up-to-date and regularly revised inventory of the main suppliers (domestic and foreign) in key U.S. supply chains will facilitate a much quicker policy response.
- (3) Public-private collaboration is required for effective interventions, including cross-industry production partnerships, and appropriate committees and decision-making units should be created based on what we learned from previous experiences.

Beware of Technological Lock-In

The pace of technological change in global supply chains can be startlingly fast. In the semiconductor industry, this is illustrated by what is referred to as “Moore’s Law” → the number of transistors on a semiconductor doubles every two years; this is supplemented by “Moore’s Second Law” → the cost of constructing a semiconductor fabrication facility doubles every four years.³⁰ Because of such rapid change, the potential for technological lock-in is particularly high in R&D and design-intensive fields, such as aerospace and semiconductors. Since it costs \$12–\$20 billion to build a new state-of-the-art chip fabrication facility, caution in planning such investments and spreading the risks across strategic production partners (both inside the United States and abroad) are prudent supply-chain practices.

The mobile telecom industry, which is the largest end-market for semiconductors, illustrates the rapidly evolving landscape in technology-intensive GVCs. The leading smartphone brands in 2019 were: Samsung (19.2 percent), Huawei (15.6 percent) and Apple (12.6 percent). Previous industry leaders like Nokia (Finland), Motorola (U.S.), Ericsson (Sweden), and Blackberry (Canada) have disappeared from the market. Current market pacesetters each have a different business model:

- *Samsung* is a highly integrated global producer, but relies on open-source software.
- *Apple* is a global innovator that relies almost exclusively on proprietary technology.
- *Huawei* has emerged as a “national champion” within China using a mix of open-source and own technology, but it is hindered by the Chinese government’s strict controls on domestic Internet access for foreign firms and by U.S.-led sanctions that restrict Huawei’s access to buying parts and components from U.S. companies.
- *Google* is now entering the smartphone GVC primarily on the basis of its software (its Android OS platform) and capitalizing on its many users from other

²⁸Gary Gereffi, “What does the COVID-19 pandemic teach us about global value chains? The case of medical supplies,” *Journal of International Business Policy* 3(3) (2020): 287–301, available at <https://link.springer.com/article/10.1057/s42214-020-00062-w>.

²⁹Faiz Siddique, “The U.S. forced major manufacturers to build ventilators. Now they’re piling up unused in a strategic reserve,” *Washington Post*, August 18, 2020.

³⁰White House (2021), *op. cit.*, pp. 34, 42 & 59.

services it owns (such as Gmail, Google Maps, and YouTube), demonstrating the disruptive potential of digital platform pioneers.³¹

Because the path to innovation in the mobile telecom industry depends on so many industries—including semiconductors, digital services, hardware devices, and telecom providers, among others—the result is a “massively modular system” that remains vulnerable to short-term disruption.³² Trying to reshore supply chains in an industry such as this with an ecosystem of hundreds of globally distributed and specialized firms and numerous critical inputs poses significant national security risks and a plethora of practical and policy difficulties.

Be Mindful of Unintended Consequences

Another concern for supply chain resiliency are the unintended consequences of policy in a hyper-connected world. This is most clearly evident with trade restrictions, such as the recent U.S.-China “trade war” as well as U.S. tariffs on imported goods from neighboring trade partners like Mexico and Canada. Such policies are intended to support U.S. firms and save American jobs, but given the dense inter-firm networks in global supply chains, restrictions on U.S. imports often have a deleterious impact on U.S.-based companies.

The North American automotive industry provides a striking example. U.S. automotive imports from Mexico contain 40 percent U.S. content (*i.e.*, parts made by U.S.-based firms that are incorporated in Mexico’s exports back to the U.S.) and imports from Canada are 25 percent U.S. content by value, whereas goods imported from China contain just 4 percent U.S. content.³³ Thus, tariffs on imports from Mexico and Canada can hurt U.S. suppliers rather than help them.

Trade policies created a different set of unintended consequences in the 1980s when the U.S. government imposed voluntary export restraints (VERs) on Japanese carmakers to limit the quantity of their exports to the American market. Although the VERs were successful in limiting Japanese exports, they induced a wave of foreign direct investment by Japanese carmakers and parts suppliers in the United States to sidestep the VERs. Subsequently, Korean and European automakers followed suit, and foreign auto “transplant” firms are now roughly equivalent to their American competitors in automotive output and employment in the U.S. market.³⁴

Long-Term Funding for Supply-Chain Research

Last month, the U.S. Senate passed the U.S. Innovation and Competition Act by a final vote of 68–32, which strengthened the role of the NSF and other leading Federal agencies to coordinate in scientific and technological innovation related to key U.S. supply chains.³⁵ This is a very significant and positive step, especially the proposed creation of an NSF technology directorate that could help focus technology research in areas of critical national importance. However, more specific attention should be devoted to the aforementioned challenges confronted by universities in supply-chain research.

One issue is to supplement the previous temporary support provided by U.S. foundations like Alfred P. Sloan and Rockefeller, which initiated a process of institution-building involving U.S. universities, but it was never designed as a long-term solution to enhancing the resilience of American industries by overcoming short-term disruptions or promoting broad-based and sustainable economic growth. For more decentralized U.S. supply-chain projects, like North Carolina in the Global Economy, a state-level focus did not guarantee local funding. The North Carolina Department of Commerce provided no financial support for this Duke GVC Center initiative, despite utilizing many of the materials from the NC-Global Economy website for internal and overseas presentations and brochures.

³¹Joonkoo Lee and Gary Gereffi, “Innovation, upgrading, and governance in cross-sectoral global value chains: The case of smartphones,” *Industrial and Corporate Change*, (2021), available at <https://doi.org/10.1093/icc/dtaa062>.

³²Eric Thun, Daria Taglioni, Timothy J. Sturgeon and Mark P. Dallas, “Why policy makers should pay attention to the concept of massive modularity: The example of the mobile telecom industry,” *Let’s Talk Development*, World Bank blog, June 18, 2021, available at <https://blogs.worldbank.org/development-talk/why-policy-makers-should-pay-attention-concept-massive-modularity-example-mobile>.

³³Gereffi (2018), *op. cit.*, p. 436.

³⁴Gereffi, Lim and Lee (2021), *op. cit.*; Timothy Sturgeon, Johannes Van Biesebroeck and Gary Gereffi, “Value chains, networks and clusters: Reframing the global automotive industry,” *Journal of Economic Geography* 8(3) (2008): 297–321.

³⁵“Chair Cantwell statement on Senate passage of the U.S. Innovation and Competition Act and NASA authorization,” June 8, 2021, <https://www.commerce.senate.gov/2021/6/chair-cantwell-statement-on-senate-passage-of-the-u-s-innovation-and-competition-act-and-nasa-authorization>.

Additional project-based funding by NGOs such as Environmental Defense Fund and Oxfam America has certainly boosted the knowledge capacities of university-based research centers and independent scholars, but several related difficulties remain. These include:

- providing incentives for universities to build and sustain *industry-oriented research communities* over time;
- facilitating the ongoing *data-collection efforts* needed to allow supply-chain datasets to meet the criteria of top-level peer-reviewed scientific journals as well as policy relevance; and
- building inter-university, cross-regional and international *research networks* that allow for robust efforts to develop analytical frameworks, generate testable propositions, and collaborate with policymakers and practitioners.

In conclusion, given the Department of Commerce's central role in ensuring the resiliency of critical U.S. supply chains, my testimony has sought to highlight the connections between firm strategies, GVC structures, and diverse government policy objectives. The opportunity to revitalize American industries from the "bottom up" seems particularly timely. Broad-based economic growth is often decentralized, and thus we need comprehensive frameworks to promote and evaluate how U.S. companies, states and communities compete across different places and within global industries. Tools like value-chain mapping and using new technologies to build resiliency within local clusters or hubs hopefully can assist this essential mission.

The CHAIRMAN. Thank you, Dr. Gereffi. We will now turn to our next witness, Dr. James Lewis. Thank you so much for being here.

**STATEMENT OF JAMES A. LEWIS, SENIOR VICE PRESIDENT
AND DIRECTOR, STRATEGIC TECHNOLOGIES PROGRAM,
CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES**

Mr. LEWIS. Chair Cantwell, Ranking Member Wicker, thank you for the opportunity to testify. The U.S. benefited for decades from a global supply chain that provided lower cost and greater efficiency. But that era is over. First, the pandemic created an understandable demand for greater resilience.

Second, predatory China will use any means to displace competitors in its quest for global primacy. We are in a conflict with China, and as in past conflicts, industrial strategy, industrial policy is essential. We do not need to abandon a global supply chain, but just shrink China's role in it. This is why the United States Innovation and Competition Act is so important. Congress has already strengthened restrictions on tech transfer to China with the Foreign Investment Risk Review Modernization Act and the Export Control Reform Act. Now it must build technological resilience. Building resilience means taking into account what the global supply chain will look like in the future, the leading role of the market and the private sector in innovation, and the need to build trust into the supply chain for technology.

And of course, the bill touches on that when it discusses 5G and open radio access networks. It must focus on semiconductors, emerging technologies, and reinforcing our national innovation system, which is the strongest in the world. USICA can do this if it is implemented effectively. Congress can start by fully funding the CHIPS Act and by authorizing the supply chain resilience programs already found in the text of the USICA. Fully funding the CHIPS Act will create jobs and is essential for resilience. Increased funding for research and STEM education is also essential to provide the inputs needed for tech leadership. Congress and the White House will guide policy, but implementation falls on the agencies.

The Commerce Department plays a key role, but it faces challenges. Commerce needs to predict, not react. It needs better analytical capabilities, clarity and roles and responsibilities, a high tech focus and close engagement with senior levels of the private sector to better anticipate tech trends. One advantage we have over China is that we have allies. A supply chain with allies increases resilience by diversifying sources. We benefit economically and strategically from an allied approach. This is in USICA and in other bills, but it is crucial for moving ahead.

The U.S. must, as it has done in the past, strengthen strategic industries. USICA identifies 10 advanced technology areas. This is where implementation should focus, right. The U.S. has used industrial policy in every major conflict of the last century. It is one reason for our success in these conflicts. This is why USICA is so important. I thank the committee for the opportunity to testify and I look forward to your questions. Thank you.

[The prepared statement of Mr. Lewis follows:]

PREPARED STATEMENT OF JAMES A. LEWIS, SENIOR VICE PRESIDENT AND DIRECTOR,
STRATEGIC TECHNOLOGIES PROGRAM, CENTER FOR STRATEGIC AND INTERNATIONAL
STUDIES

Chair Cantwell, Ranking Member Wicker, and distinguished Members of the Committee, thank you for the opportunity to testify.

The United States is creating the policies and tools needed to defend ourselves against a hostile, authoritarian China. To do this, the U.S. will need new technological and industrial strategies that will allow it to maintain its national security and economic strength. We are in some ways at the start of the undertaking. Congress and the new Administration, with the *United States Innovation and Competition Act (USICA)*, and the Administration's Executive Order 14017 and 100 Day Review, have taken important steps in this direction. Much of the burden now falls on agencies like the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Departments of Commerce and Energy.

For more than two decades, the U.S. depended on a global supply chain that provided lower cost and greater efficiency. Two things broke that global supply chain. The first is the rise of a predatory China that will use any means to displace competitors in its quest for global primacy. The second is the COVID-19 pandemic, which produced an understandable desire in many nations to reduce their dependence on foreign suppliers and instead rely on national capabilities. Many countries became uncomfortable when they realized that critical medical supplies were only available from sources like China. They want to move some critical production back onto their territories. Now the U.S. and the EU are taking a harder look at reshoring. In a way, this mimics China. Chinese policy has always pursued indigenous capabilities to reduce reliance on foreign suppliers. This supply chain nationalism is reinforced by growing and powerful competition for technological leadership and by events like the semiconductor shortage.

There is a degree of wishful thinking in some Western countries about this contest, that hope that there can be normal commercial relations with China despite stark political differences and predatory behavior. Even if one is willing to put aside any qualms about doing business with regimes that routinely violate the rights of their citizens, the governments of China and Russia have decided that the U.S. goal of building a world made up of market democracies is a threat to their survival. They have further decided that the U.S. is in irreversible decline and now is their moment to push for a world that they can dominate. The end of the Cold War in 1989 and the few decades of American primacy, now ended, are best seen as an interregnum in a longer conflict between democracy and authoritarianism. We are in many ways behind in this contest, but this can be remedied.

This is where the USICA plays a vital role. Past industrial strategies built munitions or heavy industry, but are now outdated. We need a new style of industrial policy that takes into account globalization, the leading role of the market and private sector in innovation, and the need to ensure resilience in emerging technologies.

A high-tech industrial strategy fundamentally has two complementary parts. The first is restrictions on technology transfers to opponents. Congress has strengthened protective measures for competition with China with the *Foreign Investment Risk Review Modernization Act* and the *Export Control Reform Act*. These are important components of a tech strategy.

The second part is to build and accelerate technological resilience. The high-tech industries we have today are built on a foundation of Federal funding, but in the intervening thirty years, there have been significant changes in our economy and innovation system. An industrial strategy today needs to take into account these changes and be guided by three dominant factors: the global supply chain for innovation and technology, the importance of Federal funding, and the central role of markets and the private sector in tech competition.

Previous Efforts at Strategic Industrial Policy

Historical precedent can be an ambiguous guide for policymaking. Many people talk of a new Cold War between China and the U.S. But the globalization of supply, China's dynamic, quasi-market economy, and the reluctance of some key allies to abandon the Chinese market make for a very different world than the bipolar landscape of the Cold War. The 1930s and the rise of authoritarian states bent on confronting democracies is a better precedent than the Cold War, but it too falls short. This new contest with China will last longer and the emphasis is on tech leadership and controlling a global narrative of economic success more than on displaying military power. These past experiences do not provide a perfect roadmap for action, but we can still draw important lessons from them.

In the 1950s, the Eisenhower Administration expanded the technology base created for the World War II with massive Federal funding and the establishment of an institutional framework with entities like NASA and the National Science Foundation. In the late 1970s, the Department of Defense (DoD) focused research on technologies that would offset the Soviet numerical advantage in munitions weaponry. These investments in precision munitions, stealth, sensors, and communications created a "Revolution in Military Affairs." The Eisenhower Administration's support for R&D to expand STEM education and workforce were foundational for America's tech success in the last sixty years and provides a useful precedent we should copy. Technology gave America unquestioned military superiority for decades, but this unquestioned superiority has ended as other advanced states challenge American technological leadership. USICA begins the work to restore it.

America has cut defense spending after every war. In the 1990s, we assumed conflict with peer competitors was a thing of the past. This ultimately proved to be wrong, but made it seem safe to make significant cuts in Federal R&D spending after the Cold War. Congress increased spending on life sciences, but trimmed "hard" sciences like physics, math, and materials. Government funding is essential for basic research in these areas—research that by itself has no immediate commercial value but creates the basis for commercially valuable innovation. Americans did not stop innovating after these cuts—if anything, innovation increased with the introduction of digital technologies—but it was private sector innovation aimed at commercial markets.

USICA, when it is funded, will begin to remedy these mistakes. It is a good start for repeating earlier successes in using technology to advance national security and build economic strength. But today's policy needs to acknowledge that there are crucial differences in how America creates new technologies nowadays. America's national innovation base has changed dramatically. Twentieth century American innovation was national, but today's innovation base is international, with strong research and commercial links between the United States, Europe, and Asia. Efforts at "reshoring" will not change this. While these connections can create security risk when it comes to technology transfer to hostile states, they also provide benefits that outweigh risk. A country that cuts itself off from this international innovation system will fall behind. These changes make it necessary to find ways to take advantage of a multinational commercial innovation base that leads R&D for new technologies, including 5G, artificial intelligence, biotechnology, quantum computing and alternative power sources.

The Role for the U.S. Department of Commerce

The deep interconnectedness between the U.S. and the Chinese economy forged over forty years created both opportunity and risk. We do not need to abandon a global supply chain but to shrink China's role in it. Complete bifurcation is unnecessary as there are some technologies that can be safely transferred to China while others must be restricted. The Commerce Department could make this distinction as part of its export control process. It is in the national interests to allow our com-

panies to take advantage of the Chinese market in ways that minimize risk for as long as possible. The United States has made good progress in restricting China's ability to acquire American technology—a key part of China's modernization plans—with Congress's passage of the *Foreign Investment Risk Review Modernization Act* of 2018 and the *Export Control Reform Act* (although it has had implementation problems).

These two Acts, however, are defensive. Denying China access to technology is not enough. We know from the American experience in the conflicts of the twentieth century that the U.S. must also strengthen its own technological base in this new and long-term competition with a hostile and authoritarian China. This is where the USICA is vital to protecting American security. However, the industrial policy models of the twentieth century are no longer effective. Nor do we wish to copy China's state-directed economy. Finding a new model of Federal intervention to bolster our technological base in the competition with China will be difficult.

Implementation points to the critical role of the Department of Commerce. If there is a precedent here it is the difficulties in implementing the *Export Control Reform Act*. For years, Commerce defined itself as an export promotion agency and this still has a powerful influence over its culture. The export controls Commerce is charged with administering are still largely based on the Cold War technology framework enshrined in the Wassenaar Arrangement. Sometimes agencies can modernize themselves, other times it takes Congressional direction and leadership. Thinking about what a twenty-first century Commerce Department should look like may be a good task for the committees of jurisdiction in their oversight function.

These difficulties may be less of an obstacle than they may appear, because in fact, the decisions and strategies needed to implement USICA will be made in the White House, at the NEC and NSC, and by Congress. Commerce will implement these policies and how it does so will be crucial in determining their success. In this, we can suggest two principles to guide Commerce: first to focus on emerging and foundational technologies, and second to build a symbiotic relationship with America's fast moving, risk-taking, entrepreneurial business culture.

Commerce should focus its efforts on key technologies and design policies that as much as possible reinforce the private sector. The comparatively smaller size of Federal investment versus private sector investment alone makes this a good choice. We are in a competition between economic models, between China's increasingly state-centric economy and our market driven model. A key task for policy is to identify where Federal intervention is necessary, and USICA's identification of ten key technologies categories is where the U.S. should focus its activities.

USICA gives Commerce the authority to establish a supply chain resiliency program, to encourage cooperation between the Department and the private sector to identify supply chain problems and develop solutions. Supply chain issues that arose from the global COVID-19 pandemic are one reason for these provisions. Hence, the supply chain program should initially prioritize semiconductor supply chain issues, and only cover other supply chain issues in the future.

The most immediate of these areas involves semiconductors. Federal support is necessary to achieve two goals: to move more production capability back to the United States and, to a lesser extent, to increase productivity capability (less because private sector investment will do this). We do not want to duplicate China's error of investing billions in inefficient or outmoded semiconductor production. We do want to invest in location subsidies, in research, and in opposing anti-competitive behavior.

Semiconductors

Semiconductors are the foundational technology of the twenty-first century. The United States needs to remain strong in this industry, but in the face of global competitors that make heavy use of subsidies, it will need government action and funding to maintain its position. The United States still has the largest share of the global semiconductor market. It leads in chip design and it has roughly half of the global market for semiconductor manufacturing equipment, but it lags in chip fabrication. This lag is the source of supply chain risk.

A 2019 OECD study found that of the dozen or so countries with significant semiconductor industries, only the United States did not use subsidies. We may not like it, it may not be fair, but subsidies are part of the market and the failure to provide location incentives is one primary reason why the U.S. share of semiconductor fabricating facilities has fallen by two thirds and chip fabrication moved offshore.

The semiconductor industry has a globally distributed supply chain. This is the most economically efficient, but it now creates security risks. Our goal should not be to abandon the global supply chain but to reduce China's role in it. This will not be easy, but complete bifurcation is unnecessary. We want to avoid ending up in

a position where China is the sole supplier for any segment of the chip supply chain, because they will take advantage of this to harm us. That does not mean that companies and facilities outside of China that provide key parts of the chip supply chain—in Israel, Ireland, and others—should be replaced. We benefit economically and strategically from maintaining a global supply chain in which China’s role has been decreased. China exploits us. We should in turn exploit the Chinese market as long as possible and as long as our technology transfer controls are working. This means selective decoupling and allowing some economic interactions to continue.

One open question is Taiwan. The Chinese government’s ultimate intent is to absorb Taiwan as it absorbed Hong Kong, but Taiwan will be more difficult to absorb and China may never succeed. But the intention creates risk. We depend on Taiwan for advanced fabrication of chips. This dependency requires that we ensure Taiwan’s autonomy from China, but also that we ensure resilience by getting key Asian firms to locate some of their facilities in the United States. This can be part of a larger effort to build resiliency and security by strengthening all segments of the U.S. chip industry, through investments in R&D, workforce, and subsidies, including support for other parts of the semiconductor supply chain, such as advanced packaging.

The Administration’s 100 Day Supply Chain Review offered seven recommendations to strengthen the U.S. chip industry. These include a call to fully fund the *Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Act* (which has been languishing in Congress for a year), measures to strengthen the entire chip supply chain, build the STEM workforce, use export controls to protect technology, and work with allies to harmonize policies on R&D and China—key allies like Japan are ready to do this. The recommendations in the 100 Day Review, particularly if combined with Congressional guidance and action on funding, will keep the United States strong in this core technology.

There are reasonable concerns with any effort to strengthen the chip industry. The first is that our efforts may create overcapacity. The chief cause of the chip shortage was a miscalculation by companies, in particular, car companies. They, like many others, failed to plan for the surge of pent-up demand as the pandemic waned and cancelled chip orders. In response, chip makers shifted from producing for cars to producing for items suddenly in demand during the pandemic, those that supported streaming, gaming, computing and phones. This miscalculation was reinforced by supply chain disruptions from weather and fire. Just-in-time supply left car makers with no reserves, and one question for reliance is whether and how to incentivize companies to move away from just-in-time supply. The 100 Day Review’s recommendation for better information flows can reduce the risk of future miscalculation, as more information on the market can guide Federal and private investment in production capacity. Overproduction in chips is not a long-term problem, as demand for semiconductors will continue to grow and absorb increased capacity.

A related concern is “investment in what.” The digital economy is being reshaped by cloud computing, artificial intelligence, and 5G networks. Digital technologies are being reshaped and USICA recognizes changes in telecom technology that work in America’s favor. 5G and open access technologies like O-RAN depend on chips and software, both areas of American strength (especially when compared to China). Telecom and chips are dynamic industries driven by demand for better performance. The pace of change is rapid, and this could complicate plans for Federal intervention. The semiconductor industry itself is broken into highly specialized segments and is geographically distributed. Deciding which sectors would benefit from Federal support, and determining what kind of support, is an immediate task for policy. USICA, and with it the *CHIPS for America Act* and the *USA Telecom Act*, do a good job of recognizing that there is more to the industry than fabrication facilities. The issue is how best to intervene in this complex industry. An earlier success, SEMATECH, a non-profit, public private research consortium, provides useful precedents, the most important of which is to not try to have the Federal government direct research or insist on specific technologies and to ensure that the private sector has “skin in the game.”

Role of the Government

The question of the role government is a long-standing debate in industrial policy, which we can simplify as a debate between those who argue that governments should supply the foundation for innovation through R&D funding, increased STEM education, and balanced regulation, and those who would prefer a more directive approach. The well-known case of Solyndra became the poster child for why the government should refrain from selecting a specific technology company to support, and instead emphasize market competition to identify the most successful paths forward.

Few government agencies can act like venture capital firms, something that proves to be very hard to do. Venture capital firms have a higher tolerance for risk and ring specialized expertise to identify opportunities, including using geographic proximity to markets to gain a deeper knowledge of the business. There is a mismatch between bureaucracy and innovation. There are a few examples of success for the Federal government, such as In-Q-Tel and the Defense Innovation Unit (DIU), and it would help build resilience if these and similar efforts were better funded and, in DIU's case, given increased and more flexible authorities to invest.

These difficulties should not distract us from the importance of the Federal government playing an essential role in creating new technology. That role has changed given the immense expansion of commercial innovation. The center of gravity for innovation and tech investment has moved away from government. A dynamic private sector innovation ecosystem is focused on commercial markets, but with the right authorities, funding, and mechanisms, the government can take advantage of this to improve resiliency. This will require some effort because the cultures are vastly different. Private sector investments dominate R&D budgets for new technologies, such as 5G, artificial intelligence, biotechnology, quantum computing and alternative power sources. The new innovation ecosystem is shaped by market signals on investment risk and returns more than policy.

Commerce and other agencies need to predict, not react. For example, media reporting recently highlighted problems with the supply of lumber. This is perhaps a good example of why media reporting is not always a useful guide for policy. The shortage was so short lived that the efforts to remedy it barely begun before it was over. It needs better analytical capabilities, clarity in roles and responsibilities, and close engagement with the private sector at senior levels to anticipate market and tech trends. Its industrial analysis and support function (a legacy from World War II) atrophied over the past decades and now needs to be rebuilt to focus on high-tech. A focus on emerging technologies can help avoid wasteful spending of time and money.

Cost

There are concerns over the cost of these initiatives, but critics of the price tag should consider two factors. First, China has been willing to spend for sustained periods of time to gain technological advantage. In some areas, China is keeping pace with the U.S. and even outspending it in some cases. In semiconductors, for example, it has pledged more than \$50 billion in five years from national funds and an equivalent amount from local governments. Given how much larger U.S. national income is compared to China, this should not be the case. We should not expect to outcompete China without increased Federal spending. Second, this spending is an investment, a down payment on America's technological future. Money appropriated now will create jobs and income, more than repaying the cost. Both security and economics call for the full appropriations to support the objectives laid out in USICA. Putting aside the collateral benefits to wealth creation and economic growth from USICA (and these could be substantial), it is better to overspend and stay ahead of China than to under-spend and fall behind.

A Global Approach

One advantage we have over China is that we have allies. A supply chain that involves allies increases resilience by diversifying sources. We benefit economically and strategically from an allied approach. It may seem counterintuitive, but international cooperation makes America more competitive.

Artificial intelligence (AI) exemplifies how international today's innovation base is. The technologies behind AI are not easily controlled. China has significant strength in this, but AI depends on a globally distributed R&D and innovation chain, with key nodes not only in the U.S. and China, but in Canada, the UK, Israel, Germany, and a few others. These countries share a growing distrust of China's intentions and policies that the U.S., by working with them, can capitalize upon to build security and growth. Focused Federal investments and multinational partnership structures, and revised authorities can provide the U.S. real advantage in the competition with China.

The United States has used industrial policy in every major conflict since 1860. Industrial policy is part of the reason for its success in these conflicts. The U.S. must, as it has done the past, strengthen strategic industries. This is why USICA and its implementation are so important. Industrial policy was the key to helping the U.S. win those conflicts, and the technology base built in World War Two—and expanded tremendously for the Cold War—still provides foundational benefits to our economy from investments made decades ago.

We and our allies are again confronted by authoritarian states. The terms of conflict with these hostile powers will be different, relying less on military force and more on economic and political influence. One key area for competition will be in the fields of technology and business. These provide the countries that lead in them with power and authority in the international environment. A new industrial policy is necessary again for the United States, but we will need to adjust to this new form of conflict and to the changes in research and industry that have taken place over the last thirty years. That means a new, high-tech industrial policy cannot focus on building weapons and it cannot be over-managed by Washington.

China has many weaknesses that its propaganda seeks to obscure. It faces immense problems, but under its current leadership, it intends to displace the United States. Building globally dominant high-tech industries is a part of this strategy. The U.S. must respond to China's hostility, but we can no longer rely on market forces alone to advance the national interest. Defensive actions alone will not suffice. These themes all point to the need for a renewed industrial strategy, but it cannot simply duplicate previous policies because we are now in a world where the private sector leads. This means the task for USICA implementation is to find where government intervention can best support a multinational commercial innovation base. Finding the right balance of the role of government will be difficult, but USICA, Executive Order 14017 and the 100 Day Review means that we are off to a good start.

I thank the Committee for the opportunity to testify.

The CHAIRMAN. Thank you, Dr. Lewis. Thank you so much. We are now going to go virtually to Mr. Richard Aboulafia. Not sure where—what part of the world you are in, Mr. Aboulafia, but welcome here into our committee conference hearing room.

**STATEMENT OF RICHARD ABOULAFIA, VICE PRESIDENT,
ANALYSIS, TEAL GROUP CORP.**

Mr. ABOULAFIA. Sure, Madam Chair Cantwell, and thanks to you and to the Ranking Member Wicker, and of course, members of the committee. I bring you greetings from an island off of Stockholm. It is rather a long ways away, but deeply honored to be here speaking with you today about the aerospace supply chain.

A few things to emphasize about the character of that supply chain, some recent challenges it has faced in the wake of the COVID-19 pandemic, and the associated aviation market downturn, and a few things that the committee might want to consider as it deliberates the status of our industry and our supply chain. Basically, there are three things that I would emphasize about the aviation industry supply chain.

First of all, value. The overwhelming bulk of the value add in the aviation business happens at the supply chain. It is not at all a dig at the many great prime contractors out there, but an aircraft is effectively the sum of its parts, and up to 85 percent or more of the value of the plane comes from the suppliers. Typically the prime, somewhere between 15, 20, 25 percent at most, with the rest coming from its supply chain companies. Having said that, it is also vulnerable. This is an industry—well, we have very high barriers to entry and very low levels of substitution.

So as a consequence, if there is a relatively small, what seems like an easily replaceable part that simply isn't available, the aircraft can't be built pure and simple. We saw this last year with, of course, the logistical challenges associated with the COVID-19 pandemic. And Lockheed Martin had planned on building about 140 F-35 Joint Strike Fighters for a variety of logistical reasons. Almost all of them in the supply chain, they were only able to de-

liver 123. So in terms of vulnerability, well, that is where you faced problems, I am afraid.

And then finally, innovation. And thank you, Madam Chair Cantwell, for highlighting this, really the overwhelming bulk of technological progress of fuel savings, of emissions reduction, of passenger comfort, really anything you associate with aviation. On the other side of the house, a lot of the combat effectiveness that we associate with the country's fantastic combat aircraft come from the supply chain, not the prime. So it is very important that the companies in the supply chain have a steady stream of research and development resources in order to bring these new technologies to market.

Now, the unfortunate reality, of course, is that we faced the most devastating pandemic in industry history last year because of COVID-19. You know, looking back over the many decades of the aviation industry, typically in a really bad year, you would lose maybe 3 percent of traffic year over year after for example, 9/11 or the 2008 recession or Gulf War I or any of those, maybe 2 or 3 percent. Last year we lost 66 percent of traffic globally. That is cataclysmic, especially for companies that are heavily dependent upon the aftermarket on equipment utilization.

So the financial challenges associated with this unprecedented falloff in business were very challenging for the supply chain. Now, I am very happy to say that for a variety of reasons, almost all companies have come through it. But I am very concerned about their ability to access capital in order to hire people and of course facilitate for the upturn that inevitably follows a downturn. It may sound counterintuitive, but in a lot of ways some of the greatest challenges supplier companies will face is in the recovery having come through the downturn.

And especially this is true for the labor side of things. And that is why I would commend the Government especially for its several rounds of Paycheck Protection Program legislation, because I think this has absolutely been vital in retaining skilled workers and keeping them from going elsewhere or simply just being offline for whatever reason.

It has been absolutely fantastic for the industry, and I deeply hope it continues. Other things that the committee may want to discuss, I believe the time might be right to consider basically the sustainable aviation industry R&D program. The Government has historically been very good at basic R&D, but when it comes to applied R&D, less so. And I think there are a number of promising technologies, particularly in sustainable aviation fuels and other sustainable initiatives that I think could be accelerated, and with perhaps a bit of Government assistance, play a meaningful role in companies' ability to maintain their competitiveness.

And then finally, I think another thing to discuss might be the issue with China, because China is the biggest single export market for commercial aviation companies and there is a great deal of uncertainty, both about our trade relations with China and with the rules on shipments of technology and componentry due to the creation of the military end user list by the U.S. Government.

There are so many complications involved here, but there is a great deal at stake for the future growth of the industry. Thank you so much for your time.

[The prepared statement of Mr. Aboulafia follows:]

PREPARED STATEMENT OF RICHARD ABOULAFIA, VICE PRESIDENT, ANALYSIS,
TEAL GROUP CORP.

Madam Chair Cantwell, Ranking Member Wicker, and Members of the Committee, thank you for asking for me to testify before your committee today. I am privileged to provide you with an overview of the aviation industry supplier base.

I am Vice President of Analysis at Teal Group, a leading aerospace market analysis consultancy based in Fairfax, VA. I manage consulting projects in the commercial and military aircraft field and analyze broader defense and aerospace trends. I have advised numerous aerospace companies, including most prime and many second-and third-tier contractors in the U.S., Europe, and Asia. I also advise numerous financial institutions on aerospace market conditions and industry dynamics. I have been in the industry since 1988. All my public writings and comments on the industry can be found at www.richardaboulafia.com.

Today, I would like to discuss three things with the Committee: (1) the structure and characteristics of the aviation industry supply chain; (2) the market, and other challenges to suppliers; (3) questions that should be asked by the Committee, along with my recommendations for future action. I am also happy to answer any questions you might have.

1. Industry Structure And Characteristics

The Supply Chain's Importance

The supply chain is the heart of the aviation industry, because of three factors: *Value*, *Innovation*, and *Vulnerability*.

First, the components, structures, systems, and technologies provided by the aviation supply chain represent the strong majority of the *Value* of any given aircraft. When Boeing sells a jetliner, or Lockheed Martin sells a fighter jet, suppliers, collectively, realize more revenue than the primes (Boeing and Lockheed Martin) do. There are almost no exceptions to this pattern, whether it is a transport, helicopter, business jet, or any other type of aircraft.

For a typical Boeing jetliner, 80 percent of the value gets added at the supplier level. Of course, employment, tax revenue, and other key metrics mirror this reality: the supply chain is of greater importance to the economy compared with the primes for many reasons.

Second, it is important to note that much (and often most) of the *Innovation* that takes place in aviation happens at the supplier level, and not at the prime level. Boeing's 737 jetliner, its F-15 fighter, Lockheed Martin's F-16 fighter, and many other platforms have been in production for around half a century. But the current models have very little in common, aside from exterior shapes, with the original production versions. The rejuvenated jetliners use much less fuel and produce much fewer emissions. The rejuvenated combat aircraft are vastly more effective.

The successful transformation of these aircraft is because of the tremendous innovation that has taken place at the supplier level. Suppliers have created new and improved engines, avionics, systems, electronic warfare suites, materials, and more, which have been applied to these aircraft. Therefore, a steady flow of research and development (R&D) funding, for and by suppliers, is essential for the industry's future growth, industry competitiveness, and for the overall good of the aviation transportation system.

Third, as with most complex manufactured products, an aircraft production system is only as strong as its weakest link. That is, if a supplier company fails, somebody needs to step in to buy it, or to give it the capital or other resources needed to stay in business. Otherwise, the aircraft in question is not built.

The health of the supply chain, therefore, is critical to the aircraft industry. Given the enormous stresses experienced by the supply chain over the past two years, company failure, or inadequate resources for supplier capacity expansion and technology development, are some of the biggest risks faced by the industry. The supply chain, crucial to industry success, is also its greatest *Vulnerability*.

High Barriers to Entry and High Levels of Concentration

The aviation industry has very high entry barriers. Since World War 2, only one country (Brazil), and one company (Embraer) has successfully entered the jetliner industry. Very few companies—around five—have successfully entered the smaller

jet industry. Worldwide, more companies have exited the jet industry than have entered it.

Entry barriers at the supplier level are also quite high. Most suppliers have been in business for 50 or 60 years, and while small, niche companies have been created, they are the exception. Very often, they are simply purchased by the larger, established suppliers.

There has also been a great degree of concentration in the industry. The aviation supply chain saw a series of mega-mergers over the past few decades. As a result, some supplier companies, such as Raytheon Technologies, General Electric, or Safran, are about as large, or larger, than some of the biggest aircraft primes.

Having said that, there are still a large number of suppliers at the Tier 2 or Tier 3 level that are small, and relatively fragile. While there's little risk from emerging competition (due to the high entry barriers), these smaller companies still face serious challenges in accessing capital and improving their products and processes.

Impact of Globalization

The supply chain, like the rest of aviation and aerospace, is a highly globalized industry. Components built by U.S. suppliers find applications on platforms throughout the world. In fact, one key U.S. supplier component, Pratt & Whitney's Geared TurboFan engine, has become quite successful purely on the basis of powering jets built by foreign aircraft companies.¹

However, it isn't always an equal playing field in the world. Suppliers from allied countries, such as the U.K., France, or Italy can readily find applications on U.S. aircraft, even military ones. But U.S. suppliers have a much harder time being sourced on European military aircraft.

Some of this problem results from U.S. International Traffic in Arms Regulations (ITAR) regulations. Aircraft designed with U.S. components are perceived to be problematic in international competitions, where U.S. Government decisions can prevent the sale of any aircraft that has U.S. components on board. Similarly, technology transfer restrictions have also resulted in U.S. suppliers being disadvantaged on combat aircraft built in countries without their own supplier companies.

South Korea's KF-21 is a good example of that. U.S. Government reluctance to transfer data pertaining to U.S. technologies and systems, and to provide export licenses for these systems has resulted in significant competition losses. European companies, for example, have been tapped to provide this new fighter's radar, and other systems, largely because the U.S. did not want to provide the necessary data and licenses.

Also, government-funded R&D programs seldom cross borders (although companies do successfully cross borders with their own privately-funded R&D). When governments support their industry with commercial or military R&D development programs, the beneficiaries are almost always exclusively domestic firms. That is true in the U.S., and in other major aviation producer countries.

Some countries that only have an aviation supplier industry (as opposed to an in-country prime contractor) are more willing to make these programs accessible, since their own industry depends on global trade. The Netherlands is a good example of that. But most large aviation powers, such as France or Japan, have their own prime contractors, and do not make their much larger government R&D programs accessible to companies domiciled in other countries.

One unique characteristic of the aviation supplier industry is that globalization has not seen the rush to low-cost sourcing seen in many other industries. Rather, the overwhelming majority of foreign suppliers providing components for U.S. aircraft are from high skill, high wage countries. Japan, France, Canada, the U.K., and Mexico are the top sources for these components, but almost all of the components and structures shipped from Mexico are actually sourced from transplant factories owned by U.S., Canadian, or French supplier companies.

China, notably, is not a significant source of aircraft components, even from transplant factories. In fact, at the peak level of U.S.-China aerospace trade, the trade balance between the two countries was 17-1 in the U.S.'s favor.²

2. The Market and other Challenges

An Unprecedented Downturn

The entire aviation manufacturing industry has been impacted by the worst air transport downturn in history. The Covid-19 pandemic, and the associated lockdowns and travel restrictions, have resulted in numbers heretofore unseen in

¹ <https://www.forbes.com/sites/richardaboulafia/2017/07/30/a-stunning-u-s-industrial-succes-shows-problems-with-trumps-made-in-america-push/?sh=3c9149997c0e>

² <https://dataweb.usitc.gov/>

the aviation industry. Historically, in a bad year for the market, air travel typically falls by 2–3 percent year-over-year; in 2020 it fell by 66 percent. Only massive government intervention, in the U.S. and other countries, has staved off mass airline bankruptcies.

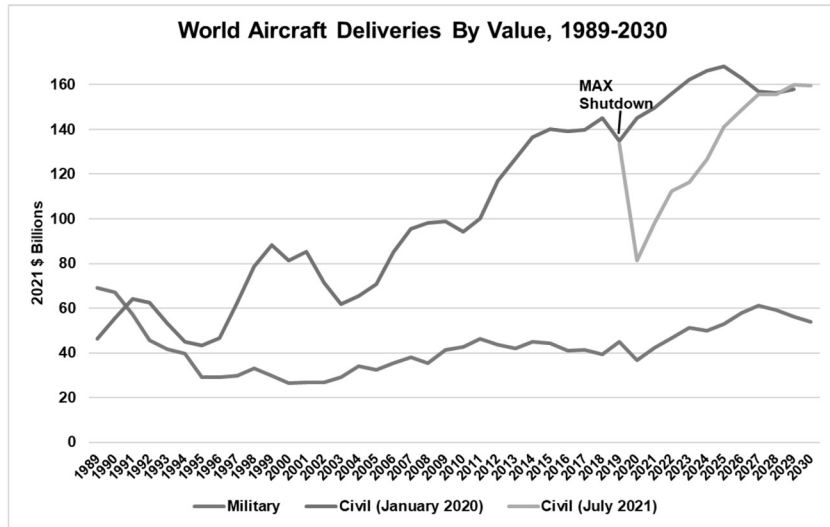
As of this writing, however, the situation is improving. The over-all economic picture is far better than feared. Domestic travel markets, particularly in the U.S. and China, have come back strongly. The most recent traffic numbers show U.S. domestic flights up 3 percent relative to the same period in 2019, the first time these numbers have turned positive since the pandemic began. Even European flights, which were down 62 percent in May (relative also to 2019) have started to make a strong recovery, with the most recent numbers down just 34 percent.³

In fact, we now expect a return to the 2019 revenue passenger kilometer (RPK) travel peak in late 2022. And meanwhile, jetliner financing is inexpensive and readily available, and fuel is getting expensive again—the perfect formula for renewed jetliner orders (particularly single aisles).

The only area of serious concern, outside of Covid-19 itself, is China, the biggest single export market (and tied with the U.S. for biggest single market). At the peak level of deliveries to China, 2018, the country took 23 percent of all jetliner deliveries worldwide. This has fallen precipitously, for both market reasons and due to geopolitical factors. This trade is under threat, due to slowing in-country growth rates, China’s reluctance to recertify Boeing’s 737MAX, and the U.S. Government’s decision to put Western components for China’s ambitious national aircraft programs on a possibly restrictive export list.

However, for the supplier base, the Covid-19 downturn came after another traumatic event: the grounding and production halt of Boeing’s 737MAX. This is the second largest volume program in the world, and easily the largest in the U.S. Some supplier companies have a very high level of exposure. For fuselage provider Spirit AeroSystems, and many of its suppliers, this level of 737MAX dependence is in the 50 percent range.

The impact of the Covid-19 downturn on the civil aviation market can be seen in the chart below. The 2020 line (red) illustrates the market outlook as of right before the pandemic (with a MAX-related downturn in 2019–2020). The green line shows current projections, but also what happened to the market in 2020. Deliveries of commercial jetliners fell by 50 percent relative to 2019, and again, 2019 was already a weak year due to the 737MAX shutdown.



The above chart also illustrates the relative sizes of the civil and military segments of the aviation industry. The civil side is simply much larger, if not always as profitable, compared with the military side of the business. Thus, while military

³Bank of America equities report, “Commercial Aerospace Tracker,” July 13, 2021

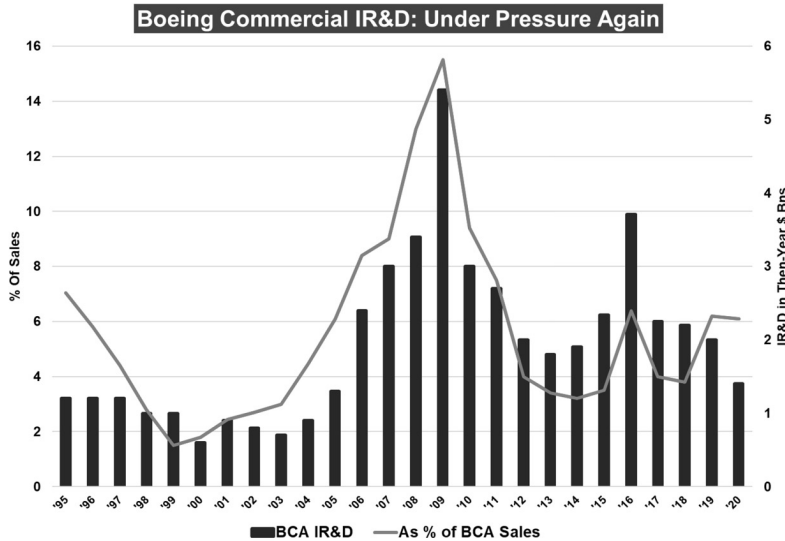
revenue has helped stabilize the supply chain, it simply cannot compare to the volumes seen in the commercial sector.

For aviation suppliers with a heavy exposure to the aftermarket, or maintenance, repair, and overhaul (MRO) part of the industry, the unprecedented falloff in utilization has resulted in a revenue decline even worse than that seen with new-build aircraft. Even for supplier companies that don't rely on the aftermarket for the majority of their business, this decline has been painful, since aftermarket work tends to be more profitable than new-build production.

Boeing's market position

Another challenge faced by the supply chain concerns Boeing's market position. Despite the industry's globalization, U.S. supplier companies, in aggregate, are more exposed to Boeing relative to its rival, Airbus. Right now, however, Boeing seems prepared to cede market share to Airbus. This may change as the market recovers, and Boeing is clearly under a great deal of financial pressure as a consequence of both the 737MAX shutdown and the industry downturn, but right now the outlook for the company's future product development efforts is a serious concern for the industry.⁴

The European company's A321neo is a very strong performer in the mid-market segment. Boeing, by contrast, has cancelled plans for its own new mid-market jetliner. It hasn't launched a completely new jet in 17 years. It continues to cut its engineering team. As the chart below indicates, it has slashed R&D, with a further 27 percent cut last year alone.



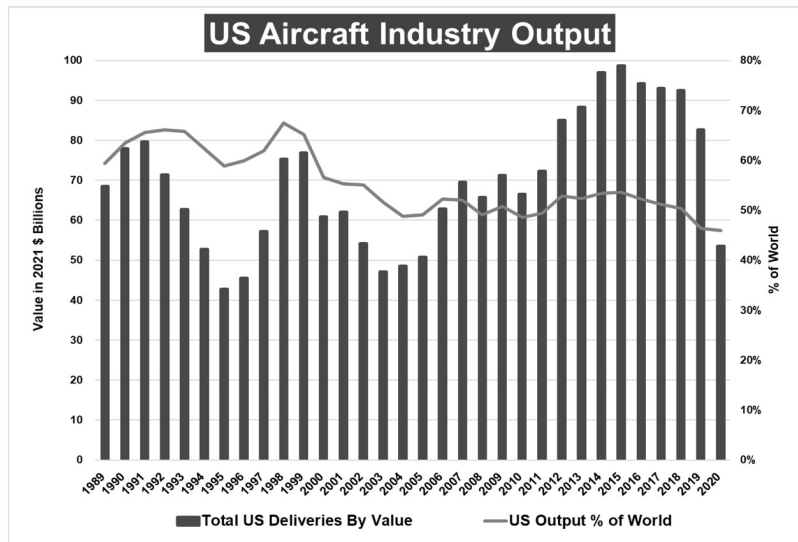
Assuming Boeing does nothing new, and the duopoly goes from a 50 percent-50 percent market share balance to a 60 percent-40 percent one in Airbus's favor (this is our projection), then on balance, U.S. aviation supplier companies will face a similar decline. The companies with substantial Airbus exposure will be immune from this, but again, many U.S. suppliers are heavily reliant on Boeing.

Boeing has also been quite aggressive with its supply chain in terms of contract terms. Boeing programs such as Partnering For Success (PFS) were designed to pressure suppliers on prices, intellectual property, aftermarket access, and other terms. It isn't clear whether Boeing will begin to take a softer approach, now that much of its supply chain faces very different circumstances (relative to the good years before the MAX shutdown, when the supply chain was healthy enough to withstand these contractual changes and pressures).

The extent to which U.S. industry relies on Boeing can be seen in the following chart, which shows U.S. aviation industry output in both absolute and relative (to

⁴ See, for example, <https://aviationweek.com/aerospace/program-management/opinion-will-boeing-become-next-mcdonnell-douglas>

the rest of the world) terms. As a percentage of world deliveries, U.S. output has been fairly stable at just over 50 percent for several decades. However, in 2019 and 2020, this shifted below 50 percent. Obviously, the serious decline in 2020 (in absolute terms) was due to the pandemic. But the decline as a percentage in 2019 and 2020 was purely due to the 737MAX production halt.



Consequences

Despite the severity of the aviation market downturn, the aviation supply chain has generally weathered the storm rather well. Several smaller companies have gone bankrupt, but these represent well under 1 percent of supplier capacity. For almost all companies, relative health has depended upon portfolio: those with the most defense work have done best. Those with the most exposure to twin aisle jets (the single most impacted part of the aviation business) or to the 737MAX, have generally been hit hardest. But again, there have been very few outright bankruptcies.

However, there are many concerns for the future of the aviation supply chain, for two reasons:

First, it is important to consider the reasons that almost all aviation suppliers have come through the crisis intact. Government support is one of the biggest reasons, particularly with paycheck protection programs. Similarly, defense spending, while not as large as commercial market numbers, is relatively strong, particularly compared with the last commercial jetliner market downturn (in 2002–2003). The Department of Defense's accelerated payments program, aimed at stabilizing the aerospace industrial base, has been very helpful.

Supplier companies have also taken almost every possible defensive action. They have sold assets, fired or furloughed workers, burned down work-in-progress, and conserved cash any way they can. These were tough calls, particularly with headcount reduction; but, when topline revenue falls drastically, the only way to avert financial disaster is to cut variable costs, which, for the most part, means cutting payroll.

Also, financing, so far, has been available to suppliers. Banks and other lenders have been patient, and have provided new financing. Interest rates are low, which helps with debt servicing.

Yet all of these measures have run their course. Debt has been increased, capacity and workforce cuts have been made, non-core businesses have been shed, and the Pentagon has done all it can. Defense budget growth has halted in real terms, and accelerated payments, inevitable, have run their course.

Second, it is important to consider the challenges ahead. When jetliner production rates rise again, many supplier companies may have a difficult time raising the capital needed to make capacity investments. Labor costs increases and other inflationary pressures could exacerbate these capacity expansion challenges.

In short, these survival tactics have resulted in a rather brittle supplier base. These companies have shed assets and taken on a great deal of debt. Inevitably, R&D funding for new technologies has been slashed too, endangering future competitiveness.

Finally, given the concerning development of Covid-19 variants, such as the Delta variant, there are valid reasons for concern regarding the recovery's trajectory. If anything were to disrupt the market recovery, such as another round of pandemic-induced lockdowns, the resulting production cuts would endanger the health of a very fragile supply chain. Concerns about its health would range from short-term financial viability worries, to long-term R&D funding questions.

3. Questions and Recommendations

Questions

In my opinion, the Committee might want to ask the following ten questions about the health of U.S. aviation supplier industry:

1. Is the market crisis over? Or, will another round of paycheck protection aid be required by the industry as a consequence of either a resurgent pandemic or an economic downturn, possibly one induced by the end of government aid programs?
2. Will financial weakness in the supply chain impact the production ramp-up that will hopefully be associated with a market recovery?
3. Human capital is a major possible bottleneck; can suppliers bring back skilled employees after deep cutbacks?
4. In addition to labor, what other inflationary pressures (energy, materials) do suppliers face? Do their contracts allow for pass-throughs of these inflated costs? How badly did prices fall for jetliners, and are suppliers further subject to declining revenue here as well?
5. Will private equity and other financing sources be available to help suppliers with capital (or to buy them) in the next few years?
6. Are U.S. suppliers at risk of acquisition by non-allied countries?
7. Are current ITAR reforms sufficient to enhance the competitiveness of U.S. suppliers on the military export market?
8. What is the status of U.S. components on the Military End User (MEU) list? The Trump Administration put many of the constituent companies of China's COMAC (their aspiring state-owned jetliner company) on a list that may, or may not, prohibit component exports. Since China's jetliners will be much more difficult (and perhaps impossible) to develop without these inputs,⁵ this was a very aggressive move, and the Biden Administration has continued this ambiguous policy. Is this part of an effort to negotiate a grand trade bargain (perhaps one including Boeing jet sales) to China?
9. Will U.S. allies stay on the same page regarding China? The Biden Administration has made working with allies on China a priority. Calling a ceasefire on the WTO complaint against Airbus is part of that, with the objective of working with the Airbus countries on a united front against China's efforts to distort the jetliner market. Will those European countries say with the U.S. in this united front?
10. Will Boeing launch a new aircraft to effectively compete with Airbus in the mid-sized jetliner market?

Recommendations

I would offer the following seven recommendations to the Committee for actions that would be useful in securing the future of the U.S. aviation industry supplier base:

1. Initiate a government R&D "Sustainable Aviation" or "U.S. Clean Skies" program for aviation suppliers. Europe has moved aggressively to establish Zero Emissions targets for aviation, and is funding a wide variety of technologies under "Clean Skies" and other programs. The U.S. should consider the same for its supplier companies, particularly since the majority of EU country-funded research is not accessible to them.

The emphasis might be on sustainable aviation fuel (SAF) and other related technologies. This initiative would echo similar work begun in France, Germany, and the European Union, the latter with its ReFuelEU legislation to

⁵<https://foreignpolicy.com/2021/02/16/china-aviation-industry-washington-trump-biden/>

boost SAF. SAF and other research programs might be coupled with airline usage mandates designed to increase the guaranteed market for the new technologies.

This clean skies initiative would also serve to employ engineers and technical workers at suppliers, who might otherwise be at risk of headcount reductions due to company-funded R&D cuts.

2. Move a greater share of government R&D dollars from basic to applied research. The composition of R&D is a serious issue because the U.S. Government is good at funding basic research but not as good at applied research. It would be good to consider a migration of Federal R&D dollars toward applied level projects to help out with U.S. competitiveness. This would also help to get technologies to market faster, and of course with supplier workforce issues. This migration would involve working with supplier companies to identify what is in the pipeline now, what the prospects are for acceleration, and how government money can help.
3. Clarify the China MEU list. For many suppliers, there is considerable uncertainty about this list: are component shipments for China's indigenous jetliner programs prohibited or not? If this uncertainty isn't a deliberate effort aimed at crafting a trade agreement with China, the terms and conditions of the MEU list should be clarified, so U.S. suppliers can again sell into this important export market without fear of legal ramifications at home.
4. Work to enhance coordination with Europe on China aviation policy. China is able to demand technology transfer from U.S. supplier companies, in large part, because it plays Europe and the U.S. off against each other for jetliner orders from Airbus and Boeing. If both sides agreed that jetliner orders would not come with pre-conditions like these (that is, if China adhered to the terms outlined in the WTO's Agreement on Trade in Civil Aircraft⁶), this would not be a problem. Eliminating technology transfer risk would help supplier companies sell into the crucial China market without fear of creating long-term competitors.
5. Continue to work on labor-centric assistance packages. Paycheck protection programs have been remarkably successful in helping the supply chain maintain its workforce during the downturn, and this will be crucial in maintaining the increased pace of output we will hopefully see as the market recovers. But if another round of PPP is needed, it would be better to have the terms and conditions lined up in advance. Also, U.S. companies continue to face a demographic "bathtub": there is a gap between many older, more experienced workers, and the younger next-generation, due to low levels of employee intake during the 1990s and early 2000s. There may be ways for the government to help with mentoring and training programs.
6. Direct the Department of Defense to provide greater clarity on its spare parts order patterns and inventory levels. Several suppliers report that they benefited from a significant run-up in components orders at several times over the last year, but then, suddenly, orders fell to nothing. It's possible that DoD was increasing its orders as a way of helping supply chain companies during the crisis, but, inevitably, this resulted in filled warehouses, so orders have fallen off. Either way, guidance for industry on these patterns would be very helpful.
7. Accelerate and improve ITAR reform. It might be best to go back to the commitment made in the Export Control Reform (ECR) during the Obama Administration to review the Munitions List on the ITAR to see what might be added or removed. This would involve looking carefully at what technologies are now more widely available from competitors, in which case our controls were simply closing the market to U.S. industry, not keeping them from potential adversaries. Also, this means looking at what new and emerging technologies might have significant military applications and should be controlled, preferably in concert with our allies.

Again, thank you very much for asking me to provide testimony to the Committee. I will now be happy to answer any questions.

The CHAIRMAN. Thank you, Mr. Aboulafia. I just want to point out that Senator Wicker and I worked very hard on those COVID-19 packages as it related to aviation. And then most recently, Sen-

⁶https://www.wto.org/english/tratop_e/civair_e/civair_e.htm

ator Moran and I worked on a package that was just focused on aviation supply chain manufacturers. And that program just became, I think, operational or available for the actual applications last month.

So I hope that many of the supply chain maintenance will take advantage of that. We definitely are hearing the impacts of both COVID-19 and now shortages of a workforce just at the time we need to pick back up. We will now turn to Mr. Lex Taylor. Thank you so much. Senator Wicker gave you a robust introduction. Thank you so much for being here. We look forward to your comments.

STATEMENT OF WILLIAM A. (LEX) TAYLOR III, CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, THE TAYLOR GROUP INC.

Mr. TAYLOR. Thank you, Chair Cantwell and Ranking Member Wicker for, as well as the rest of the Committee here, and virtually thank you for allowing me to be here. I appreciate the opportunity to tell you a little bit about our company. I feel like I am preaching to the choir a little bit. We all have the same goals in mind. But I hope I can tell you a little bit about our company, how it is affecting us at this point in time. And I think you can translate it to many, many companies across this Nation.

The Taylor Group is a manufacturer of heavy industrial lift trucks, primarily for material handling industry. And we also build power generator sets for residential and commercial applications. And we are a remanufacturer of material handling equipment for the U.S. military. The business began as Taylor Machine Works in 1927 and still operates as a family privately owned business. We are proud to wave that flag in Lewisville, Mississippi.

Our products are manufactured in America and exported around the world. In total, we have 1,200 employees with an average annual sales of a little over \$550 million. Our products operate every day, in every prime industry, steel or metals, wood, concrete, intermodal transportation, just to name a few. Approximately 430 vendors support our thousands of parts and components that go into building our products. These businesses are based all over the world and are critical to our ability to produce products and support our customers.

Some of these suppliers are also our customers. The supply chain is very interwoven and the companies within it depend on each other to keep the industry and thus the wider economy going. I appreciate the committee holding this hearing to discuss the challenges facing our supply chain, why this interruption happened, and solutions to right the ship. America was clearly headed for further economic growth at the beginning of 2020, but then the unthinkable happened.

The virus, the COVID-19 virus, was the primary culprit to shut this industry down, shut this supply chain down, and it is where we are today. So where are we? Yes, the supply chain is a disaster. It is in disarray. That is why we are here. Delays in deliveries have forced manufacturers like Taylor to resort to unorthodox and expedited methods of getting critical supplies. This situation is causing inflation to run rampant throughout the supply chain. So far, we

have kept our lines running, but are facing 30 to 75 percent price increases from our vendors and transportation companies.

Three examples of this are microchips, of course, steel, and container costs, just to name a few. Our products operate via some form of computer interface. So the chip shortage is extremely concerning. In addition to the availability of the right inventory items such as chips keeping our product lines running, it depends on receiving inventory on time. Steel is a major component of our products, both in its structure and the components that are made of steel that go into our products.

We are facing price increases weekly, and in some cases, every 24 hours. These average—and then the average cost of containers have gone from \$4,000 a container to \$18,000 as I speak today due to this low supply and high demand. Major shortages of key workers are also contributing to the supply chain crisis. Too large national trucking companies that support us have reported to us that they are trying to fill over 2,000 driver applications today. They claim that the Government employment subsidy is particularly detrimental to getting prospects to come back to work.

And then therefore, with all this said, our company has, in order to protect its financial liquidity and viability, we have had to institute price increases. And this is happening all over the country. As I said, inflation is rampant. The worst part is we have orders, but we don't have confidence in our supply chains to meet the demand.

We still have 40 employees now on layoff still from the COVID year. This means 40 families in need with no pay or benefits. We want to hire those workers back and hire even more. But we don't dare make such a large investment when we cannot commit to fulfilling customer orders on time now. The same story is playing out in thousands of manufacturers across America. For Taylor, our purchasing, engineering, and manufacturing teams are doing a Herculean job to keep our lines rolling, satisfy our customers, and keep our people employed, with a goal to get those on layoff back. This cannot be sustained, however, much longer.

Our vendors tell us they do not see an end to this supply problem until the end of 2022 at the earliest. I suspect there are thousands, hundreds of thousands of other family businesses facing similar issues as us. We wake up every day, working all day to maintain our production lines, maintain our employment, and keeping our customers happy.

My request to this committee is not to overreact with solutions that may cause unintended consequences. Rather, I encourage you to support a free market system and allow it to do what it does best and find solutions that are practical and driven by the private sector. Chair Cantwell, thank you again, Ranking Member Wicker, and the committee for allowing me to speak to you today and I look forward to any questions.

[The prepared statement of Mr. Taylor follows:]

PREPARED STATEMENT OF WILLIAM A. (LEX) TAYLOR III, CHAIRMAN/CEO,
THE TAYLOR GROUP INC.

Chair Cantwell, Ranking Member Wicker, and Members of the Committee: Thank you for the opportunity to appear before the committee today. And let me thank you all for your commitment of service to this great nation. My name is Lex Taylor and I serve as Chairman of the Board and Chief Executive Officer of The Taylor Group.

My hope is to share about the challenges facing my company and, to some extent, all of our fellow manufacturers, due to the supply chain interruptions. My comments are my own and will focus primarily on my company.

By way of brief introduction, The Taylor Group is a holding company with ownership of several entities—three of which are Taylor Machine Works (a manufacturer of heavy industrial lift trucks), Taylor Power Systems (a manufacturer of stand-by and prime power generator sets for residential and commercial applications), and Taylor Defense (a remanufacturer of material handling equipment for the U.S. military). The business began as Taylor Machine Works in 1927 and today still operates as a privately owned family business based in Louisville, Mississippi. Our products are manufactured in America and are exported around the world. In total, we have 1,200 employees in our entire system, which also includes service, financial, and retail businesses. We are considered a small mid-cap firm with average annual sales of over \$550 million. Our products operate in every prime industry, including metals, concrete, intermodal, and wood to name a few. Our machines are operating all over the world moving goods and services daily.

With thousands of parts and components that go into building our products, we are supported by approximately 430 vendors. Of these we consider 121 to be Tier 1 suppliers. These supply chain businesses are based all over the world and are critical for our ability to produce products and support our customers. In fact, some of these suppliers are also our customers. The supply chain is very interwoven and the companies within it depend on each other to keep industry and thus the wider economy going.

A key part of this chain is transportation. Transportation in all facets—including road, rail, water, and air—is an integral part of the supply chain formula. And the transportation companies in our supply chain are also customers of Taylor. As an example, we have transmissions, counterweights, axles, and diesel engines coming to us from offshore sources. These major components come containerized to both East and West Coast ports of entry. Our units are the predominant mode of container handling in those ports once they are off-loaded. Not to belabor a point, but our small business is just one of thousands of businesses in this story, and the slightest interruption in supply is a detriment to the continuous flow of goods and services across this Nation and the world.

I appreciate the committee holding this hearing to discuss the challenges facing our supply chains, why this interruption happened, and solutions to right the ship. There is no question that this Nation was on track and heading for further economic growth at the beginning of 2020. But then, the unthinkable happened—a pandemic that brought tragedy to the world and caused a dramatic economic slowdown. If we can all agree on one thing, it is that the COVID-19 virus was the single culprit that triggered the supply chain debacle we are experiencing today.

There has been, and will be, much testimony as to how uncertainty and government intervention to control the spread of the virus led to exponential drops in consumer demand and the cascade of events that led to the almost complete shutdown of the economy for the better half of 2020. With the help of the Association of Equipment Manufacturers and, to a lesser extent, the National Association of Manufacturers, an effort was pushed forward by our company and other manufacturers to urge the Treasury and the Federal Reserve to underwrite a national manufacturing “floorplan” program. Our proposed program would have allowed manufacturers to continue to build their products and stock the equipment for future sale during the dark and uncertain days of 2020. Much like the successful Payroll Protection Program the Congress instituted at the Small Business Administration, the goal of our initiative was to keep people employed and secure the supply chain to be ready when the pandemic ended. A notable difference was that our proposal would have required companies receiving Federal support to pay the money back. This effort was unsuccessful because of the political wrangling and failure of the government to understand the big-picture consequences of letting supply chains falter.

So here we are. The supply chain is a disaster. Some of that is due to the shortage of generic, programmable, or hard-coded microchips. Our products, like so many others, operate via some form of computer interface, so the chip shortage is extremely concerning. In addition to the availability of the right inventory items such as chips, keeping our production lines running depends on receiving inventory on time. Delays in deliveries have forced manufacturers like Taylor to resort to unorthodox and expedited methods of getting critical supplies. This situation is causing inflation to run rampant throughout the supply chain. So far, we have kept our lines running but are facing 30 percent to 75 percent price increases either from our vendors or the transportation companies, or a combination of both.

Steel is a major component of our products, both in the structure of our machines and the components within our machines. We are facing price increases weekly and,

in some cases, every 24 hours due to lack of availability. So much of our supply, such as engines, transmissions, and sub-assemblies, come from overseas and container shortages have become a detriment to supply—particularly with the average cost per container currently at \$18,000, up from \$4,000 only 6 to 12 months ago. In order to protect financial liquidity, we have had to institute price increases, and this is happening all over our country. As I said, inflation is rampant.

Major shortages in key workers are also contributing to the supply chain crisis. Two large national trucking companies we use are trying to fill over 2,000 driver positions to meet demand, but can't find them. Their claim is that the government unemployment subsidy is particularly detrimental to getting prospects to come to work.

We have over 40 employees still laid-off from COVID that we want to bring back but cannot because, while we have received customer orders that would justify their employment, a lack of confidence in supply is preventing it. This is 40 families that are in need with no pay or benefits. We want to hire those workers back, and hire even more, but we do not dare make such a large investment at a time in which we cannot commit to fulfilling current customer orders on time. Keep in mind, this same story is playing out in tens of thousands of manufacturers across America.

Let me conclude by saying that, as for Taylor, our purchasing, engineering, and manufacturing teams are doing a herculean job to keep our lines rolling, satisfying our customers, and keeping our people employed with a goal to get those on lay-off back on board. Engineers are finding alternative component solutions to replace the components that are in short supply. Purchasing is finding alternative delivery solutions to ensure the lines are supplied—utilizing hot shot delivery services, air transport instead of ships, and even sending a vehicle to pick up a part in a distributor or retail store. Manufacturing is alternating personnel and reorganizing the process flow—trying to hang on to employees instead of laying them off. This cannot be sustained for much longer.

Our long-term investments in research and development and workforce training have allowed us to remain as nimble as possible during these challenging times. Working with partner organizations, such as our community colleges, has helped bring expertise and resources to address some of these problems. But state and local programs alone are unlikely to deliver a solution to such a complex problem. Our vendors tell us they do not see an end to this supply problem until the end of 2022 at the earliest. Like all manufacturing employers, we will do our best to maintain steady employment until that time. My request is that this committee not act to overcorrect with solutions that may cause unintended consequences. Rather, I encourage you to support the free-market system and allow it to do what it does best and find solutions that are practical and driven by the private sector.

Again, thank you for allowing me to introduce my company and provide insight about the challenging issues. The good news is that demand is strong, which translates into jobs and economic growth. The bad news is that nothing was done during the pandemic year to avoid the destruction of the supply chain, and thus this economic engine is faltering.

Chair Cantwell, Ranking Member Wicker, and Members of the Committee, thank you again for the opportunity today, and I look forward to your questions.

The CHAIRMAN. Thank you, Mr. Taylor. We will look forward to getting some more specifics on that business and opportunities during the Q&A. Thank you for being here. Dr. Gil, thank you so much. Look forward to your testimony.

STATEMENT OF DR. DARIO GIL, SENIOR VICE PRESIDENT AND DIRECTOR, IBM RESEARCH

Mr. GIL. Chair Cantwell, Ranking Member Wicker, members of the Committee, thank you for the opportunity to testify on the critical need to bolster our semiconductor supply chain. I am Dario Gil, the Senior Vice President of IBM and Director of IBM Research. I am responsible for billions of dollars of R&D annually to develop cutting edge technologies, from advanced semiconductors to artificial intelligence to quantum computing. I am also a member of the National Science Board. Semiconductors are the beating heart of

modern electronics and really power every sector of our economy and facet of our lives.

The CHAIRMAN. Mr. Gil, I think people want you to pull that microphone a little closer to you or turn it on.

Mr. GIL. The mic is not working, unfortunately. OK.

The CHAIRMAN. That is better.

Mr. GIL. Let me see if I can do this. Is this—hopefully it is better.

The CHAIRMAN. Yes, thank you so much.

Mr. GIL. OK. Semiconductors are really the beating heart of modern electronics and power every sector of our economy and facet of our lives. For example, our smartphones use semiconductors under 10 nanometers. In May, IBM unveiled the world's first two nanometer chip, which actually I have brought with me today. And what it could do is it could quadruple battery life for our smartphones and really slash their carbon footprint and consumption or use of our data centers, and really shows the power of R&D. But for over a year, we have experienced the consequences of semiconductor supply chain disruptions. Failing to produce chips in the U.S. hinders our ability to develop future emerging technologies. And the facts are simple. We only manufacture 12 percent of the world's capacity.

Global leaders churn out advanced semiconductors at 7 nanometers and 5 nanometers, yet we manufacture nothing under 10 nanometers. For the U.S. Government to bolster the semiconductor supply chain, it needs to do three things: invest, create effective partnerships, and focus on results that benefit all Americans. We need sustained investments in domestic manufacturing and R&D for advanced chips. The winning recipe is clear, to have products to manufacture, you need to innovate new technologies, then manufacture, innovate then manufacture.

While foreign Governments invest in advanced semiconductor R&D and manufacturing capabilities, we are lagging. Federal research and development represents a smaller percentage of GDP today than in 1964. The president's 100 day supply chain review and bipartisan consensus in Congress demonstrate a will to invest in addressing supply chain challenges, including boosting leadership in advanced R&D. The Senate has provided a strong catalyst for investment by overwhelmingly voting in support of USICA and the CHIPS Act. Now, let's talk about partnerships.

Semiconductor innovation is fueled by partnerships. IBM's two nanometer chip breakthrough was built on decades of collaborative R&D with partners in New York. Bolstering American semiconductor capacity requires a scalable partnership model. The National Semiconductor Technology Center, or NSTC, is a major first step, and IBM encourages the Senate to fully fund and empower it. We cannot afford to waste time building semiconductor innovation capabilities from scratch. The NSTC could deliver results in months if we leverage existing expertise and billions of dollars in semiconductor infrastructure.

The Albany Research Center, home to many companies and university partners, is already working on advanced logic pathfinding a new semiconductor materials. It offers an ideal environment from which to build and scale NSTC. As a proud member of this eco-

system, IBM is prepared to take a leadership role to make the NSTC success. The NSTC should be an industry led public private consortium that bridges gaps between industry, academia, and Government in advanced semiconductor R&D, prototyping, packaging, and manufacturing.

It should enable American innovators, big and small, to quickly move semiconductor designs to any U.S. foundry. But we need more than physical assets and manufacturing plants. We need to invest in the American worker through education and training programs to create good paying jobs and opportunities for decades. This moment demands great urgency and results that generate dividends for all Americans.

As I have outlined, the U.S. needs to address semiconductor supply chain disruptions by investing, creating effective partnerships, and ensuring outcomes that benefit Americans today for generations to come. Thank you. I look forward to your questions.

[The prepared statement of Mr. Gil follows:]

PREPARED STATEMENT OF DR. DARIO GIL, SENIOR VICE PRESIDENT AND DIRECTOR,
IBM RESEARCH

Introduction

Good morning Chair Cantwell, Ranking Member Wicker, and distinguished Committee members. I thank you for this opportunity to address the Committee on the critical need to bolster the semiconductor supply chain in the United States today and for generations to come. My name is Dario Gil, and I am a Senior Vice President of IBM and Director of IBM Research, the research and innovation engine of IBM. In addition to my leadership role at IBM, I am a member of the National Science Board of the National Science Foundation and the Board of Governors of the New York Academy of Sciences, and serve as co-chair of the MIT-IBM Watson Artificial Intelligence (AI) Lab.

IBM pioneers cutting-edge computing technologies. In May, we unveiled the world's first 2 nanometer chip, which could quadruple cell phone battery life, cut the carbon footprint of data centers, and drastically speed up a laptop's functions. We are also a leader in quantum computing and were the first company in the world to build a programmable quantum computer and make its computing power available through the cloud.

IBM Research is a leading-edge corporate research lab with 3,000 scientists and engineers working to build next-generation technologies that will underpin United States leadership in hybrid cloud, AI, cybersecurity, quantum computing, and accelerate the process of scientific discovery. We are committed to pushing the boundaries of technological and scientific discovery to positively shape our world.

Today, I would like to talk about three key actions the United States government should make to address the supply chain manufacturing challenge in the semiconductor industry and to avert a crisis—*invest*, create effective *partnerships*, and ensure *outcomes that benefit Americans today and in the future*.

Invest in the Semiconductor Supply Chain

First, let me speak about the need to invest in restoring the semiconductor supply chain. At the heart of the current supply chain challenges we face, which every American can now see and feel, is a tiny and often invisible ingredient that is crucial to safeguarding economic growth, national security, and our continued ability to achieve technological and scientific advances. Semiconductors. Semiconductors are the beating heart of modern electronics—they power every sector of our economy and every facet of our lives. This phone, every American's phone, could not function without them.

Semiconductor advances will be essential to unlocking fresh advances in technologies such as AI, 5G, and hybrid cloud. The set of manufacturing processes used in different generations of chips are referred to as technology nodes. A smaller technology node results in a faster and more efficient chip.

At IBM, we define advanced semiconductors as those below 10 nanometers. While the global leaders churn out advanced nodes at 5 and 7 nanometers, the United

States does not manufacture any advanced nodes under 10 nanometers.¹ Some say we should not care about manufacturing advanced nodes. But we had better. This phone runs on them, and iPhones have used 5 and 7 nanometer chips since 2019.² And that's just phones—picture a world where laptops and other advanced machines did not work—or do not work that quickly or well. This could be our reality if the United States does not take action to address the current semiconductor shortage and ensure it does not happen again.

The facts are simple: although the United States maintains 47 percent of the global market for semiconductors and electronics, we only manufacture 12 percent of the world's capacity.³ When it comes to the production of ultra-advanced nodes at 7 nanometers and below, just two countries—Taiwan and South Korea—dominate 100 percent of global production.

While the governments of other countries have invested in research and development and manufacturing incentives to boost advanced semiconductor nodes and manufacturing capabilities, the United States has not kept pace. In the last 30 years, total Federal investment in research and development has never represented more than 1.2 percent of our GDP, and Federal research and development constitutes a smaller percentage of GDP today than it did in 1964.⁴ A 2019 report from the Organization for Economic Cooperation and Development (OECD) found that all countries with significant chip industries *except* the United States employ government incentives.⁵ Analysts have concluded that our failure to incentivize the semiconductor industry has helped push chip manufacturing abroad.

These stark facts raise three key issues, which collectively inject an unacceptable degree of uncertainty and risk into our economy, national security, and innovation ecosystem.

First, a dearth of domestic semiconductor manufacturing capacity at all nodes crimps our access to basic ingredients that power even the most elementary devices, such as garage door openers. As a result, nearly all industries in the United States are vulnerable to global semiconductor supply chain disruptions. In 2021, semiconductor shortages idled auto production in multiple states.⁶ And a lack of point-of-sale machines means that restaurants are struggling to make up business lost to the pandemic.⁷ Projections show that by year's end, the shortage will impact 169 industries, and shrink 2021 GDP growth by half a percentage point.⁸ This threatens both our post-pandemic recovery, and our long-term uninterrupted access to the building blocks of critical technologies.

Second, the lack of domestic semiconductor manufacturing capacity, especially for advanced nodes under 10 nanometers, also saps our ability to work with allies to promote United States-designed and manufactured chips in global markets. America could be exporting advanced semiconductors under 10 nanometers to supercharge our technological and scientific leadership abroad. But, in lacking production capacity for advanced chips, we are foreclosing on the prospect that emerging technologies will be pioneered and manufactured in the United States. We must reverse this trend.

Third, the lack of investment in research, development and prototyping undermines our efforts to retain strong American leadership in this strategic gateway technology. Using history as a guide, the United States should recall that we have not always lacked domestic manufacturing capacity: as recently as 1990, we manu-

¹“2021 Factbook,” *Semiconductor Industry Association*. <https://www.semiconductors.org/wp-content/uploads/2021/05/2021-SIA-Factbook-FINAL1.pdf>.

²“Apple iPhone 12 Will Be Powered by The A14 Bionic 5nm Chip, Already Seen In The New iPad Air?” *News 18*, October 13, 2020. <https://www.news18.com/news/tech/ahead-of-iphone-12-launch-apple-execs-shed-light-on-a14-bionic-design-performance-2958803.html>.

³“Global Wafer Capacity, 2021–2025,” *IC Insights*. <https://www.icinsights.com/data/reports/5/9/brochure.pdf?parm=1625240565>.

⁴“How Much is Enough?,” *Center for Strategic and International Studies*, April 21, 2021. <https://www.csis.org/analysis/how-much-enough>.

⁵“Let the chips fall where they may: A story of subsidies and semiconductors,” *The Organization for Economic Cooperation & Development*, December 4, 2019. <https://www.oecd.org/trade/let-the-chips-fall-where-they-may/>.

⁶“Ford to Idle or Curb Output at More Plants Because of Chip Shortage,” *The Wall Street Journal*, June 30, 2021. <https://www.wsj.com/articles/ford-to-close-or-curb-output-at-some-plants-because-of-chip-shortage-11625068975>.

⁷“No Chips, No Tips: How the computer Chip Shortage threatens Thousands of Restaurant Service Jobs,” *The Washington Post*, June 11, 2021. <https://www.washingtonpost.com/business/2021/06/11/restaurant-workers-computer-chip-shortage/>.

⁸“The Semiconductor Shortage of 2021,” *Goldman Sachs*, March 17, 2021. <https://www.goldmansachs.com/insights/pages/the-semiconductor-shortage-of-2021.html>.

factured 37 percent of global semiconductor capacity.⁹ We can produce a significant percentage of chips in the United States again. The United States government has played a significant role in supporting manufacturing and research in key areas, and it needs to step up once again to secure onshore semiconductor production and secure supply chains.

Thankfully, the President’s 100-Day Supply Chain Review, and a bipartisan consensus in Congress, demonstrate a will to address both short and long-term supply chain manufacturing challenges through investment. And, they recognize that while new manufacturing in the United States is important to improving the resilience of our supply chains, we must also invest to maintain leadership in advanced research and development. Crucially, the United States Senate has provided a strong catalyst for investment by overwhelmingly voting to support USICA and the CHIPS Act.

Forge Partnerships

I have spoken about the need for investment, and now let me turn to the need for partnerships. At IBM, we have a strong track record of semiconductor innovation. These innovations are the product of decades of research and development carried out by IBM in New York State. These innovations stem from partnerships—where IBM scientists work in close collaboration with public and private sector partners to push the boundaries of logic scaling and advanced semiconductor capabilities.

As a nation, we must build on this collaboration and take full advantage of existing semiconductor ecosystems. IBM strongly supports the recommendation contained within the President’s 100-Day Supply Chain review aimed at strengthening our semiconductor manufacturing ecosystem by promoting collaboration.¹⁰ At IBM we understand the power of collaboration and have expertise in creating successful partnerships that cut across domains. In addition to our semiconductor innovation ecosystem—which led to the 2 nanometer chip—during the pandemic we worked with the Federal Government, industry, and academia to create the COVID–19 High Performance Computing Consortium—which provides access to the world’s most powerful supercomputing resources to support COVID–19 research. The consortium was launched and scaled with unprecedented speed when competitors all came to the table to mobilize for a greater purpose.

Today, we find ourselves at another inflection point. And again, IBM is committed to working across industry, government, and academia, this time to leverage the initial down payment provided by the CHIPS Act to boost short and long-term semiconductor supply chain resiliency.

A major first step to building American capacity would be to establish the National Semiconductor Technology Center (NSTC), as included in the 2021 NDAA and the CHIPS Act within USICA. IBM believes the NSTC could be a lynchpin for addressing supply-chain disruptions if it leverages proven ecosystems in the following ways:

First, the NSTC should be established immediately and then move fast.¹¹ The short-term semiconductor shortage, paired with the specter of long-term global competition for supply, means there is no time to waste building out United States semiconductor innovation capability. The shortest and most efficient path to deliver results is to leverage our strengths, building on billions of dollars in previous and existing semiconductor infrastructure investments, while at the same time working to forge new industry-led innovation pipelines.

Second, the NSTC should leverage existing, proven ecosystems for semiconductor research and development with strong track records of leading-edge innovation. For example, the NSTC could be built around the existing multi-company semiconductor ecosystem infrastructure in Albany, NY, which is already home to advanced photo-lithography capability including EUV (Extreme Ultra-Violet Lithography), advanced logic pathfinding, AI hardware research, and the development of new semiconductor materials. By leveraging proven ecosystems such as the Albany Research Center, the NSTC could be operational in as little as 6–12 months as opposed to years. While IBM is prepared to lead such a consortium, we recognize that success requires maximizing participation of all partners.

⁹“Turning the Tide for Semiconductor Manufacturing in the US,” *Semiconductor Industry Association*. <https://www.semiconductors.org/turning-the-tide-for-semiconductor-manufacturing-in-the-u-s/>.

¹⁰“Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth,” *The White House*, June 2021. <https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf>.

¹¹ *Ibid.*

Deliver Sustained Outcomes

Investment and partnerships are critical to supply chain resiliency, and now I would like to turn my attention to how we leverage them to deliver outcomes. The President's 100-Day Supply chain review makes note of the extremely complex nature of semiconductor supply chains, and the need for public and private interests to work together to bolster multiple segments of this supply chain. While the United States leads the world in semiconductor research, design and tooling, there is no integrated, collaborative mechanism between industry, academia, and government in advanced development, prototyping and packaging, and advanced manufacturing capabilities. This creates substantial supply chain vulnerabilities.

A well-structured and governed public-private NSTC could address this shortfall. It could also serve as an important link between academic research, government R&D labs and programs, company specific R&D, and product manufacturing. This is what is needed to get this right and to ensure we reap the benefits and protections of our investments long into the future.

The NSTC should be built as an industry-led, agile public-private consortium with widespread industry participation, including small, medium, and large companies, entrepreneurs, and VC's. Having access to NSTC capabilities and expertise can help lower the barriers to entry to the capital-intensive semiconductor industry. Rather than creating another government program office to operate the NSTC, it should use an industry-led consortium model proven in the semiconductor industry and other industry sectors. An agile model would allow the NSTC to have an operating team up and running in months, not years.

Also, leadership, accountability and a strong technical agenda are critical for consortium success. Oversight of funding from Federal and state governments as well as the member contributions is critical. A Board of Directors with an Executive Committee consisting of key industry and government stakeholders would provide this function and determine technical directions and program management with input from a technical advisory committee and consortium members.

The NSTC should take a manufacturing-agnostic approach to be an accelerator in moving designs to multiple fabrication plants in the United States. Such an approach would help spur new capacity and job creation in America, enabling American innovators, big and small, to move semiconductor designs to any manufacturing plant. And it would provide needed flexibility in the United States manufacturing supply chain to support both government and commercial needs.

Finally, I would like to explain why STEM education and developing a semiconductor workforce is critical to ensuring that Americans of all backgrounds can participate and benefit from the investments and partnerships we forge. A robust semiconductor ecosystem requires far more than just the physical assets of research and development labs and manufacturing plants. Ultimately, semiconductor ecosystems are driven by the diverse and constantly evolving talents of American workers. Investments to bolster semiconductor supply chains by supporting ecosystems requires a skilled workforce fluent in semiconductor research and development, manufacturing, and advanced packaging. As a result, workforce development, education, and tight integration with universities, community colleges and other training programs are critical components of the NSTC. Investments in a semiconductor workforce will alleviate supply constraints and enable the creation of semiconductor know-how necessary for future technology developments in hybrid cloud, and AI.

A May 2021 study commissioned by the Semiconductor Industry Association found that, from 2021–2026, \$50 billion in CHIPS Act funding would result in the creation of 185,000 temporary jobs annually and add \$24.6 billion annually to the United States economy as new semiconductor manufacturing facilities come online. Beyond 2026, the study found that CHIPS Act investment would add 280,000 permanent jobs to the United States economy.¹²

We should meet this demand for talent by harnessing CHIPS Act funding as a force for inclusive job creation that spurs long-term innovation. The NSTC should lead workforce programs to help train workers for jobs in the industry across the United States.

In addition, to maintain our global competitiveness, we must also dramatically increase the number of individuals from underrepresented communities in STEM

¹²"Robust Federal Incentives for Domestic Chip Manufacturing Would Create an Average of Nearly 200,000 American Jobs Annually as Fabs are Built, Add Nearly \$25 Billion Annually to U.S. Economy" *Semiconductor Industry Association*, May 19, 2021. <https://www.semiconductors.org/robust-federal-incentives-for-domestic-chip-manufacturing-would-create-an-average-of-nearly-200000-american-jobs-annually-as-fabs-are-built-add-nearly-25-billion-annually-to-u-s-economy/>.

fields, as noted in the National Science Board's Vision 2030 report.¹³ IBM has committed to investing \$100 million in technology, assets, resources, and skills development through partnerships with historically black colleges and universities through the IBM Skills Academy Academic Initiative. But, while the private sector devotes significant funding to STEM education, we need to do more to collaboratively address urgent areas of need, share resources, and bring the combined weight of the government and industry together to ensure increased diversity in STEM fields.

For a start, we should reform the Higher Education Act (HEA). For example, Congress could loosen Federal work study restrictions to accommodate off-campus work experience in the private sector; expand Pell Grants to cover skills education for part-time students and mid-career professionals; and make career-oriented education beyond bachelor's and other traditional education degrees eligible for Federal student loans.

Also, IBM supports an Executive Order that expands the Department of Labor's Employment and Training Administration apprenticeship efforts to provide good paying sector-based pathways to jobs in the semiconductor industry. This expansion can be built on the successful work started in 2019 to update the traditional apprenticeship model with paid, hands-on learning for the digital era in careers in coding, design, and cybersecurity. This program was particularly attractive to mid-career workers who want to build new skills or break into new industries without incurring student debt or taking time off from work. The program grew twice as fast as expected, and as a founding member of the GTA apprenticeship coalition, we are proud to share our apprenticeship framework with some of America's top employers.

Meanwhile, in 2020, IBM joined with other employers, education institutions—including community colleges—and education service organizations to demonstrate an education and employment record exchange. Improving the technical infrastructure to better support the exchange of education and skills-based credentials would significantly ease the management and exchange of these certifications, empower learners with trusted skills-based information, and align their skills to in-demand jobs. The Department of Commerce played a critical role in the 2020 demonstration and should convene stakeholders to resolve governance issues in the electronic exchange of credentials between educators, and employers.¹⁴

Lastly, and importantly, in addition to workforce training, IBM also understands that strong semiconductor ecosystems must also include support for medium and small sized enterprises that contribute to supply chain resiliency. The Albany Research Center is a model for how a multitude of partners can drive semiconductor research and innovation—and jobs.

Conclusion

My testimony today focused on the risks posed to the United States by current supply chain disruptions, and the urgent steps we must take to develop a semiconductor ecosystem that supports economic and job growth, and our national security. We have an unprecedented opportunity before us—to unlock fresh advances in technologies and ensure United States leadership. Semiconductor supply chain shortages present a danger with potentially dire consequences for our economy, jobs, and national security. But through investment, partnerships, and maintaining a focus on long-term outcomes, we can succeed in meeting these challenges. Thank you.

The CHAIRMAN. Thank you, Dr. Gil. Thank you so much for that testimony. Thank you for covering a broad view of the various sectors that we are going to talk about here. Mr. Miller, thank you so much for joining us. We look forward to your testimony.

STATEMENT OF JOHN S. MILLER, SENIOR VICE PRESIDENT OF POLICY AND GENERAL COUNSEL, INFORMATION TECHNOLOGY INDUSTRY COUNCIL (ITI)

Mr. MILLER. Chair Cantwell, Ranking Member Wicker, and distinguished members of the Committee, on behalf of the Information Technology Industry Council, or ITI, thank you for the opportunity to testify today on implementing supply chain resiliency.

¹³"National Science Board Vision 2030," *National Science Board*, May 2020. <https://www.nsf.gov/nsb/publications/2020/nsb202015.pdf>.

¹⁴"American Workforce Policy Board (9/23): IBM Pilot Video," *United States Department of Commerce*, September 23, 2020. <https://www.youtube.com/watch?v=w9y0J0DmPvE>.

As the current co-chair of the Information and Communications Technology Supply Chain Risk Management, or ICT SCRMM Task Force, the United States preeminent supply chain public-private partnership, I welcome the committee's interest on this important topic. ITI represents 80 of the world's leading ICT companies. The global ICT industry respects the U.S. Government's obligation to address the resiliency of global supply chains, including the semiconductor and broader ICT supply chains.

We believe that Government and industry must work together, along with international partners and allies, to achieve the trusted, secure, and resilient global supply chains needed to protect National Security and which are an indispensable building block for competitiveness, innovation, and economic growth. ITI welcomes the broad, holistic, and strategic approach reflected in the America's supply chains Executive Order and related 100 day report, which is also echoed in the Senate's United States Innovation and Competition Act or USICA.

While my written testimony commends numerous promising supply chain programs and initiatives contained in that bill, I would like to take this opportunity to especially thank the committee for authorizing emergency appropriations for the CHIPS Act and ORAN funding for establishing a supply chain resiliency program housed in the Department of Commerce and for providing increased investments in the Manufacturing USA and Manufacturing Extension Partnership programs. We look forward to working with Congress to get these important strategic programs fully funded and over the finish line.

ITI has consistently urged the U.S. Government to pursue this type of broad strategic approach to supply chain policymaking, which includes promoting a thoughtful, harmonized, risk based, evidence driven approach to facilitate transparency and predictability, designing measures to advance and protect U.S. National Security objectives without putting American competitiveness at risk, and prioritizing close Government industry collaboration to most effectively leverage resources and expertise.

Of course, crafting sound policy measures to address the global supply chain resiliency challenges that were laid bare by the COVID-19 pandemic does not guarantee the successful execution of those policies by the Commerce Department or other Federal agencies. So this hearing poses a key question, how can we most effectively implement recent Congressional and Administration policies to improve supply chain resiliency? I offer four recommendations in this regard.

First, Commerce should develop and execute a strategic, coordinated plan for implementing its numerous supply chain obligations. Given the sheer volume of supply chain taskings laid at Commerce's doorstep by successive Administrations, as well as the new responsibilities contemplated by USICA, a coordinated and strategic approach within Commerce is necessary to effectively implement supply chain resiliency. One key feature of such an approach is to identify and empower one entity within Commerce to lead and coordinate this work. Another is to prioritize close coordination with industry, including by leveraging existing partnerships, information sharing programs, and innovation ecosystems.

The ICT SCRM Task Force, which is currently working with the Commerce Department and our sponsor, the Cybersecurity and Infrastructure Security Agency, on implementation of the Americas Supply Chains Executive Order, provides an excellent model of public-private collaboration that Commerce can draw inspiration from and coordinate with as it launches the new supply chain disruptions task force.

Second, Congress should ensure that Commerce has adequate resources to effectively implement supply chain resiliency policy, not only by fully funding the CHIPS Act, but by making sure the Department is adequately resourced in terms of both funding and staff. Commerce can also help itself in this regard by focusing the scope of the prior Administration's Executive Order on securing the ICTS supply chain and related rulemaking to ensure that covered transactions are too prioritized and targeted to discrete National Security risks.

Doing so would allow U.S. companies to conduct global business with certainty, improve U.S. competitiveness, and help Commerce more effectively deploy its resources. Third, Congress should ensure robust liability protections to promote and incentivize the sharing of supply chain risk information. We appreciate this committee's extended protected critical infrastructure information program liability protections as part of the USICA Supply Chain Resiliency Program to spur much needed sharing of supply chain risk information.

However, after months of careful study, the ICT SCRM Task Force developed a legislative proposal to amend the Cybersecurity Information Sharing Act of 2015 that would provide stronger liability protections for such sharing, a preferred approach for the reasons stated in my written testimony. Finally, Commerce and other U.S. Government stakeholders should deepen engagement with international partners on supply chain resiliency.

ITI welcomed the recent establishment of the U.S., EU Trade and Technology Council as providing just this sort of opportunity to strengthen cooperation between allies on this and other critical issues. Thank you for the opportunity to testify today. I look forward to your questions.

[The prepared statement of Mr. Miller follows:]

PREPARED STATEMENT OF JOHN S. MILLER, SENIOR VICE PRESIDENT OF POLICY AND GENERAL COUNSEL, INFORMATION TECHNOLOGY INDUSTRY COUNCIL (ITI)

Chair Cantwell, Ranking Member Wicker, and Distinguished Members of the Committee on Commerce, Science and Transportation, thank you for the opportunity to testify today. I am John Miller, Senior Vice President of Policy and General Counsel at the Information Technology Industry Council (ITI).¹ I have deep experience working on public-private supply chain policy initiatives in the United States, including serving as the current Co-chair of the Cyber and Infrastructure Security Agency (CISA)-sponsored Information and Communications Technology Sup-

¹The Information Technology Industry Council (ITI) is the premier global advocate for technology, representing the world's most innovative companies. Founded in 1916, ITI is an international trade association with a team of professionals on four continents. We promote public policies and industry standards that advance competition and innovation worldwide. Our diverse membership and expert staff provide policymakers the broadest perspective and thought leadership from technology, hardware, software, services, manufacturing, and related industries. Visit <https://www.itic.org/> to learn more.

ply Chain Risk Management Task Force (ICT SCRM Task Force)² as well as Vice Chair of the of the Information Technology Sector Coordinating Council (ITSCC).³ I am honored to testify before your Committee today on the important topic of *Implementing Supply Chain Resiliency*. The global information and communications technology (ICT) industry respects and takes seriously the U.S. government's (USG) obligation to address the resiliency of global supply chains, including the ICT supply chain. We believe the USG and industry must work together, along with partners and allies, to achieve the trusted, secure, reliable, and resilient global supply chains that are a necessary priority for protecting national security and are also an indispensable building block for supporting competitiveness, innovation, and economic growth. We welcome the Committee's interest and engagement on this subject.

ITI represents 80 of the world's leading ICT companies.⁴ Most of ITI's members service the global market via complex supply chains in which technology is developed, made, and assembled in multiple countries, and service customers across all levels of government and the full range of global industry sectors, such as financial services, healthcare, and energy. Thus we acutely understand the importance of ensuring the resiliency of global ICT supply chains as not only a global business imperative for companies and customers alike, but as critical to our collective national and economic security. As a result, our members have devoted significant resources, including expertise, initiative, and investment in cybersecurity and supply chain risk management efforts to create a more secure and resilient Internet ecosystem, inclusive of ICT supply chains.

Last month, ITI welcomed the Senate's passage of the *U.S. Innovation and Competition Act (USICA)* as critical to helping the United States remain competitive on the international stage by prioritizing and expanding essential investments in research, development, and technological advancement. USICA takes important steps to expand U.S. innovation leadership, including key measures to help build a strong ecosystem for developing advanced technologies and creating new jobs in communities across the country. ITI was particularly pleased that the bill provides robust funding for the *CHIPS for America Act (CHIPS)* to boost U.S. investments in the semiconductor ecosystem—including promoting a strong, skilled workforce for advanced manufacturing, strengthening the semiconductor supply chain, and increasing U.S. manufacturing capacity—all of which are essential for U.S. economic and national security.

We were similarly pleased to commend the White House's publication of the final report stemming from the 100-Day Reviews under Executive Order 14017 on *America's Supply Chains (ASC EO)* just a couple of days after *USICA*'s passage, which signaled the Biden Administration's commitment to building trusted, secure, and resilient supply chains and echoed some of *USICA*'s key proposals. Importantly, the administration outlined a clear vision to strengthen U.S. semiconductor leadership, including efforts to address research and development, increase manufacturing, and build a skilled workforce, a forward-looking and complementary approach to enhance economic competitiveness and bolster national security. Together, these mutually reinforcing steps taken by the administration and Congress hold the promise of making the U.S.—and ultimately global—supply chains stronger and more resilient, advancing U.S. competitiveness, and harnessing U.S. innovation.

Of course, acknowledging the pressing global supply chain resiliency challenges laid bare by the COVID-19 pandemic and crafting sound policies to address them does not necessarily guarantee the successful execution of those policies. So the key question—as the subject of this hearing foreshadows—is how can we most effectively implement recent Congressional and administration policies to improve supply chain resiliency?

²The ICT Supply Chain Risk Management (SCRM) Task Force—sponsored by CISA's *National Risk Management Center (NRMC)*—is the United States' preeminent public-private supply chain risk management partnership, established in response to these realities and entrusted with the critical mission of identifying and developing consensus strategies that enhance ICT supply chain security. The Information Technology Sector Coordinating Council and Communications Sector Coordinating Council are co-chartering entities of the Task Force along with NRMC. Visit <https://www.cisa.gov/ict-scrm-task-force> to learn more.

³The *Information Technology Sector Coordinating Council (IT SCC)* serves as the principal entity for coordinating with the government on a wide range of critical infrastructure protection, cybersecurity and supply chain risk management activities and issues. The IT SCC brings together companies, associations, and other key IT sector participants, to work collaboratively with the Department of Homeland Security, government agencies, and other industry partners. Through this collaboration, the IT SCC works to facilitate a secure, resilient, and protected global information infrastructure. Visit <https://www.it-scc.org> to learn more.

⁴See ITI membership list at: <https://www.itic.org/about/membership/iti-members>

I will focus my written testimony on four areas bearing on this question: (1) *the importance of a strategic, holistic and coordinated approach to addressing supply chain resiliency* including the need to prioritize public-private collaboration; (2) a discussion of *the Biden Administration's emerging approach to supply chain resiliency and the relevant provisions of USICA*; (3) *the U.S. Department of Commerce's (Commerce) increasingly important role in supply chain resiliency and security, and its recent track record of implementing supply chain policy initiatives*, including various taskings from the prior administration; and (4) *recommendations for how Commerce and the USG more broadly can most effectively implement supply chain resiliency going forward*.

1. A Strategic, Holistic and Coordinated Approach is Foundational to Implementing Supply Chain Resiliency

While supply chain security is not a new topic, particularly for large technology companies managing sophisticated global supply chains, the heightened U.S. policy-maker focus on supply chain resiliency and security over the past few years is unprecedented, as evidenced by the more than 30 active Federal supply chain security and resiliency measures inventoried by the ICT SCRM Task Force since late 2018. The palpable impacts of the COVID-19 pandemic on global supply chain resiliency further intensified the focus on this issue. The increased policy attention on supply chain issues prompted ITI earlier this year to prominently feature recommendations regarding supply chain security and resiliency in our *Policy Memo for the Biden-Harris Administration and 117th Congress*⁵ and issue a set of *Supply Chain Security Principles*⁶ intended to lay out strategic considerations to guide U.S. policy-makers tackling these issues in 2021 and beyond.

Although supply chain security and resiliency are not one and the same, they are closely related insofar as national security (including cybersecurity), trustworthiness, availability and competitiveness are all facets of the broader term resiliency, and ITI's recommendations are applicable across both concepts.

Our recommendations noted the change in administrations and a new Congress offered the opportunity for a strategic review of U.S. supply chain security and resiliency policy to develop a more coherent, streamlined, and effective long-term approach, consistent with the holistic assessment of the ICT and other industrial base supply chains called for by the *ASC EO*.

Key pillars of ITI's recommendations in this regard have consistently included the following:

Pursuing a holistic, streamlined, coherent, and strategic approach to supply chain resiliency and security policy. The Federal government's ability to provide consistent regulatory approaches and supply chain security guidelines is critical to securing the U.S. innovation economy and ensuring supply chain resiliency. ITI shares the concerns of members of this Committee regarding threats to global ICT supply chains, which implicate cybersecurity, national security, economic security, and U.S. competitiveness. However, these legitimate concerns have too often manifested in uncoordinated, inconsistent approaches across various departments and agencies. We have encouraged the establishment of a lead agency on supply chain risk management to manage a coordinated and effective approach to varied and disparate activities occurring at all levels of government.

Promoting a thoughtful, harmonized, risk-based, evidence-driven approach to supply chain resiliency policy to facilitate transparency and predictability. The approach to supply chain security over the last several years has primarily focused on country-of-origin, particularly China, which has led to an over-reliance on this attribute and short-circuited more fulsome risk analysis. While country-of-origin is one risk factor bearing on supply chain security as well as resiliency, it should not be the sole and dispositive factor animating U.S. supply chain policy, or in determining trustworthiness. It is noteworthy that the ICT SCRM Task Force working group on Threat Assessment catalogued a total of 188 supplier-related threats, with country of origin being just one. A successful supply chain resiliency strategy must widen the aperture to consider a full array of relevant threats and considerations, not only to address identifiable, material, concrete national security risks directly tied to actionable threats articulated in USG intelligence or vulnerability assessments, but also to consider other facets of resiliency including supply chain resiliency invest-

⁵See ITI's *Policy Memo for the Biden-Harris Administration and 117th Congress: Advancing Innovation to Make the U.S. More Globally Competitive* at https://www.itic.org/documents/general/ITI_CompetitivenessMemo_Final.pdf.

⁶See ITI's *Supply Chain Security: Principles for Strategic Review* at https://www.itic.org/policy/ITI_SupplyChain_Principles2021.pdf.

ments, U.S. competitiveness, availability and domestic manufacturing capacity, and workforce development.

Designing measures to advance and protect U.S. national security objectives without putting American competitiveness at risk. Lack of clarity in scope and process in any rulemaking, legislation, or other policy mechanism makes for an uncertain business environment and threatens the ability of companies to compete with foreign companies not subject to U.S. or similar foreign requirements. Overbroad policy approaches or approaches that duplicate or conflict with existing mechanisms, such as those embodied in the prior administration's *Executive Order on Securing the Information and Communications Technology Supply Chain (ICTS EO)*, stifle U.S. innovation, technological leadership, and competitiveness. Members of this Committee should seize the opportunity to advance supply chain security policy approaches that are not only compatible with but drive global policymaking norms.

Collaborating closely with industry including leveraging industry resources and expertise. ITI's members understand we cannot tackle current and future supply chain challenges on our own, and that industry and government share responsibility to facilitate the global competitiveness of the U.S. technology sector and other critical sectors. Public-private partnerships and other multi-stakeholder approaches are essential to addressing supply chain resiliency and security. Government and industry often have access to unique information sets—only when this information is shared can all relevant stakeholders see the complete picture. These partnerships are essential to (1) identify potential threats; (2) understand how and whether the risk can be managed; and (3) determine what actions should be taken to address risks without yielding unintended consequences.

ITI has consistently encouraged *U.S. policymakers to leverage the existing ICT SCRM Task Force as a focal point for public-private collaboration on supply chain security.* The Task Force has brought together subject matter experts from the private sector and from across the USG, including multiple Commerce stakeholders, and has produced several actionable tools and other work products that can be used by industry and government to address supply chain security challenges, including related to information-sharing, threat modeling, procurement, vendor attestation and small and medium-sized businesses' unique needs. The administration should look to this established public-private mechanism for creative, actionable solutions, and should prioritize implementing and operationalizing Task Force products across the USG and incentivizing their promotion and uptake across the critical infrastructure community. I have been honored to serve as a co-chair of the Task Force on behalf of the IT sector since its inception, so I speak from personal experience in pointing out that the Task Force has focused on many of the same issues prioritized in USICA, and in recommending the Task Force as a good model for Commerce to emulate as it seeks to implement new programs such as the nascent Supply Chain Disruptions Task Force.

ITI has also advocated for inclusion of other key tenets in any strategic approach to supply chain resiliency, including *viewing supply chain risk management through the lens of trustworthiness and prioritizing bi-directional sharing of supply chain risk information.*

2. The Emerging U.S. Policy Approach to Supply Chain Resiliency as Reflected in USICA/EFA and the 100-Day Report

ITI is pleased that both the Biden Administration and Congress have taken on board many of our policy recommendations in charting a broader, more holistic, and strategic approach to improving supply chain security and resiliency, as illustrated by both the *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100-Day Reviews Under Executive Order 14017 (100-day Report)* under the *ASC EO* and the supply chain provisions in *USICA*.

ASC EO and the 100-Day Report. The *ASC EO* embraces the type of broader, holistic approach we have been advocating for the past few years, which balances important national security considerations with other considerations such as U.S. competitiveness. ITI particularly welcomed the *100-Day Report's* conclusions and recommendations on semiconductors, which tracked closely with several of ITI's recommendations offered in response to Commerce's RFI on the 100-day semiconductor review. We welcome the Biden Administration's commitment to building trusted, secure, and resilient supply chains, and we support its plan to realize that goal. Importantly, the administration outlined a clear vision to strengthen U.S. semiconductor leadership, including efforts to address research and development, increase manufacturing, and build a skilled workforce.

Support for CHIPS Funding. The 100-Day Review calls for \$50 billion to fund the *CHIPS* and outlines additional steps to increase the domestic semiconductor manu-

facturing capacity and strengthen the U.S. technology workforce through STEM and training for semiconductor manufacturing. It also encourages enhanced cooperation with global partners and allies to ensure the stability of the global semiconductor supply chain. This forward-looking incentive will enhance economic competitiveness and bolster national security.

Request for a Supply Chain Resiliency Fund. We support the recommendation stemming from the 100-day Report which calls on Congress to fund the Supply Chain Resiliency Program proposed under the *Endless Frontiers Act (EFA)*, a part of *USICA*. This program, which requires close collaboration with the private sector, would help to formalize the ongoing activities taking place under the *ASC EO*, which are imperative to strengthening supply chain resiliency. While we appreciate the effort to provide needed liability protections to spur the sharing of supply chain risk information (SCRI) as part of the program, we also believe these protections could be further strengthened, as further articulated below.

Supply Chain Disruptions Task Force. We welcome the administration's plan to work with industry to develop a coordinated, streamlined, and holistic long-term approach to address semiconductor supply chain issues in a coordinated and holistic manner. The ICT SCRM Task Force provides a preeminent model in this regard, and we recommend synchronizing the efforts of this newly proposed Task Force with it to avoid duplication and leverage potential synergies that may result.

Collaboration on the Year-Long ICT Assessment. As the administration undertakes the longer-term assessment of the ICT industrial base, we continue to encourage close collaboration with the private sector to understand how it views the ICT supply chain, what it views as critical, where it sees gaps, and how government can best provide support. The ICT SCRM Task Force has been pleased to assist in the early stages of this assessment, as further explained below.

USICA/EFA Supply Chain Provisions. As stated previously, ITI commended the Senate's passage of *USICA* as providing a much-needed prioritization and expansion of critical investments in research, development, and technological advancement, including in the critical areas of semiconductor manufacturing, and addressing supply chain resiliency more broadly. A few key provisions include:

Emergency Appropriations for CHIPS and ORAN Funding. The emergency appropriations to fund provisions within *CHIPS* and the *Utilizing Strategic Allied Telecommunications Act* are imperative to maintaining a competitive edge in two technology areas key to U.S. leadership. As such, we are very supportive of the emergency appropriations, which provide an additional \$52 billion to fund the semiconductor programs outlined in the FY2021 NDAA, and \$1.5 billion to fund the Public Wireless Supply Chain Innovation Fund, which will help to support R&D for open architecture, software-based networks—technologies which the United States could leverage to address challenges related to vendor diversity that have emerged in recent years.

Commerce Supply Chain Resiliency Program. We welcome the proposal to develop a Supply Chain Resiliency Program housed in the Department of Commerce. As has been reiterated throughout the testimony thus far, there is a need for a more streamlined, coordinated approach to supply chain activities and this program would ideally help to achieve that objective. That being said, some of the activities listed under the purview of the Supply Chain Resiliency Program are already being undertaken pursuant to the *ASC EO*, though we appreciate that this program would formalize the review process called for there on a perpetual basis. We are further supportive that the program explicitly includes participation of the private sector in identifying and mitigating supply chain gaps. We also appreciate of the inclusion of liability protections to spur voluntary sharing of SCRI similar to those provided through DHS' Protected Critical Infrastructure Program (PCII), though as explained below we believe those protections could be further strengthened. To effectively implement this program alongside all the other programs the Commerce Department is currently tasked with implementing, it needs to be appropriately resourced.

Investments in Manufacturing USA and Manufacturing Extension Partnership. We appreciate that the *EFA* would seek to quadruple the Manufacturing Extension Partnership program, including adding a specific track for cybersecurity and workforce development. This program has been helpful to manufacturers seeking to grow and we believe sustained funding will continue to help improve supply chain resiliency and U.S. competitiveness. Similarly, we appreciate that additional funding is provided for the Manufacturing USA program, aimed at supporting U.S. leadership in advanced manufacturing through this robust public-private partnership mechanism, another area that will be key to supporting supply chain resiliency.

Regional Technology Hubs. Although not strictly a supply chain provision, we welcome funding for the regional technology hubs, which will help increase the geographic diversity of supply chains across the U.S. Such hubs will support innovation, especially among smaller players across the United States, and spur additional workforce development and commercialization activities.

3. Commerce's Increasingly Important Supply Chain Policy Role and Implementation Track Record to Date

Commerce, as the Federal steward of U.S. economic growth, competitiveness, job creation, and opportunity, is a key USG partner to ITI, the tech sector, and industry writ large. Commerce thus must play a central role in helping to make the ICT and other critical supply chains more resilient and secure. However, it cannot and should not be expected to do so alone or in an uncoordinated or ad hoc manner; rather it should continue to leverage its historical role as a convener and partner to industry and should also work closely with interagency partners to solidify the emerging U.S. policy approach to supply chain resiliency, as explained in the previous section.

However, it is important to view the new responsibilities the White House and Senate have proposed adding to Commerce's plate in the context of what has already been a significantly expanded role for Commerce in supply chain security and resiliency during the previous administration.

Commerce's Implementation Track Record for Supply Chain Policies and Programs Launched During the Prior Administration. Commerce is currently implementing several supply chain policy activities, rules, programs, and initiatives, including many launched during the last administration. The most significant of these include the following:

ICTS EO Interim Final Rule (IFR) and Licensing Process. Commerce bears primary responsibility for implementing the previous administration's ICTS EO, including taskings to finalize an IFR impacting a wide array of commercial ICTS transactions and to establish a new licensing or pre-clearance process applicable to a similarly large number of transactions. At present, the IFR provides the U.S. Secretary of Commerce (Secretary) with broad authority to review practically every single ICTS transaction with any nexus to an identified "foreign adversary," and casts a cloud of uncertainty over all other ICTS transactions given the list of named foreign adversaries could change at any time. When combined with the Secretary's additional power to block and unwind deals and the absence of an established, effective voluntary pre-clearance/licensing process (which Commerce has been delayed in developing or implementing), the fact that the broad IFR is "live" creates immense uncertainty in the business community that will result in an unnecessary, chilling effect on innovation and commerce. Commerce's responsibility for implementing these broad authorities under the ICTS EO alone raises significant questions regarding whether it has the resources or capacity to implement several new contemplated supply chain resiliency programs on top of this broad multilayered rule. *The implementation status of the IFR and the licensing program are uncertain at this time.*

Establishing a Process to Review Transactions Including Those Involving Chinese Apps. Although technically part and parcel of the ICTS IFR, as we understand it Commerce had separately been working on developing a meaningful transaction review process that would have also subsumed multiple other prior administration EOs directed at Chinese apps. While some of those EOs have been withdrawn by the Biden administration (see below), there remains a need for Commerce to develop a meaningful process for reviewing ICTS transactions. *The implementation status of Commerce's transaction review process is uncertain at this time.*

IaaS EO. The Commerce Department is currently tasked with implementing portions of the previous administration's *Executive Order on Taking Additional Steps to Address the National Emergency with Respect to Significant Malicious Cyber-Enabled Activities* (IaaS EO), including promulgating regulations for identity verification of foreign account holders and regulations that enables the Secretary, in conjunction with other agencies, to require IaaS providers to take "special measures" blocking them from doing business in certain foreign jurisdictions or with foreign persons identified to be engaged in patterns of conduct allowing for the use of IaaS products in malicious cyber-enabled activities. *The two sets of regulations required to be promulgated by Commerce pursuant to the IaaS EO, whose authorities overlap in some respects with the ICTS EO, are not due until next week, while implementation of a third section of the EO is delayed.*

NDAA 2021 Provisions. Commerce is responsible for establishing the *CHIPS* grant program pursuant to section 9902 of the 2021 NDAA and the National Semiconductor Technology Center (NSTC) pursuant to section 9906, as well as for con-

ducting a “Study on Status of Microelectronics Technologies in the United States” pursuant to section 9904. As stated elsewhere in my testimony, ITI encourages full funding of the *CHIPS* grant program and additionally suggests that efficient implementation of the NSTC by Commerce can leverage existing, proven industry ecosystems for semiconductor R&D where there are strong track records of innovation. The implementation status of the *CHIPS* grant program is pending funding via the emergency appropriations in *USICA*.

Additionally, although not directly related to supply chain resiliency, it is notable that, over the past few years, Commerce (specifically BIS) has been tasked with *significantly expanding the export controls system to emerging and foundational technologies* via implementation of ECRA, and *BIS has also been called upon to make numerous additions to the Entity List*. All this increased activity, while certainly justifiable for national security reasons, has also had an undeniable impact on the ability of Commerce/BIS to devote resources to the implementation of supply chain resiliency initiatives.

The unclear, and in many instances delayed, implementation status of numerous of the above-listed items helps to underscore the volume of supply chain resiliency and security responsibilities Commerce has accumulated and the resulting resource challenges it faces.

Commerce’s Implementation Track Record for Supply Chain Policies and Programs Launched During the Current Administration. Commerce has more recently been charged with implementing several supply chain policy activities, rules, programs, and initiatives by the current White House, layered on top of all the activities stemming from the previous Administration. The most significant of these include the following:

ASC EO. The *ASC EO* gave Commerce two significant taskings: first, to conduct a 100-day review of the critical semiconductor supply chain and submit a report to the White House; and second, to lead a year-long comprehensive review (with DHS) and submit a report on supply chains for critical sectors and subsectors of the ICT industrial base, including the industrial base for the development of ICT software, data, and associated services.” Because the ICT SCRM Task Force was asked by DHS and Commerce to help in the initial scoping of this review, I am confident in stating based on the work thus far that Commerce and DHS/CISA will both be required to expend significant additional resources to complete the *ASC EO* tasking over the next several months. I commend Commerce for its work in completing the 100-day review and for its initial outreach and partnership with the ICT SCRM Task Force on scoping the initial work for the year-long assessment and report.

EO on Protecting Americans Sensitive Data from Foreign Adversaries. This *EO* withdrew multiple *EOs* issued under the prior Administration banning transactions with certain Chinese apps in favor of a more process driven approach aligned with the regulatory regime required by the *ICTS EO*. It calls on Commerce to issue reports and evaluate on a continuing basis transactions involving connected software applications that may pose an undue risk of sabotage or subversion of the design, integrity, manufacturing, production, distribution, installation, operation, or maintenance of ICT or services in the United States (amongst other things). *The implementation status of this EO and how it practically relates to the implementation of several of the above articulated taskings is unclear.*

Executive Order on Improving the Nation’s Cybersecurity (Cyber EO). Commerce, particularly through the National Institute of Standards and Technology (NIST) and NTIA, also has a primary role in implementing section 4 of the new *Cyber EO* pertaining to strengthening the software supply chain. NIST has been tasked with identifying standards and best practices for the software supply chain, defining critical software, recommending minimum standards for source code testing, and initiating pilot programs related to IoT devices and software development practices. NTIA has been tasked with publishing minimum elements for a software bill of materials (SBOM), and it is noteworthy that NTIA has previously devoted a significant amount of resources over the past two years to running a multistakeholder process to conduct foundational work on SBOM.

It bears emphasizing that Commerce was responsible for all the above taskings even before the implementation of any potential USICA/EFA mandates or funding programs, should the bill pass the House and be signed into law. There are significant, legitimate questions that should be asked including: How do the above Commerce taskings relating to supply chain resiliency and security fit together? Does Commerce have sufficient resources and expertise to implement all these tasking simultaneously? And which bureau, office or other entity within Commerce is best equipped to lead and drive a coherent and coordinated approach to implementing supply chain resiliency across Commerce’s many taskings?

4. Recommendations for Effective Implementation of Supply Chain Resiliency Policy

My testimony thus far helps to illustrate the substantial amount of progress that has been made by the Biden Administration and Congress to identify problems regarding the resiliency of key supply chains and craft sound policies to address these issues. However, such progress will not necessarily translate into effective implementation of those policies by Commerce and other Federal stakeholders, particularly given the existing array of taskings Commerce is already implementing. Below I offer recommendations intended to help position Commerce and other relevant Federal stakeholders for success in implementing the various emerging planks of U.S. supply chain resiliency policy, along with Commerce's many ongoing holdover responsibilities in this area.

Commerce should develop and articulate a strategic, coordinated plan for implementing its numerous supply chain taskings. As mentioned earlier in my testimony, ITI has consistently advocated for a centrally coordinated and holistic USG-wide approach to supply chain resiliency and security policymaking. Given the volume of supply chain taskings that have been layered upon Commerce by successive administrations as well as the new responsibilities contemplated by USICA, a coordinated, holistic, and strategic approach *within Commerce* is also clearly necessary to effectively implement its numerous supply chain taskings. Commerce is the preeminent Federal stakeholder equipped to balance important U.S. competitiveness and economic interests with national security. Two key features of a strategic approach to achieve this balance should include identifying and empowering a specific entity within Commerce to lead and coordinate this work and ensuring that Commerce does not attempt to do all this work itself. Rather, Commerce should prioritize working with industry and other Federal partners to create synergies and stretch scarce resources.

Congress should ensure that Commerce has adequate resources to effectively implement supply chain resiliency policy, including fully funding CHIPS and providing Incentives to enhance the domestic semiconductor ecosystem. ITI encourages the USG to provide meaningful incentives to increase domestic semiconductor manufacturing capacity of both leading edge and mature node semiconductors and to increase semiconductor R&D funding and prototyping. We encourage the U.S. House of Representatives to follow the Senate's lead and provide robust funding for *CHIPS* at the \$50 billion level included in the 100-Day Report and Senate passed *USICA*, without distorting the incentives or the semiconductor market by favoring some sectors or applications over others, as a fundamental first step to boost the domestic semiconductor supply chain. These efforts should remain open to all multi-national chip manufacturers that meet the standards and guidelines set forth in *CHIPS*. Beyond that, it is imperative that Commerce is adequately resourced—in terms of both funding and staff—to carry out the full slate of supply chain resiliency policy activities identified above.

Commerce should prioritize close coordination with industry, including by leveraging existing partnerships, information sharing programs and innovation ecosystems. Policymakers and companies each have important and distinct roles to play in implementing supply chain resiliency. The USG has information that companies do not have about national security threats, whereas companies have information that governments do not have about their network operations and how they detect, manage, and defend against risks to data, systems, networks, and supply chains. Both policymakers and industry should communicate regularly and robustly about relevant risks (consistent with limitations relating to classified information and business confidentiality), including through opportunities for industry input in regulatory rulemaking processes, public-private task forces and other collaborative mechanisms, and informal relationships between policymakers and companies. As I stated earlier, the ICT SCRM Task Force provides an excellent model of public-private collaboration on supply chain matters that Commerce can draw inspiration from as it helps to launch the new Supply Chain Disruptions Task Force, which we urge Commerce to synchronize with the ICT SCRM Task Force.

Congress should ensure adequate liability protections to promote and incentivize the sharing of supply chain risk information. We appreciate the attention of the Senate Commerce Committee to include liability protections as part of *USICA*'s supply chain resiliency fund to spur much needed voluntary sharing of SCRI. Increased information-sharing regarding risks related to suppliers and other aspects of the ICT supply chain can help both the government and industry to identify and mitigate supply chain risks. Currently, companies face challenges in sharing supplier risk information. This includes the legal risk of sharing potentially derogatory information about a supplier, the administrative barriers for Federal personnel to share detailed, actionable information with individuals who do not hold clearances, and instances

where the Federal Government withholds vulnerability disclosures for offensive purposes. The ICT SCRМ Task Force has developed a legislative proposal that would amend CISA 2015 to provide liability protections for companies that share SCRI information in good faith. This is a superior approach to the proposed extension of certain PCII protections in the Senate-passed USICA for several reasons. Most notably the PCII liability protections may not extend to industry-industry sharing of SCRI (which is much needed for companies to share information across their supply chains) and PCII may not preclude all regulatory uses of shared SCRI. Further, the PCII sections of USICA would not preclude potentially expensive lawsuits (because the provisions do not result in an automatic dismissal of lawsuits as does CISA 2015). Finally, PCII comes with heavy administrative burdens (including that companies need to apply to be part of the PCII program, be approved by DHS, and mark all covered materials), whereas CISA 2015 protections are automatically conferred to all shared information.

Commerce should focus the scope of the ICTS EO to ensure that covered transactions are prioritized and targeted according to discrete national security risks. In its current form, the ICTS EO and associated rulemakings will not only have potentially devastating effects on U.S. competitiveness and innovation, casting a cloud of uncertainty over almost all ICTS transactions with foreign entities, with limited benefit to ICTS security, but because the current scope of the ICTS EO and IFR remain so broad, implementation “as-is” will also sap a disproportionate amount of Commerce resources. We agree that supply chain security is imperative to facilitating trust, but the ICTS EO in its current state does not achieve those objectives, in large part because it focuses on risks associated with foreign adversaries to the exclusion of other risk-based considerations. Therefore, revising the EO and the scope of its rulemaking to ensure it is targeted at identifying and managing the greatest risks would allow U.S. companies to conduct global business with certainty, thus improving competitiveness and allowing for continued innovation across borders, while also freeing up otherwise limited Commerce resources.

Commerce and other USG Stakeholders should deepen engagement with international partners and pursue a coordinated approach to supply chain resiliency. Global ICT SCRМ challenges ultimately call for globally scalable solutions, and we encourage the USG to collaborate with international partners and allies on supply chain resiliency issues to further common approaches to technology-related national and economic security risks—including through promotion of global, consensus-based, industry-led standards. For example, ITI welcomes the recent establishment of the U.S.-EU Trade and Technology Council as providing an opportunity to strengthen engagement and cooperation between the U.S. and EU on semiconductor and other strategic supply chains by conducting joint supply chain reviews to identify collaborative actions to improve resilience across semiconductor and other strategic supply chains.

Conclusion

Members of the Committee, ITI and our member companies are pleased you are examining how best to implement supply chain resiliency.

The USG has an unprecedented opportunity to lead on supply chain resiliency policy, and to do so it must work collectively, via public-private collaboration and across the Federal government, both domestically and on the global stage. Commerce is appropriately at the center of this effort, but to succeed in implementing the many critical programs, rules and other taskings addressed in my testimony it must adopt a holistic, coordinated approach, exhibit strong leadership, embrace partnerships across industry and government, and be well-resourced and committed to the task.

ITI stands ready to provide you with any additional input and assistance in our collaborative efforts to develop policy approaches to supply chain resiliency that continue to leverage risk management-based solutions and public-private partnerships as the most promising way forward for addressing complex and evolving global ICT supply chain threats.

I thank the Chair, Ranking Member, and Members of the Committee for inviting me to testify today and for your interest in and examination of this important issue. I look forward to your questions.

Thank you.

The CHAIRMAN. Thank you, Mr. Miller. And again, thank you to all the panelists. I feel like discussing this subject is, while you all have been studying, a new day for supply chain analysis and impact as far as what we should be doing. And you all gave us some

good ideas on that. Some differences. Dr. Lewis, you were unabashed, industrial policy, let's go. Definitely more analysis, Dr. Gereffi. And very direct things in the last two witnesses about what Commerce should be doing specifically.

So I want to pose my question, I think, Mr. Aboulafia, to you and Mr. Taylor and then just see whoever else wants to jump in, about this notion that we try to get at with USICA, somewhat about the supply chain, but really just about innovation. So if you are right, Mr. Aboulafia, which I think you are right—if there are 2 million people working in the United States in aerospace or the sector of semiconductors, and yet the innovation is happening at Mr. Taylor's level or Mr. Taylor is seeing the world and knowing what needs to happen, how do we really get that input and that strategic involvement? How do they get their views on the table, I guess is my point?

So we now have two proposals, strengthening tech sectors and strengthening tech hubs. Say, you have big parent companies who are just chasing the market, whether it is Intel chasing semiconductor markets or Boeing chasing international aviation markets, but yet the supply chain is the nose, the next level of innovation has to happen. How is it that we are going to drive the resources and innovation down to that level so that they can access that? So, Mr. Aboulafia?

Mr. ABOULAFIA. Yes, thank you for your question, Madam Chair. And it is true, I am afraid the bigger companies at the top tend to drive the conversations and tend to have a bit more of a direct pipeline to the R&D centers within the Federal Government.

Now, the good news is that thanks to some of the megamergers we saw back over the past 15 or 20 years, a lot of the supply chain is concentrated in companies such as Raytheon Technologies, General Electric, Honeywell, and many others that had sort of become their own effective economic and business powerhouses. I would like to see greater coordination between these first tier contractors. But how do you get the smaller companies involved, the ones that are also quite critical to both innovation and production?

And whether that happens through the auspices of trade groups such as the Aerospace Industries Association or perhaps maybe just standing up other committees and organizations within, say, NASA's Commercial Aerospace Directorate, I think it is absolutely essential. And I think there is greater recognition in the Government of the importance of these supplier companies. You know, one of the great saving aspects of this crisis has been the accelerated payment program by DOD, which is basically called for faster transfer of dollars from the primes to the suppliers.

So I think that kind of greater awareness of the importance of the supply chain. But it is a very good question under what auspices that happened and how that happens. But I think it is essential.

The CHAIRMAN. Dr. Lewis, you called for a greater role for Commerce to play, as you said, a more predictive role. What do you think we should do here if the supply chain is identifying the innovation, but they are like Mr. Taylor, they are running their business every day? They know what needs to happen, but they are not in control of the supply chain.

Mr. LEWIS. Thank you, Chair Cantwell. I focus on the high tech sector and on some of the innovation startups we have now spreading around the country. That is a really good sign. It used to be Silicon Valley. It is still Silicon Valley, New York, and Boston, but you are seeing research hubs spring up around the country and that is where the bill could make a useful contribution. We have a strong innovation system. It is based on research universities, venture capital, and then entrepreneurs. So those three elements are what produces innovation. They are really good at it. There is one dilemma, and this is a hard one. They follow the market.

So if they think—they all want to be unicorns, the next billion dollar company or the next Amazon. In talking to friends at the Defense Innovation Unit, which is DOD's effort to connect to the startup community, we are doing great on software. We are maybe lagging a little behind on hardware. And that is I think what one of the bill points out, the bill focuses on. So how do we get greater connectivity between the national innovation system and the industry? With my colleague here, Mr. Taylor, I would agree.

Let the market do it and then look for the places where the market isn't working. The market isn't working in a few places and the bill does a good job of fixing that. But we can use both Federal and private sector to make this work.

The CHAIRMAN. Mr. Taylor.

Mr. TAYLOR. Chair Cantwell, what I can relate it to, we are small business and therefore the overhead structure that it takes for innovative work, it gets limited. You are focusing what you have to do in materials and labor and the supply chain to produce the product and get it to the market. So we use the research university system, and many small businesses use that resource. I am thinking my distinguished panelists from Duke University, I am not sure what they have there. Mississippi State, which is just 30 minutes from us.

There are some rules and regulations that that are governed by the State of Mississippi, the Institute of Higher Learning, IHL, has a mandate that if an entity, say Taylor, wants to invest some capital in a research of something for product innovation, engaging the university, if faculty are involved, immediately, if there is patentability coming from that research, because faculty is involved, it stays at the university level. You know, I am not sure about that.

If an industry is willing to make the financial investment and lose the patent downside of that. So there are some—there are some play in the hand in hand of partnering with the university system, but that is something that could be improved in Mississippi.

The CHAIRMAN. Thank you. That is why I have held up this Rose Holleman model, because they do not—they don't claim anything on the patent. And researchers, companies like you just go right to them and say, help us solve this problem. And if that was more regional in various parts of the country, it would just be a ready-made asset. Senator Wicker.

Senator WICKER. Very good point, Madam Chair and Mr. Taylor. I meant at the end of my opening statement, Madam Chair, to ask unanimous consent to enter into the record a *Washington Post* story from yesterday entitled, "Biden Targets Shipping Costs As

Pandemic Ravages Global Supply Chains.” I ask unanimous consent.

The CHAIRMAN. Without objection.
[The information referred to follows:]

BIDEN TARGETS HIGH SHIPPING COSTS AS PANDEMIC RAVAGES GLOBAL SUPPLY CHAINS

Regulator warns of potential shortages amid ongoing disruption

By David J. Lynch

July 14, 2021 at 6:00 a.m. EDT

Shipping a container of hazardous chemicals from Shanghai to Chicago used to cost John Logue about \$6,600. Now, the Royale Group chief executive pays as much as \$29,000—and that’s if he is lucky enough to find space on one of the much-sought-after cargo vessels plying the Pacific trade routes.

Logue’s oceangoing headaches are mirrored on land, where Royale Group shipping containers routinely get stuck in rail yard logjams that lead to costly and unpredictable storage charges.

Earlier this month, BNSF, one of the Nation’s largest railroads, increased its fees in Los Angeles and Chicago, adding to Logue’s woes.

The Royale Group’s double-barreled freight troubles, which hamper both existing operations and Logue’s efforts to return manufacturing to the United States, illustrate the market power of the handful of shipping companies and railroads that bring goods from distant factories to American homes.

“We’re at their mercy,” Logue said. “Sometimes, we just throw up our hands. . . . It’s lunacy.” On Friday, *President Biden* called on regulators to crack down on consolidation in the shipping and rail industries, as part of a *broad executive order* promoting competition throughout the U.S. economy. Freight may seem a prosaic topic for presidential attention. But the smooth movement of goods has perhaps never been more essential, amid the explosion of e-commerce that accompanied the pandemic. Transport bottlenecks in June helped fuel the highest inflation in 13 years, rattling Americans with sticker shock on goods such as used cars, airfare and bacon. Indeed, some regulators and executives warn that abnormally high shipping costs and related supply chain disruptions could lead to scattered shortages this year as *the U.S. economy heals*. Imports of products including tires, food and water purification chemicals could be affected, according to Carl Bentzel, a commissioner of the Federal Maritime Commission.

“I am extremely concerned now about the economic impact caused by the current situation. This could be the first time the public sees the impact of maritime shipping disruption since World War II,” he said.

Trump is long gone, but trade frictions between the U.S. and Canada remain

But global cargo carriers and U.S. railroads insist that the administration has misdiagnosed the supply ills. The nation’s ports, terminals, trucking fleets and rail lines are being overwhelmed by a pandemic-related import surge, not strangled by monopolies, they said. Either way, with industry groups opposing new regulations, an early untangling of snarled U.S. *supply chains* is unlikely.

The White House officials who drafted Biden’s order say high freight costs, resulting from a lack of competition, are an economywide drag. Nine cargo carriers, organized in three shipping alliances, control more than 80 percent of the global market for oceangoing vessels. Likewise, there are just seven major railroads, down from 33 four decades ago, according to the White House.

“It’s like interest rates or oil,” said Tim Wu, special assistant to the president for technology and competition policy. “It gets less attention, but for consumers and American exporters, the price of moving goods is very important.”

Distinguishing between the effects of industry consolidation and the pandemic, however, is difficult. Importers and exporters have complained for more than a year about soaring freight charges, amid a shortage of shipping containers, truck chassis, drivers and dockworkers. Biden’s aides acknowledge that the pandemic is responsible for much of *the disruption*. But they say the lack of competition enabled cargo carriers and railroads to exploit the pandemic by driving prices to historic highs.

Industry officials and some independent analysts disagree. Drafting regulations to address the current situation risks unintended consequences once the economy regains its footing, according to Lars Jensen, CEO of Vespucci Maritime, in Copenhagen.

“The current state of affairs is extreme and is entirely driven by the ripple effects of the pandemic. It tells us absolutely nothing about the general structure of the industry at all,” he said.

Over the past four years, eight of the top 20 shipping lines disappeared; nine survivors sought to escape a history of meager profits by organizing themselves into three rival alliances. The shipping consortia operate akin to airline industry pacts, with carriers alternately cooperating and competing. Members of an alliance share space among their vessels, even while operating from some of the same ports.

The arrangement has paid off for the major carriers. Maersk reported a record \$2.7 billion profit for the first three months of this year, up from \$185 million in the same period last year. As demand cratered in the pandemic’s early months, the alliances quickly canceled more than 400 sailings, according to S&P Global. That avoided ruinous losses from a price collapse but led to exporters’ complaints of price gouging.

Then demand for cargo space unexpectedly surged, as Americans bought laptops, furniture and electronics for the work-from-home era.

Over the past year, the cost of shipping a container from China to a U.S. West Coast port has risen by more than 156 percent, reaching historic highs, according to the Freightos index.

Yet over the long term, there is little sign of soaring prices. During the first three years of the alliance era, that cost increased by just 14 percent. Prices from China to Europe over the same period actually declined slightly, according to Freightos.

“Freight costs didn’t matter,” Jensen said. They do now.

A rate rise in the U.S. might trigger big problems in the developing world

At Royale Group, based in Bear, Del., Logue said he spends twice as much time managing his supply chain as he did only a few years ago. On Monday, a carrier abruptly canceled a shipment, leaving him scrambling.

Many of Royale’s cargoes involve hazardous chemicals for the pharmaceutical, automotive and electronics industries, which require special handling. So carriers often opt to avoid the hassle if they can transport a routine product instead, Logue said.

“The three major alliances have a lot more bargaining power and control than they ever have before,” said Matt Godden, CEO of Seattle-based Centerline Logistics, which provides refueling services.

After years of moving production offshore, Logue has been trying to bring work back to the United States. Congested ports, crowded rail yards and a shortage of truck drivers have him improvising.

But he blames a host of factors for the current freight difficulties, including outdated port infrastructure and technology, *tariffs*, tensions between the United States and China, and the pandemic. Lack of competition “is maybe part of the problem,” Logue said.

American consumers could feel the impact of *stressed supply lines*. La-Z-Boy this month blamed “shipping container issues” for delivery delays and shortages of electrical components for some of its more expensive and profitable power recliners. Likewise, KushCo Holdings, which produces packaging for cannabis products, told investors that rising freight costs were a “drag on” profits, and Constellation Brands said it was having trouble keeping retailers stocked with its Ruffino and Kim Crawford wines.

Clothing manufacturer Levi Strauss is circumventing the worst backlogs, including at the ports of Los Angeles and Long Beach, by shipping more goods by air and rerouting ocean cargoes to the East Coast. Harmit Singh, Levi Strauss’s chief financial officer, told analysts on a recent earnings call.

“A lot of people are talking about not being able to get containers, not being able to get onto a ship,” Singh said. “[Our] team has done an extraordinary job, on getting us guaranteed space—guaranteed pricing, as well, which is helping us to control our costs. So this is a big challenge for the industry.”

In calling for independent regulators to act, the president may be pushing on an open door. Martin Oberman, chairman of the Surface Transportation Board, which governs the rail industry, said the president’s call for pro-competition regulation dovetailed with his long-standing concerns.

“While consolidation may be beneficial under certain circumstances, it has also created the potential for monopolistic pricing and reductions in service to captive rail customers,” Oberman said.

Freight rail rates have risen by about one-third since 2003, though the industry notes that they are down by 44 percent since deregulation in 1981.

At the Federal Maritime Commission, which oversees ocean shipping, officials have the authority to challenge carrier actions that “unreasonably” raise prices or

reduce service. Even before the president's order, the agency had begun investigating industry practices regarding extra charges for shipping containers that are not promptly removed from their facilities, known as detention and demurrage fees.

The White House last week labeled those charges "exorbitant" and invited regulators to respond. The charges are controversial because customers like Logue often are billed thousands of dollars by shipping companies or railroads for not claiming their shipments quickly enough, even when they are unable to do so because of congestion or a lack of trucking services.

"You've got to be a real Houdini to get stuff out of one of these rail yards," he said. The charges can add up. Norfolk Southern Corp. billed customers for more than \$93 million in demurrage fees in the first quarter, up from \$61 million in the same period last year, according to the STB, which has required railroads to report such data since 2018. At Royale Group, Logue said he hopes Biden's initiative will help. But the ongoing import tsunami coupled with constricted freight channels has him pessimistic.

"When you've limited the supply of something, the natural tendency is that the price is going to go up," he said. "I don't think it's going to come back down."

Senator WICKER. And let me just mention, it starts off "shipping a container of hazardous chemicals from China to Chicago used to cost John Locke about \$6,600. Now, the Royal Group Chief Executive finds pays as much as \$29,000, and that is if he is lucky enough to find space on one of the much sought after cargo vessels plying the Pacific trade routes. His ongoing headaches are mirrored on land where Royal Group shipping containers routinely get stuck in rail yards, logjams, and lead to costly and unpredictable storage fees."

So thank you for letting me do that. Mr. Taylor, you mentioned that you are 30 miles away from Mississippi State University, a land grant institution and a leader in research. But you are not in a major technology hub. So what unique challenges do folks in your position—you have got 1,200 employees. You would like to hire another 40 back. And you are the big employer and economic engine in that area. What suggestions do you have to make it easier for small and medium sized businesses who are not in these large hubs?

Mr. TAYLOR. Yes, those that are not in those corridors like we are—we are distanced from the distribution hubs, so that distance plays a factor in timing of deliveries. One thing that comes to my mind is that from that distance, usually interstate highway systems are used, of course, and then State service highway systems are used. At least in Mississippi, and I think in many rural parts of the nation, this infrastructure bill is being discussed and negotiated here in the capital now is vitally important. But I would say that if there is anything that can be done in that regard is not only refurbish our highways, refurbish our bridges to get them to standard, to use as many alternatives to source components to us and then ship our products out, but also improve.

We build lifting equipment, and we see the customer base wanting bigger equipment because their machine tools, their processors are putting out bigger packages for efficiency. Well, those bigger packages usually take weight and impact the load limits that we currently have in our Nation.

If the infrastructure system could be passed and it could cause an improvement in capacity, not just the service, but the capacity of transporting goods and services, rural facilities like us could have a better application for delivering high end product or getting more component per delivery or truck or per rail.

Senator WICKER. So strengthen our roads as we as we build them.

Mr. TAYLOR. Strengthen, yes.

Senator WICKER. Mr. Miller, you mentioned a liability concern. We are going to want people to participate in this monitoring program. That will be voluntary, won't it? The Government is not going to make people do that. What will the absence of a liability protection provision have on the willingness of companies to participate?

Mr. MILLER. Thank you, Senator Wicker. There are some very significant considerations that companies have to consider when sharing the type of information we are talking about, supply chain risk information. You know, oftentimes that type of information is, quite candidly, derogatory information about suppliers, you know, somewhere in their supply chain. And there are just a whole number of State and other causes of action that, you know, expose them to very significant legal risk if they were to, you know, say something, you know, about a supplier, for instance, that, you know, hey, we—you know, this is a bad company, right.

We don't even have to get into details. Things like tortious interference with contract, breach of contract, defamation. I mean, these are all very serious, you know, business disparagement. There is a number of different really significant legal risks and companies want to share this information, but there is not a clear pathway to doing it without those type of liability protections.

Senator WICKER. Well, thank you very much and I am going to take a little liberty up. Does anybody want to tell us we didn't quite get the CHIPS Act right and we need to make an amendment or two? If anybody would like to make a suggestion in that regard, either now or on the record, that would be helpful to us. Anyone? We will take that for the record. And is it—raise your hands, is it perfect? I think we are on to something. I assume, I am supposed to—yes, Dr. Gil?

Mr. GIL. Yes. Thank you, Senator Wicker. I think it is—.

Senator WICKER. Reach in for that microphone.

Mr. GIL. That is right. I am reaching. I do think is an excellent piece of legislation. I think the consideration that we should have is how do we have a sustained effort throughout the decade. Right, the consideration, of course, and the priorities to get it passed and implemented and executed properly in the next 5 years.

But the semiconductor industry is notorious for having to engage in long term planning and long term execution of roadmaps. So I think that, you know, hopefully these bipartisan Acts and consensus of getting these done will also be the basis and the success that we enable with that to sustain it over time.

Senator WICKER. Thank you. I yield.

**STATEMENT OF HON. RICHARD BLUMENTHAL,
U.S. SENATOR FROM CONNECTICUT**

Senator BLUMENTHAL. Thanks. Thanks, Senator Wicker. I am next in the order and then I am going to call on someone. I will have to leave, as did Chairman Cantwell. Just by way of explanation, we are in the middle of a vote right now and there are two votes so we will be shuttling back and forth. I want to focus on

drones which may not seem to be a kind of supply chain at first blush, but the presence of drones grows literally every day, every year in this country. They have commercial applications, recreational uses, and present grave National Security threats. And more to the point, for purposes of today's hearing, the overwhelming number of drones in the United States are made in China.

Anybody disagree with that proposition? I am going by public reports, but you may have better information. Last week I had the opportunity to visit Aquiline Drones, which is based in Hartford, Connecticut, to tour their Made-in the-USA facility. We talked about the need for growth in the domestic drone market and in the components and parts that go into drones. Aquiline is at the forefront of some of the most advanced applications of drone technology. It is not a huge company. But to go to your point, Dr. Gil it is one that is doing research and investment.

Senator Scott and I introduced the American Security Drone Act, which was incorporated as part of the competition package passed by the Senate this past June. And the Act helps protect Federal agencies from insecure drones and it spurs domestic alternatives, but it is only the beginning in my view of what we need to do.

Let me ask the witnesses here whether you agree with me that the prevalence of Chinese drones represents a security threat from the standpoint of surveillance potentially within the United States, certainly lost opportunity because the market is only growing for them here and around the world, and what can be done about it? Anyone who would like to take a crack at that question?

Mr. LEWIS. I will go first. Thank you, Senator. So I actually had DJI come in and, when we could still have meetings, and demonstrate their products to me. They are really good. I tried to get them to give me one, but they wouldn't do it. We are in a situation where DJI, the Chinese company and a couple other Chinese companies, dominate the global market. And it is a good question to ask how we got there.

A rule of thumb I use is that if it connects to China in any way, it could be a source for intelligence gathering. And that is why I think that the legislation to restrict Federal agency use of Chinese drones is essential. And we do not want to underestimate our opponents' ingenuity in seeking intelligence collection. So what do we do about it? And some of it is we don't always want to copy the Chinese what we want to look at some of the things they have done, which include subsidies for research, subsidies for STEM education, and really closing their own market, not openly, but closing their own market to foreign suppliers.

China wants to bifurcate. I mean, they are the ones who came up with the idea of indigenous economy. So we will need to think how we rebuild our drone industry and that will not happen automatically. We still do quite well in UAVs, the big drones for military purposes. Can we use some of that to encourage those companies to go down market? Can we find ways to support these innovative startups like you were talking about?

And we will need to do that. I don't think that is part of the legislation that I have seen, but it is the model that you have used

in USICA probably needs to be applied to drones because it is a security risk. Thank you.

Senator BLUMENTHAL. Thank you. Anyone else? My time actually has expired. I am going to turn to Senator Fischer, but before I do, I just want to second what you just said, Dr. Lewis. I think that the prevalence of Chinese drones, because they are essentially, even if used by companies here for commercial purposes or whatever, they are essentially eyes in the sky. And the UAVs, ironically, may be used by the military for surveillance but used abroad, whether it is Afghanistan or any other countries where we are conducting military operations.

So we may have a bit of a recess before Senator Fischer takes over. I understand she may be running a little bit late, but I want to thank all of you for being here today, and it has been very useful. Thank you. So we are turning now to Senator Fischer.

**STATEMENT OF HON. DEB FISCHER,
U.S. SENATOR FROM NEBRASKA**

Senator FISCHER. Senator Blumenthal, I am here.

Senator BLUMENTHAL. The floor is yours.

Senator FISCHER. Thank you, Senator Blumenthal. And thank you to our panel today. A harmonized and complementary Government role is essential when we look at sound policy that strengthens our Nation's supply chain resiliency. And it is important that policymakers avoid a top down bureaucratic approach on this issue, which may be too heavy handed or slow to respond.

Mr. Miller, you noted in your testimony that the Commerce Department should prioritize working with industry and other Federal partners to create synergies and stretch scarce resources. In what major ways can lawmakers ensure that the Government is agile and efficient in this approach?

Mr. MILLER. Thank you, Senator Fischer. You know, there are a variety of different ways that lawmakers can do that. And I do sincerely believe that, you know, you have laid out several ways in the USICA bill. You know, the Manufacturing USA and extension partnership programs are certainly one example. You know, the formation of the new supply chain disruptions task force is another. You know, I will say that the Commerce Department, for instance, has been participating in the ICT supply chain risk management task force as well.

And, you know, I think Commerce Department in particular does have a long history of successful partnerships with the private sector. You know, I am thinking in particular of various programs that that NTIA and NIST have run. You know, as I did state in my testimony, you know, I do think that the Commerce Department should develop a coordinated strategy to really, you know, create synergies and maximize these efforts, but I do think that there is an opportunity to do that.

And, you know, Congress, by authorizing these programs, is going to be very helpful in that regard. Thanks.

Senator FISCHER. Where would you suggest that Congress look for some good examples of programs that might be valuable for us to drill down into and see if they would work at a Governmental level?

Mr. MILLER. Well, I mean, I you know, I do think that, you know, in terms of existing programs, you know, some of what we have—some of the suggestions in the 100 day report is one place. You know, I do think that, you know, having, you know, the White House involved in in really setting the tone there is important. And, you know, certainly there is a lot that is going to need to be done, I think, in terms of drilling down when we look at the supply chain resiliency program and you seek—you know, I think some of the other my fellow witnesses have said really making sure that we have a sustained effort in implementing the CHIPS Act.

You know, it is a long game, right. I mean, it is not just drafting a bill and giving Congress or anyone else a pile of money. It is really having a sustained strategy to follow through on these programs that hold so much promise that I think is important.

Senator FISCHER. Thank you very much. Dr. Gil, in your testimony you also touched on the importance of an agile approach to address the ongoing semiconductor shortage. Right now, timing is the key for the next steps necessary to build American semiconductor capabilities and domestic production. You highlighted that the National Semiconductor Technology Center could be the foundation for addressing supply chain disruptions.

But you also stated that rather than creating another Government program office to operate NSTC, it should use an industry led consortium model. I appreciate the suggestion on this front. Could you please expand on what key elements of the model may make it more responsive or agile?

Mr. GIL. Thank you, Senator. I think a characteristic of the model is to build on our strengths that we have as a Nation in the entire supply chain of semiconductors. Actually, we have wonderful strengths on equipment manufacturers, in the electronic design industry and electronic design automation, on fabulous companies, as well as fabrication and R&D, and R&D strengths, not only in industrial sector, but also with universities.

So I think the most important thing that we have got to get right is to bring a broad coalition where we bring the strengths in an environment that lifts all those boats. And we have precedent for being able to do this successfully in the past. There have been moments, in fact, in the very semiconductor industry in the 80s when we were confronting great challenges and the context of then was in competition with Japan at a time, where the creation of Semitech and other environments where industry and universities and the Federal Government came together resulted in great success.

So there is precedent for us coming together. And I would say that will be the number one priority that we got to do, a broad coalition of leaders to make this happen and to build on the strengths of previous investments and infrastructure that we have had. I think the biggest risk that we would have is to sort of ignore those trends and start something brand new. That sounds exciting and perhaps sometimes a little bit more academic but doesn't lead to the results that we are going to want because in the end, we want the manufacturing capacity in the United States, and we want the innovation capacity to deliver results.

Senator FISCHER. OK. Thank you. I see my time is up and Senator Klobuchar is here, so thank you very much. Senator Klobuchar.

**STATEMENT OF HON. AMY KLOBUCHAR,
U.S. SENATOR FROM MINNESOTA**

Senator KLOBUCHAR. Oh, thank you very much, Senator Fischer. And thank you to the panel. We are proud of the work that has been done on this bill, the U.S. Innovation and Competition Act. And I guess I will start with you, Mr. Miller. Part of this bill, the—something I worked on with Senators Wicker, Coons, and Portman creates an Office of Manufacturing Industrial Innovation Policy, and it prioritizes across agency coordination because we know we have a lot of agencies working on manufacturing. Can you speak to the importance of interagency coordination when it comes to the supply chain?

Mr. MILLER. Absolutely, Senator Klobuchar, and thank you for the question. The importance of industry—of interagency coordination really can't be overemphasized in this case. You know, there is a couple of different reasons for that. You know, number one, there really are quite a number of ongoing supply chain related activities across the Federal Government.

You know, I think it is—you know, even though I focus on the ICT supply chain, it is clear, and it has become even more clear from the global pandemic that global supply chains and the importance of supply chains are really important to all U.S. industries. So it is really a situation where if we are going to have a coordinated strategy, you know, we need to be in sync across agencies and across sectors to really make sure that, you know, we have everyone pointed in the right direction.

And that is why the program you referenced is important to really prioritize that sort of coordination.

Senator KLOBUCHAR. Very good. I hear Dr. Gil, you have a nanochip with you and I actually recently visited SkyWater in Bloomington, Minnesota, a very successful chip producer that produces 65 and 90 nanometer chips. In your testimony, you note the importance of this. And can you speak about investing in U.S. based companies in the production of semiconductors?

Mr. GIL. Yes, thank you for the question, Senator. You know, semiconductors, in the end, is the lifeblood of the electronics industry, I know of almost every product that we can imagine, right. In fact, I think there has been an awakening for all of our fellow citizens to discover just how ubiquitous they are and how it can affect the production of almost every item that they rely on.

So I think it is absolutely imperative that we maintain the dual mission of innovating to imagine new products of what we are going to do with semiconductors, and we are not only talking about the traditional electronics, it is going to be the world of AI, the world of quantum computing, the world of next generation wireless.

New capabilities in cyber security are going to rely on this. And it is a combination of that creativity and breakthrough with our ability to manufacture in the United States. And that is a dual equation that we absolutely have to get right, and it will lift many, many boats across all the industries.

Senator KLOBUCHAR. Very good. Thank you very much. Mr. Miller, in your testimony, you note your support for funding for Supply Chain Resiliency Program, which would include the Commerce Department working with the private sector. Do you want to elaborate on that public-private partnership and how important that is as we look to the future in doing this right?

Mr. MILLER. Yes, absolutely. You know, I think it has been a theme that has already emerged during this hearing about how important it is for the Government and the private sector to work together on supply chain challenges in particular. You know, there are a variety of reasons for that. You know, not the least of which is that, you know, we are talking about massive, in many cases extended global supply chains where, you know, it would be impossible for the Government to have visibility into what is happening in those supply chains without, you know, constant and continuous coordination and communication with industry.

You know, there is also, you know, limited resources, I think, on both sides of the ledger. So to the extent that people can combine together forces, that is really great. And again, leveraging existing partnerships and innovation ecosystems is great.

Senator KLOBUCHAR. Thank you. And I will get it the rest in writing. I just want to ask one last question in my time to Mr. Aboulafia. And in your testimony, you talk about the role of research and technologies like sustainable aviation fuel can play in reaching zero emissions. Can you touch on that for me? I am very interested in that.

Mr. ABOULAFIA. Yes. Thank you, Senator. I am afraid there is not a lot of clarity in terms of the path toward reducing emissions beyond traditional development of equipment. But sustainable aviation fuels appears to be one of the most likely ways. Hydrogen, for example, not so promising despite all the talk, but sustainable aviation fuel seems to offer a way forward. You know, there is an awful lot of different initiatives setting up around the world, and I wouldn't want to see U.S. industry hamstrung because of the lack of parallel initiatives.

And it also seems that it is important to get industry on the same page because it is absolutely essential to make these developments, if you will, technology ecumenical. Basically, we should be able to put sustainable aviation fuel in existing equipment so make sure we are working with, well, the 25,000 jets we have out there, rather than trying to invent bespoke technologies to work with it.

And then finally, it might behoove the Committee and others in Government to consider mandates as a way of creating a guaranteed market for when these products come online, as we saw in the car industry. That might be a productive use of Government resources.

Senator KLOBUCHAR. OK, very good. Thank you, everybody.

The CHAIRMAN. Thank you, Senator Klobuchar. Senator Peters.

**STATEMENT OF HON. GARY PETERS,
U.S. SENATOR FROM MICHIGAN**

Senator PETERS. Well, thank you, Madam Chair. Dr. Gil, I certainly applaud IBM's work to achieve incredible breakthroughs with respect to advanced semiconductors. As you are well aware of,

these are tiny devices just the size of a fingernail, basically, that will literally shape the course of the 21st century by powering our cutting edge technologies like artificial intelligence and supercomputing. However, I think it is important for us to remember that the advanced chips are just one part of the story.

There is an entire ecosystem of semiconductor technologies that our economy depends on, including what are called so-called legacy chips. And so I bring this up in relation to the auto industry, where the chips shortage right now of these legacy chips is forcing production shutdowns. And this has had a devastating impact on auto workers in Michigan as well as across the country. And I am afraid it could even become worse in the coming months. But I also want to be clear, as you know, this is not just about automobiles.

A wide range of industries and devices depend on these legacy chips, from farming equipment to medical devices as well as military vehicles. Even the CEO of Apple, Tim Cook, said in April that a shortage of legacy chips was causing the most problems for his company. And that is why I worked with Senator Stabenow to include legacy chips in a \$52 billion package to reshore domestic production of semiconductors, which passed the Senate last month through the U.S. Innovation and Competitive Competition Act.

So my question to you, Dr. Gil is, can you elaborate on the role that legacy chips play in the broader economy and employment in the United States? And could you comment further on why swiftly passing this U.S. Innovation and Competition Act is absolutely essential to keeping our Nation at the forefront of semiconductor manufacturing globally?

Mr. GIL. You are absolutely right, Senator, on the reliance on the importance of many, many generations of what is referred to as semiconductor nodes, different technologies that are a part of our automobiles and industrial equipment, aerospace and defense, et cetera. One observation I will make is undoubtedly the case that we have to have a great urgency on being able to address the current supply chain shortages, including the legacy chips. But I will make the obvious point that those legacy chips were the future chips of a decade ago.

And this industry that this element of planning for solving issues of today but planning for tomorrow is vital. And what looks like advanced nodes right now, 5 years from now, 7 years from now, will become what we are referring to today as the legacy chips that we are confronting now. The legislation of the CHIPS Act does a number of things that are really, really important of that today and tomorrow. So in the context of the National Semiconductor Technology Center, there is a great emphasis as well on the assisting with the design and the portability of these designs to multiple foundries on packaging, and test, et cetera.

So I think this legislation is actually going to be very, very consequential in helping the broader ecosystem be more productive in the design and production of chips, including their indispensable legacy ones. But I will continue to make the point that we need to do both, the today and tomorrow.

Senator PETERS. Well, thank you. And Mr. Miller, I serve as Chair of Homeland Security and Governmental Affairs Committee, where yesterday we passed the Supply Chain Security Training

Act. This legislation directs GSA to develop a coordinated Federal Government wide training program to prepare personnel to identify and mitigate supply chain threats to enhance Federal supply chain cybersecurity long term. This bill addresses Federal supply security.

And Mr. Miller, in your testimony, you mentioned, “uncoordinated inconsistency” approaches to supply chain resiliency and security policy, including cybersecurity. So my question for you, Mr. Miller, how should CISA’s mandate be improved to ensure that it is indeed the lead agency to coordinate efforts on supply chain risk management? And if so, how can its resources and authorities be improved to fulfill that mandate?

Mr. MILLER. Thank you for the question, Senator Peters. You know, I do think that CISA has clearly prioritized supply chain security and resiliency I think already over the past couple of years. You know, it was a few years ago that the Secretary really prioritized supply chain security in particular in, you know, kind of, you know, spearheading the formation of the ICTs supply chain risk management task force.

You know, I have been pleased to serve as the co-chair of that. I do think the National Risk Management Center also has a very clear mandate to focus on supply chain as well. You know, in terms of anointing or making sure that that CISA is really named, as I think your question implied, as the as the lead agency there, I think we would be very supportive of that.

There are many different dimensions of supply chain, and the Commerce Department and others have to have a role in it, particularly when we look at through the broader lens of resiliency. But when we are looking at security in particular, you know, CISA is well positioned to lead there. So any support that the Congress is able to provide, I think is well received by us.

Senator PETERS. Thank you for that answer. Thank you, Madam Chair.

The CHAIRMAN. Thank you. Thank you, Senator Peters. So I have a couple of questions. I am not sure we are going to see other members here, but I wanted to cover a couple of things. Dr. Gereffi, you talked about the research of this particular issue, too. And from our witnesses and the questions from our colleagues, you can definitely see, everybody is advocating for more expertise and definitely a larger role for Commerce. So how do we get that expertise given any one of these things? As Mr. Aboulafia said, maybe you should have a dedicated supply chain focused just on aviation and obviously we are heading that way on semiconductors.

I could make the case we should have had a better analysis on aluminum, given where we are with the aluminum sector and the shift that is happening. How do we—what do we need to do if we are going to say we want a larger Federal role? What is it we need to do to have the research about these sectors, again, if a lot of the innovation or the awareness about the next phase of innovation is at the very base level of the supply chain? You have got to turn your mic on. Yes.

Mr. GEREFFI. Senator, thank you, Senator Cantwell. I think in the past when we wanted to focus on specific industries, we had programs like national industry centers at things like the Sloan

Foundation supporters I mentioned in my testimony. But I think to get the universities involved, we end up having to take a more interdisciplinary approach. And so I think one of the critical issues is trying to find some of the key industry areas that are cutting edge where the universities can supplement.

And that is where I think your National Science Foundation Technology Initiative, the Technology Directorate, could be a key because NSF does tie into universities in a very direct way. And but I think it has to connect also to those industrial clusters where the industries are located, in particular parts of the country. So a combination of NSF, which is going to tie into applied funding, the multidisciplinary that comes from industry clusters, and then linking that across different industries that are specialized, I think is probably one of the key ways to go for universities.

The CHAIRMAN. I see you nodding, Dr. Gil. You agree with that?

Mr. GIL. I very much agree with that. I mean, in the context of serving in the National Science Board and the evolution that we see and the potential of the technology and innovation translation new directorate, by bringing the best of the university, what historically would have done in centers, by imagining a new catalyst where we can bring universities and industry at all scales together through these NSF sponsored centers, I think would be a unique model that would allow us to address some of these concerns.

The CHAIRMAN. Well, it certainly could be more translational, and it certainly could be more informational back up the chain. I don't mean to use that word intermittently.

So when you are talking about getting somebody over at Commerce to understand what is happening in Mr. Taylor's business or what is happening in aviation or what is happening in semiconductors, it is not that there aren't people at NIST. But when you want to call a shot and say, oh, well, we need a specific R&D supply chain effort for aviation or semiconductors, you should have somebody farther up at the Department of Commerce making that decision.

Mr. GEREFFI. Just one further comment. I think that when we look at the existing technology areas in the U.S. that are well developed, Seattle with Aerospace or Silicon Valley or Austin with IT or Boston 128, in all of those cases, we have well-established universities that are connected with private companies. But one thing that is happening now is we have a whole new set of technologies that is transforming the cutting edge of research. So artificial intelligence, quantum computing, all of the different areas that are coming out of the digital revolution.

So I think that is where we need to bring universities back into the equation, because what worked 5, 10, 15 years ago is changing very fast now. And so that to me is the real challenge. How do we have that discussion between industry and universities and Government taking these next generation technologies and bringing them into the picture?

The CHAIRMAN. Well, that is where the hub and the center come together. And that is—you know, it may be a new fashion, but Dr. Lewis, did you have a comment on that?

Mr. LEWIS. Thank you, Chair Cantwell. Commerce used to have a technology Administration. Technology used to be one of their

central missions, and they got rid of it some time ago. So one of the things to think about is you were talking about NIST isn't a policy agency. They do great work, but they don't do policy. So if you are going to rebuild that capability at Commerce at the senior level, further up the chain, we might want to look at what Commerce has in place. A lot of talent there, a lot of strengths, but not focused on the technology mission in a way it might have been 10 years ago.

The CHAIRMAN. And thank you, I like that suggestion because I do think you have to have—as it is changing so fast you have to develop expertise. Mr. Aboulafia, there is, you know, this effort on thermoplastic that I have heard about. I have heard about it because, you know, obviously in the aviation supply chain, getting material for airplanes that have material flaws in them requiring you to start over, you know, is a big deal.

So thermoplastics give you that ability. But the most I have heard about this research is that it is over in Europe and there are companies like Boeing that are participating. I have also heard of it from companies in Spokane who are saying, I am doing this, and we need to do more of this. But how do we get the focus on the core technologies that need to happen in aerospace if these are just voices in the supply chain or for example, Europe has had associations just because they are Europe or Max Planck Institutes, where everybody always works together.

What is it that we need to do to identify the next generation technology that seems to be already there in the supply chain, but the supply chain is made up of just small individuals trying to compete? What do we need to do?

Mr. ABOULAFIA. Well, I suppose that it is encouraging the very fact that, Madam Chair, you are hearing about this technology indicates that there is some equipment and technologies that are coming to public view, to your view. You know, when it comes to materials, that is actually a very good example of the kind of thing that I think should be accelerated because they can be brought to market a bit quicker.

But that despite the emphasis on creating these materials in the supply chain, and it is up to the primes to specify them at the end of the day. So bigger companies like Hexcel or something like that could create these advanced materials and some of the smaller companies. But ultimately it comes down to the primes. And this is one point where I guess I will slightly reverse myself.

I think it is up to the primes to identify what technologies they are able to bring into next generation platforms, be it materials, be at various advanced control systems, be it avionics or whatever else. They might be the best source to say, well, this is something we would like to see on our next generation jetliner or next generation business jet or combat aircraft.

In the case of thermoplastics, you know, there is a lot of work going on in the interiors field, so that might be the sort of intermediate end user people who create interiors and want to bring some new capabilities to market. But in general, these are exactly the sort of technologies that I think could migrate from basic to a more advanced supply level of R&D. And yes, it is sort of noteworthy that a lot of other companies or a lot of other countries are

engaging in this research. One thing about this is that being in the Netherlands and Belgium or other places, these are effectively neutral aviation powers.

It is not—if it is taking place in France or Britain or Germany, it is probably not addressable as much to U.S. contractors. And I think that's important to remember. And the reason, I think for the U.S. to have that greater capability in identifying these technologies and well, working with U.S. R&D programs and getting them to market.

The CHAIRMAN. Thank you. Senator Scott.

**STATEMENT OF HON. RICK SCOTT,
U.S. SENATOR FROM FLORIDA**

Senator SCOTT. Thank you, Chair Cantwell. I want to thank everybody for being here today. I have been up here for about two and a half years, and I am a business guy, and a lot of times what people come up here to do is they always ask, what can the Government do to solve a problem?

Can you all talk about what your industries are doing and what you think we could be doing without Government and without increasing our debt? And we have almost \$30 trillion worth of debt now. Could each of you talk about what the private sector should be doing and what you are doing?

Mr. GIL. I will be happy to start. Thank you for the question, Senator Scott. So one element, and I will speak for IBM, is we have had an unwavering commitment to invest in R&D. I am proud to lead the research division, IBM. We have had a research division for 76 years. We continue to employ over 3,000 scientists, work full time to continually to invest and create the future of information technology and artificial intelligence and quantum computing, semiconductors, et cetera.

So I think that, you know, the private sector needs to continue to have a very, very strong commitment to R&D and invest in our workforce so that we can continue to create differentiated products. That is one thing I would advocate strongly.

Mr. TAYLOR. Senator, I would say that one of the things we are doing as a small manufacturer is we are building more and more relationships with partners. There is just a lot of technology that as a small company you can't do yourself. Build that relationship. And I am talking about a relationship, not finding a vendor, but building a relationship with that vendor that seeks a long strategic approach to the innovation or the product you want to present to the consumer. And these partnerships are very, very important, particularly to small manufacturers. But I think any size manufacturer that is where the expansion will be.

Senator SCOTT. Anybody else?

Mr. LEWIS. Just quickly, Senator, and thank you for the question. You know, one thing that the private sector can do, and associations like we have here today are helpful on that, it needs to send clear messages to Government on what would be helpful to do, where there are areas that go outside of the purview of the USICA that we need to address, like monetary policy, like tax policy. We need to get those signals from the private sector on the

guidance for Federal policy. And that would be an area where I think there's room for improvement.

Mr. GEREFFI. Can I just add one thing, also Senator Scott, you know, I think beyond the R&D investments as well, you know, one of the things that that the private sector is doing is lending, expertise and resources to the Government. You know, as I stated earlier, particularly in the supply chain context, Government entities don't always have, you know, a lot of visibility into what is going on in across these supply chains. So partnering with the Government, working, you know, on public private-partnerships and task forces and really, you know, devoting industry resources to help, you know, advance the shared Government industry mission is something that I know that the ITIs companies are doing.

And another is also partnering on, you know, some of the workforce development programs and things like that to really try to, you know, help rebuild the talent pipeline. That that's another thing that our companies are doing.

Senator SCOTT. Thank you. Is there anything that any of you think we, the Government, should stop doing that would help the supply chain? A lot of people come up and say what we should do more. I was in business. I got tired of Government. I mean, they are always just a pain in the rear. I mean you get fed up with it. OK.

The CHAIRMAN. Go ahead, Mr. Aboulafia.

Mr. ABOULAFIA. Oh, thank you very much, Madam Chair. Senator, if I may know, there is one aspect I think, of the Government's approach to the supply chain that could probably change a bit. The Pentagon has a rather patchy procurement policy when it comes to aftermarket componentry. And given the reliance of the supply chain on aftermarket components for a lot of their profits, ultimately the kind of lumpy buying habits and frankly absence of guidance at times is a bit of an issue for the supply chain.

So perhaps greater guidance from the Pentagon and other Government purchasers of componentry about what they are doing to fill their warehouses or when they are destocking or what their purchasing patterns are going to be in the coming couple of years would be extremely helpful, I think, to a lot of the supplier companies I would—I speak to. But if I may just quickly address your previous question, it is a really interesting one about what private the private sector should be doing.

One change I would like to see them make is have less of an adversarial approach to their supply chain. Many companies at the prime level kind of regard them as something to be, frankly, fresh for profit, basically. Got to harmonize margins and whatever else.

I would like to see more of a partnership between the primes and the subs. And perhaps this crisis will illustrate the rather vulnerable nature of the supply chain and the importance of having that partnership and working together in tandem to be more resilient.

Senator SCOTT. Thanks, everybody. Thank you, Chair Cantwell. Thank you. Senator Sullivan.

**STATEMENT OF HON. DAN SULLIVAN,
U.S. SENATOR FROM ALASKA**

Senator SULLIVAN. Thank you, Madam Chair, and thanks for this really important hearing. I want to start with a kind of a couple questions I am going to toss out there. Somewhat related to Dr. Lewis and Dr. Gil. I was recently in South Korea and Taiwan on a bipartisan Senate delegation with Senator Coons and Senator Duckworth.

And I would like to get both of your views on this issue of selective decoupling. And I was very surprised and actually pleased both in Taiwan and in South Korea meeting with their senior Government leaders, but also senior private sector executives, how they do see this selective decoupling coming and they seem very forward leaning on making the choice about being in the United States both foreign direct investment in our country, which they are starting to do, and being more interested in, you know, if there is a choice, the choice is the United States.

I was very pleased by that.

And then, Dr. Gil, this obviously relates to semiconductors too. In terms of Taiwan and South Korea, both of their big semiconductor manufacturing companies are looking at major, major investments in our country as well. So maybe, Dr. Lewis, if I can start with you and this issue on Taiwan, where it is very clear the ultimate goal is for the Chinese Communist Party to absorb Taiwan. I don't think that is a good idea, forcefully or not, but how do we think about that when we think about selective decoupling as well?

Mr. LEWIS. Thank you, Senator. I am very grateful to the Chinese Communist Party because they make our task so much easier. Every time they open their mouths, countries move in our direction.

Senator SULLIVAN. That is really happening. I think you are right.

Mr. LEWIS. Yes, and so we need to think then how do we build a unified approach with our allies and partners like Taiwan and South Korea? How do we streamline the path for them to work here? You know, it would be great to have TSMC in the U.S. Sure, they are a competitor, but I feel confident our companies can compete with them.

Senator SULLIVAN. Well, they are obviously strongly contemplating that, as you know.

Mr. LEWIS. Contemplating and location are not the same. And so how can we make it easier for them to get here? Same for Samsung. Very strong presence in Texas, but we depend on Samsung and TSMC.

An issue for the Congress and for the Administration is, do we feel comfortable with that dependency? Mixed answers there. We may not have a choice in some cases. So how do we smooth the path to work with them? Also, you were in Asia, but we need to think about our European allies. They are a little more ambivalent when it comes to cutting off trade with China.

Senator SULLIVAN. But that is changing, I get the sense.

Mr. LEWIS. No, I was going to say—

Senator SULLIVAN. The more the Chinese Communist Party opens its mouth, the more I think our European allies are recognizing what the reality is.

Mr. LEWIS. Let's look at the results of the elections in France and Germany, because I think when those are over, it might be easier to see new directions in European policy.

Senator SULLIVAN. Dr. Gil?

Mr. GIL. To borrow the microphone. You are absolutely right, Senator Sullivan, about the strength of South Korea and of Taiwan in terms of production. I refer in my testimony that they represent 100 percent of the manufacturing capacity below the 10 nanometer node. So I think is our dual policy that would be very beneficial to the United States.

One is absolutely encourage their investments here onshore, which, you know, they do have plans to do. But seeing it through and the signaling that the CHIPS Act does, it is absolutely sending a very clear message about the importance and the resurgence of semiconductor industry in the United States and the need to invest. And on top of that, also be able to foster through the creation of NSTC and manufacturing capacity with U.S. manufacturers to complement that. I think there will be a wonderful outcome, actually, that this decade we have the sum of all of those in the United States.

Senator SULLIVAN. Thank you. And Madam Chair. I mentioned this to Senator Wicker. It was very interesting. Those companies and countries were very closely tracking what was going on with our legislation and the CHIPS Act. If I can ask just one final question, if that is OK?

The CHAIRMAN. Senator Thune is waiting but go ahead.

Senator SULLIVAN. Dr. Lewis, I will just very quickly, and it is a long question, so I will try and keep it very short. One, asymmetric advantage the Chinese have over us is that we have an entire finance class, Wall Street, a lot of our big private equity groups that seem very comfortable investing in not just China, but Chinese AI, Chinese military, Chinese Communist Party related companies, and of course, any Chinese financiers who want to relate, who want to invest in something related to the Pentagon or something would help us, the Chinese Communist Party will crush them.

How do we think about our own Americans, I get disturbed by this to be perfectly honest, who seem very happy, free, open, willing to invest in our biggest competitor, sometimes in military applications that could someday be used to kill Americans? I find this very, very troubling and yet some of our biggest finance executives seem to be completely fine with it.

I am sure they make a lot of money doing it, but it certainly isn't a patriotic undertaking, in my view. Any thoughts on that?

Mr. LEWIS. Thank you, Senator, and you will be happy to know that the Chinese are also closely tracking the progress of the bill. I got to be on Chinese television trying to explain that when I was called the Endless Frontiers Act. So they were very upset by it, which is good, right?

Senator SULLIVAN. That is a good sign.

Mr. LEWIS. Yes, this is going to be a hard problem. We are at the start of a long process of, if China continues on its current path, they will become more and more of an opponent, more and more of a place that we will not want to do business with and we will not want our allies to do business with as well.

But right now, there are still transactions that are safe to make. And so the question for policy is, how do we get them—how do we exploit China the way they exploit us? How do we find places where it is safe to do business and the places where we will need to close off? That space is shrinking—that safe space is shrinking. But that is what I would look at is, let's see where the Chinese come out in a few years.

They are probably not so happy either. So but we will have to find ways to balance making money in China, which is good, versus the National Security risk.

The CHAIRMAN. Thank you. Thank you.

Senator SULLIVAN. Thank you, Madam Chair. Senator Thune.

**STATEMENT OF HON. JOHN THUNE,
U.S. SENATOR FROM SOUTH DAKOTA**

Senator THUNE. Thank you, Madam Chair. Mr. Lewis, earlier this year, I reintroduced the bipartisan Network Security Trade Act to ensure that the security of our communications infrastructure is a clear trading objective of the United States.

And let me just say that I believe it is critical that our global communications infrastructure is not compromised by manufacturers like Huawei Technologies, which is supported by the Chinese Communist Party. Can you talk about the importance of this legislation so that we can address the barriers to the security of our communications networks and supply chains?

Mr. LEWIS. Thank you, Senator. I think the bill is very valuable because one thing I hope we have all learned is that the use of Chinese technology creates real risk of espionage. So the bill makes a valuable contribution. It is not just an American problem.

We have done well in this country and starting to remove, from all the big companies, Huawei technology. But now we need to think of the other places we connect to as well. So an important step is to continue to push on the need for secure communications technology. That is why I think the bill is invaluable. And I am glad you reintroduced it. Thank you.

Senator THUNE. Thank you. And this is a follow up and this is related to the pandemic. But that is obviously has accelerated the rise of the digital economy. And with more individuals and businesses online, our country has got to make smart investments in the technologies that are reshaping the way we live.

What steps do we need to take to ensure our communications supply chain can meet the needs of the future when we think about new technologies like 5G and A.I.? And is there a role for Government to play? And if so, you know, what is it to make sure that we lead to technological advancements and stay ahead of countries like China?

Mr. LEWIS. Thanks again, Senator. Sure, there is a number of areas where we could use a good collective approach with the private sector and Government. The first is in standards bodies. We

all know that. The U.S. is doing better in standards than you might think, but the Chinese are not giving up. Second, R&D and STEM. The companies tell me they have workforce shortages and so we can help with that.

Spectrum allocation, the U.S. has made good progress in moving spectrum to commercially—we are in a new kind of National Security contest and the old spectrum allocations might need to be reconsidered, but we have done OK at that. Finally, a larger business question. Building the infrastructure is good.

Making sure the infrastructure is secure is important. But how you use that infrastructure is also crucial. So we need to find ways to accelerate innovation in the use of 5G, and dare I say it 6G. Thank you.

Senator THUNE. Yes, let's hope so. Mr. Miller, in your testimony, you talk about the need for a strategic plan for implementing the numerous supply chain initiatives that are underway. What risks do we face if we don't have a coordinated approach to supply chain resiliency? And are there existing public-private initiatives reviewing supply chain risk that could serve as a model?

Mr. LEWIS. Thank you, Senator Thune. Yes, I mean, again, I think it has been a big theme of the hearing today about the need for a coordinated approach. You know, as I as I mentioned in my testimony, I think an excellent model is the Cyber Security and Infrastructure Security Agency led ICT Supply Chain Risk Management Task Force. You know, it is a—one of the best features of that task force is that although it is sponsored by CISA, it involves about a dozen Federal agencies and partners, including the Commerce Department. It includes experts and participation from across both the IT and communications sectors.

And it has really involved Government and industry rolling up their sleeves and, you know, working on developing real proactive solutions that could actually help address some of these—the variety of supply chain challenges. You know, and I would also say that one of the things that we have been working on most recently is, you know, trying to figure out how to make sure that the products are getting out into the supply chains themselves, into the bloodstream, if you will, and also specifically addressing the small and medium sized businesses who, you know, quite candidly comprise 90 percent or so of the supply chains.

And really trying to figure out how do we help those companies in particular.

Senator THUNE. Thank you. Madam Chair, my time has expired. I have a question which I can submit for the record for Mr. Aboulafia.

The CHAIRMAN. Go ahead, Senator Thune.

Senator THUNE. OK, well, let me just—you mentioned in your testimony, the aviation industry experiencing several recent disruptions stemming from the pandemic and geopolitical concerns and aircraft groundings. As the pandemic recedes across the world, what materials or components do you believe represent the biggest constraint on domestic aircraft manufacturing in coming years?

Mr. ABOULAFIA. Thanks for your question, Senator. I think there is a number of areas of concern. Frankly, labor wage inflation might be one of the biggest. One of the quirks of the commercial

industry is that we are effectively deflationary. That is to say, pricing for our finished systems have been declining in real terms for quite some time now, I am afraid. And that actually accelerated. The deflationary trend accelerated during the pandemic in an effort to stimulate demand.

So unless contracts for the supply chain allow for the appropriate path through mechanisms, I think we are going to be stuck between higher materials prices, higher energy prices, and most of all, I think higher labor prices.

But historically, just to get to the heart of your question, it is really the castings and forgings that have typically produced bottlenecks mostly made from more exotic metals and things like that. Some sort of turbine componentry and things along those lines.

Senator THUNE. OK, thank you. Well, it seems like—argue for our investment in more of those exotic metals in our own supply chain? Yes, alright. Thank you, Madam Chair. Thank you all.

The CHAIRMAN. Thank you, Senator Thune. I just have one last question. You know, we talked about, you know, some of the aspects on the adversarial side. What about on the allies side? Dr. Gereffi, you have written about this as a way from your research to prioritize things. What should we be doing to think about building alliances on supply chains? How should we be looking at that as a Government? And who in the Government should be doing that?

Mr. GEREFFI. A lot of people on the panel have already mentioned, for example, in semiconductors, how important the alliances are between the U.S. companies, Samsung, TSMC. I think getting the international companies investing in the U.S., as we now hope to see, is going to be very important. I think from the Government's point of view, I think the industry associations that are working with Government agencies are probably a good place to begin to encourage more of that collaboration.

But so I think there is collaboration among the big companies, and then there is also that collaboration between lead firms and their first tier smaller suppliers. And perhaps that is an area that has been less well developed, that we don't really see very far down those supply chains beyond the big companies. And that is maybe where these industries can get better routed in the U.S. and we could start to have that small business or medium-sized business development.

And that collaboration is probably very important. I think it is probably private sector led. Oftentimes there is going to be those top companies that are encouraging the small companies. But the U.S. Government as well, with its policies, can be encouraging the kind of investment at local levels that would help that

The CHAIRMAN. Anybody else on the ally front? Yes, Dr. Lewis or Mr. Miller.

Mr. LEWIS. Sure. Thank you. I see others want to speak too. The Tech and Trade Council was an important step. The Europeans really wanted it. It was their idea. And so they are looking for ways to partner with us. That is good. They are worried about, what they are afraid might be trade nationalism in the U.S. So Buy America is something that they react to.

We should be worried about some of tech governance initiatives. I think they say it is not aimed at American companies, but some days it sure looks that way. But the I just was at a meeting with one of the European Commissioners on this and there is a real desire to build partnership. There is not as much appreciation in Europe of the risk of China, but it is growing, as we heard. And so we are entering a long period of dialog that moves us in the right direction. Thank you.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. Thank you. I was—I will echo both the point about investment and actually attracting investment from partners and allies to the U.S. as one thing for sure, as well as the U.S. Trade and Technology Council. You know, one of the promising features of that, as Mr. Lewis indicated, is that, and I think it has already been announced that one of the things they are specifically forming a working group on is semiconductor and other strategic supply chains.

And then just a final note on the international front on this topic. You know, for the past two or 3 years now that there has been kind of the Prague principles and focus on 5G security, which has a significant number of supply chain components, and again, brings together several different U.S. partners and allies to focus on the security aspects of the supply chain issue.

The CHAIRMAN. Thank you. Mr. Taylor.

Mr. TAYLOR. Sure. And I think one other item, it sort of goes back to what Senator Scott said and even Senator Thune, but this investment in international business is coming here and establishing a footprint in our own American industries also.

I would ask the Commerce Department to take a strong look at revitalizing or re-supporting, whatever the word might be, the permitting processes. It is long. It is laborious. It is debilitating, and it really hinders greenfield production—a greenfield building growth or expansions or just additional lines for the processes and antiquated ways that we all have to go through for a permit to get that innovation started, get that factory started or additions to a factory started. So I would ask that that be looked at.

The CHAIRMAN. Thank you. Thank you very much. Well, this has been—did you have one last thing you want to say on this point, Mr. Gil?

Mr. GIL. Just 30 seconds that when we grow our investments like is being done with this piece of legislation, it really serves as a beacon for our allies to desire to partner with us much more strongly.

The CHAIRMAN. Thank you. I think that is a good summation to USICA and one of the reasons why we did it. This has been a great deep dive on the supply chain. Thank you all very much. Thank you for your expertise and for your knowledge about this. A lot of great information has come out of it. I definitely believe, as Mr. Aboulafia says, that we have to look at the supply chain in a more collaborative way. When I reflect back about what our discussion has been here, I keep thinking, what if we would have had a better partnership on that years ago? Would we be in the same situation we are in now with the semiconductor industry?

So we are trying to have more illumination about these sectors and how important they are not just from their technology perspective, but also what they mean for jobs and for our economy and certainly for National Security issues.

So thank you all very much. This hearing record will remain open for two weeks until July 29, and any Senator can submit questions for the record, if they do so by July 22. And we ask you to respond so that we can fill that record by the 29th of July. And with that, this concludes our hearing. Thanks. Thanks very much again.

[Whereupon, at 12:30 p.m., the hearing was adjourned.]

A P P E N D I X

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL TO
DR. GARY GEREFFI

Supply Chain Research and Mapping. In your testimony, you emphasized the need for tools such as value chain mapping and of efforts to build regional clusters or hubs, connected to other portions of the value chain.

Question 1. What role should value chain mapping at the Department of Commerce play in helping the United States predict and prepare not only for supply chain disruptions but also for emerging economic opportunities?

Answer. Value-chain mapping is a practical tool that requires us to link several kinds of economic and commercial statistics, including: data on international trade (imports and exports); national production statistics (output by firms producing goods and services in the U.S. market); industry statistics (using standardized and detailed industry classification schemes to indicate the economic activities of firms); and occupational and employment data (linked to companies and industries, located in particular U.S. states and zip codes). Each variable (trade, production, industry, occupation, location, etc.) has different classification systems used by the U.S. government, and harmonized codes used by multilateral agencies, like the United Nations Statistics Office or the World Trade Organization (WTO).

A significant, but manageable, challenge in value-chain mapping is *technical*—i.e., to develop “correspondence” indexes (or crosswalks) that link industry, occupation and trade classification systems at similar levels of detail.¹ Different parts of the U.S. government, such as the Department of Commerce (and the U.S. Census Bureau it houses) and the U.S. International Trade Commission (USITC), have data collection and analytical units that manage complex national economic databases on trade, production and employment, and much of this is publicly available (although not easy to manage without the statistical skills used in handling large databases).

Another problem for the Department of Commerce (or any other large U.S. government agency) is *institutional*—i.e., which unit in Commerce or elsewhere in the government would be best suited to incorporate value-chain mapping as part of its core mission? Answering this question would require conversations with various government units, possibly the International Trade Administration (ITA) and its related Bureaus of Industry and Analysis within the Department of Commerce, to find an appropriate fit for value-chain research.

In studies such as the Duke GVC Center project on “Manufacturing Climate Solutions” that focused on clean technologies and U.S. jobs, for each product analyzed (e.g., LED lighting, high-performance energy-efficient windows, and U.S. concentrating solar power technology), a value-chain diagram was created to illustrate the core technology and its constituent parts, a geographic map identified the main factories in the United States that supplied manufactured inputs for these products, and a table estimated the number of U.S. jobs associated with current and projected demand for each of these technologies.² The value-chain approach thus combines a variety of sources, including company websites and annual reports, interviews with company managers and industry experts, and other business sources.³

¹See U.S. Census Bureau, “Guidance for Industry and Occupation Data Users,” available at <https://www.census.gov/topics/employment/industry-occupation/guidance.html>.

²Gary Gereffi, Kristen Dubay, and Marcy Lowe, “Manufacturing climate solutions: Carbon-reducing technologies and U.S. jobs,” Duke CGGC, Durham, N.C., November 2008, available at https://gvcc.duke.edu/wp-content/uploads/greeneconomy_Full_report.pdf.

³For discussions and illustrations of the methodology involved in value-chain mapping, see Stacey Frederick, “Global value chain mapping,” in Stefano Ponte, Gary Gereffi, and Gale Raj-Reichert (eds.), *Handbook on Global Value Chains* (Edward Elgar Publishing, 2019), pp. 29–53; and Gary Gereffi and Karina Fernandez-Stark, “Global value chain analysis: A primer,” 2nd edition (Duke GVC Center, 2016), available at https://gvcc.duke.edu/wp-content/uploads/Duke_CGGC_Global_Value_Chain_GVC_Analysis_Primer_2nd_Ed_2016.pdf.

There are two related issues in high-quality value-chain studies: (1) the need for *supply-chain transparency* in analyzing the structure of U.S. and global industries; and (2) assessing *lead-firm strategies* to identify multiple pathways to innovation and commercial success among close competitors in the same industry. In terms of supply-chain transparency, many U.S. and other multinational corporations (MNCs) are becoming far more open about identifying the names and locations of the firms that make up their manufacturing supply chains. For example, Nike now publishes an interactive “manufacturing map” of where Nike products are made (<http://manufacturingmap.nikeinc.com/>) that includes the number of factories, countries and workers involved in making finished goods as well as material inputs. Patagonia is also a leader in mapping its supply chain footprint,⁴ and most large companies such as VF, H&M, Apple, and adidas publish lists of global suppliers. In addition, U.S. multinationals are collaborating more explicitly with academic researchers by sharing supply-chain data on overseas plants to assess whether factory monitoring improves labor conditions and economic performance.⁵

Just as the structure of supply-chains offers insights into the overseas performance of U.S. companies, comparisons of the global strategies of U.S., Asian and European MNCs competing head-to-head in the same industry tell us how and why top companies pursue distinct international production and sourcing strategies, and how current disruptions are likely to shape their future approaches to investment and innovation.⁶

Since good supply-chain research goes beyond a simple integration of publicly available statistics, it might be easier to launch a U.S. value-chain resiliency initiative as a targeted pilot project with a handful of priority U.S. industries or states willing to collaborate with the U.S. Department of Commerce or other research entities. Initially, a major objective of value-chain analysis at the government level would be to prove its usefulness in looking at specific industries that are vulnerable to supply-chain disruptions, such as the recent White House 100-day supply chain review report on four critical U.S. industries. Alternatively, value-chain studies on specific U.S. states can benchmark how they are doing in their priority industries and spot emerging opportunities, such as the North Carolina in the Global Economy project carried out at Duke University. Although many value-chain mapping studies can serve as guides, there is a pressing need for comprehensive new research given the manifold disruptions of the current era.

Question 2. How can investing in regional technology hubs support robust and resilient domestic chains?

Answer. Regional technology hubs bring together the entire local ecosystem needed for successful industrial development: technology and innovation opportunities provided by large firms; smaller providers of goods and services that occupy lower tiers in the supply chain; the educational and training inputs of faculty and graduates of research universities as well as community colleges; a local workforce trained to meet existing needs and that can expand as investments increase; and the regional political and business leadership required to address critical gaps or shortages and align stakeholders around a shared vision of the future.

The United States has many highly successful regional technology hubs that are specialized in established and emerging industries, such as Silicon Valley (information technology (IT)), Seattle (aerospace; software), Austin, TX (IT), Boston’s Route 128 (IT; defense), Pittsburgh (steel; biomedical), and others. However, significant signs of robust and resilient domestic supply chains are visible in a new generation of cities and regions that are modernizing traditional industries or promoting new sectors tied to the emerging digital economy. The Research Triangle region of North Carolina enjoys this kind of growth pattern, where a traditional industry like textiles for apparel or home furnishings has shifted to “technical textiles” used in the medical, defense and aerospace industries, and new digital-economy engineering

⁴Patagonia, “Working with Factories,” <https://www.patagonia.com/our-footprint/working-with-factories.html>; Patagonia, “Supply Chain Environmental Responsibility Program,” <https://www.patagonia.com/our-footprint/supply-chain-environmental-responsibility-program.html>.

⁵Richard M. Locke, Fei Qin, and Alberto Brause, “Does monitoring improve labor standards? Lessons from Nike,” *Industrial and Labor Relations Review* (61, 1) (2007): 3–31; Greg Distelhorst, Jens Hainmueller, and Richard M. Locke, “Does lean improve labor standards? Management and social performance in the Nike supply chain,” *Management Science* (63, 3) (2016), <https://doi.org/10.1287/mnsc.2015.2369>.

⁶Pavida Pananond, Gary Gereffi, and Torben Pedersen, “An integrative typology of global strategy and global value chains: The management and organization of cross-border activities,” *Global Strategy Journal* (10, 3) (2020): 421–443; Gary Gereffi, Hyun-Chin Lim, and Joonkoo Lee, “Trade policies, firm strategies, and adaptive configurations of global value chains,” *Journal of International Business Policy* (2021), <https://link.springer.com/article/10.1057/s42214-021-00102-z>.

hubs are being created with major investments from big companies like Apple, Google, IBM/Red Hat and Amazon to develop cloud and quantum computing, driverless vehicles, and big data analytics.

While numerous U.S. states can point to selected examples of regional technology hubs, a key goal of value-chain mapping is to permit a more rigorous identification of such opportunities by analyzing both existing industries and new investment opportunities for current firms in the region. The industry profiles of “bottom up” value chain analysis at the state level can inform prospective investors about the firms and economic activities already present in the region, as well as “value chain gaps” that new investors could fill to significantly increase the competitiveness of the region. State-level value chain analysis should do global benchmarking to identify production stages where global overcapacity or environmental constraints exist (e.g., mineral processing) as well as identify emerging opportunities and threats (e.g., artificial intelligence, the industrial Internet of things, and cyber-security).

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JACKY ROSEN TO
DR. GARY GEREFFI

Critical mineral supply chain. Nevada is home to dozens of critical mineral resources, including lithium, which is integral for battery technology in electric vehicles. In fact, Nevada has the only operating lithium mine in North America, as well as several proposed lithium projects and battery recycling companies. Despite our state’s leadership in this space, the United States relies on imports for a majority of the critical minerals necessary to our economic advancement and national security. In addition, our country has virtually no domestic processing capacity, so the lithium and other materials that we produce are shipped overseas for processing.

Question 1. As someone with a background in clean energy supply chains, can you discuss the economic benefits and potential job opportunities if we were to invest in critical mineral manufacturing and processing here in the U.S.? And how can we increase U.S. processing capacity for lithium and other critical minerals necessary for clean energy, both to bolster the supply chain and enhance our national security?

Answer. Thank you for this excellent question, Senator Rosen. It illustrates very well how the supply-chain approach is useful in looking at U.S. competitiveness from the bottom up—i.e., by analyzing U.S. industries from the perspective of the individual states where they are economically most significant.

Critical minerals supply chains, like other natural resource industries, have three main stages: (1) raw-material *extraction*; (2) the *processing* of natural resources; and (3) the downstream component and end-product *user industries* for these raw materials. The question you are posing is where Nevada (and the United States, more generally) fit within these three stages of the lithium industry value chain.

1. **Raw-material extraction**—A variety of countries are major global suppliers of critical mineral resources used in the production of advanced-battery technologies:
 - Lithium—Australia produces more than half the global total; Chile is second
 - Copper—Chile is the world’s largest producer; Peru is second
 - Nickel—Indonesia, Australia and Canada are among the top producers
 - Rare earth elements—China has about 60 percent of world output, followed by the United States (16 percent)⁷
2. **Lithium processing**—However, China dominates in the processing of all these raw materials, and in rare earth minerals, China accounted for 80 percent of global imports in 2019.⁸
3. **Main U.S. user industries for lithium**—Advanced batteries used for electric vehicles are among the most important product markets for processed lithium, but utility-scale lithium-ion batteries are also significant for the clean energy grid in the United States.

In terms of the critical minerals supply chain, a central question for the United States is where in the chain it can get the greatest payoff from additional investments and new technologies. Currently, there is global excess processing capacity for critical minerals in general, with both China and India expanding their processing capacity significantly since the 2000s. Because the prices for processed min-

⁷ <https://www.statista.com/statistics/270277/mining-of-rare-earths-by-country/>.

⁸ <https://www.cnbc.com/2021/04/17/the-new-us-plan-to-rival-chinas-dominance-in-rare-earth-metals.html>

erals are quite low and the negative environmental impact of refining and smelting activities tends to be very high, most raw material exporting countries use China for their processing.

What does this mean for Nevada, which has a significant share of U.S. lithium deposits and mining but no lithium-processing capacity? Given U.S. environmental regulations, probably it would only make sense to invest in major lithium-processing facilities in Nevada if companies could use advanced processing technologies that would sharply reduce the environmental impact of lithium processing; this is likely to be very costly unless the processing could be carried out on a large-scale basis within the U.S. market and beyond. The innovation opportunities for U.S. battery production and storage are probably much greater and more immediate, but this will also require further investments in advanced-battery technologies, as outlined in the White House *100-day supply chain review report*.

Domestic solar manufacturing. The solar industry employs 7,000 workers in Nevada, the most solar jobs per capita in the entire country. If we are to address the climate crisis and continue creating good-paying jobs in the renewable energy sector, we must have Federal policy that promotes the affordable deployment of solar projects. Unfortunately, the previous administration imposed costly Section 201 tariffs on imported solar panels and cells. These misguided tariffs have cost us an estimated 62,000 solar jobs across the U.S. and have not led to an increase in domestic solar manufacturing, which represents less than 10 percent of all solar jobs in the U.S. In fact, the United States currently has no meaningful production capacity for wafers, cells, solar glass, machine tools, and other system components.

We need to be investing in domestic solar manufacturing and reducing our reliance on imports, especially from countries and regions that rely on forced labor.

Question 2. Dr. Gereffi, how our country can increase our domestic renewable energy manufacturing capacity? And how can Congress support the solar industry to create manufacturing jobs here at home and bring down costs for end-users?

Answer. Senator Rosen, this is another very important supply-chain question focusing on one of Nevada’s critical industries, the manufacturing of solar panels. There are several supply-chain themes that are relevant to your question.

- (1) *The unintended (negative) consequences of U.S. trade restrictions*—I provided a few illustrations in my written testimony, but you offer a great example for solar panels where Section 201 import tariffs on solar panels and cells did not increase U.S. domestic manufacturing, and arguably led to U.S. solar job losses of 62,000 jobs.
- (2) *Residential solar versus utility-scale solar*—I would distinguish between these two segments of the U.S. renewable energy solar value chain, just as in lithium-ion batteries, there are distinct industry segments for electric vehicles versus utility-scale storage batteries. States like Nevada, Arizona and California are very important for the U.S. “concentrating solar power” supply chain, but their value for the U.S. economy is linked to the creation of national power distribution networks that reach the distant populations centers in the United States.⁹ Different technologies are involved in the manufacturing versus the distribution parts of the solar value chain.
- (3) *Where the jobs are: manufacturing versus installation*—It sounds like the 7,000 solar workers in Nevada are largely in solar panel manufacturing. However, in most solar markets, the largest number of jobs occur in installation. According to the U.S. *National Solar Jobs Census 2020*, there were just over 30,000 manufacturing jobs in solar but this was dwarfed by the 155,000 installation and development jobs in solar.¹⁰ Thus, domestic solar manufacturing and solar installation both have significant and complementary U.S. job creation potential, but the quantity, benefits and location of jobs will vary according to their position in the solar value chain. Each state should develop its strategy and industry development plan accordingly.

⁹See Chapter 4 in Gereffi, Dubay and Lowe, “Manufacturing climate solutions: Carbon-reducing technologies and U.S. jobs,” Duke CGGC, Durham, N.C., November 2008, available at https://gccc.duke.edu/wp-content/uploads/greeneconomy_Full_report.pdf.

¹⁰National Solar Jobs Census 2020, May 2021, p. 8; available at <https://www.seia.org/sites/default/files/2021-05/National-Solar-Jobs-Census-2020-FINAL.pdf>.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KYRSTEN SINEMA TO
DR. GARY GEREFFI

Role of Critical Minerals. To produce semiconductors and transmit electricity, the United States relies on critical minerals, many of which are mined outside of our Nation's borders. This poses a risk should our supply of critical minerals be disrupted by natural disasters or the actions of hostile actors in other nations.

Question 1. Please describe the importance of secure and reliable supply chains to our Nation's mineral and energy security. Can you describe how supply chain vulnerabilities have the potential to impact access to affordable energy and economic recovery goals?

Answer. For many decades, the United States has built its central approach to energy and mineral security around securing access to petroleum and fossil fuels that were heavily concentrated in regions characterized by intense geopolitical conflict (such as the Middle East) or political volatility and high inequality (Venezuela, Bolivia, Central Africa). The development of shale gas and extensive energy reserves within North America has greatly lessened the energy dependence of the United States on foreign oil, and the rapid expansion and lower costs of clean energy technologies (solar, wind, hydroelectric, etc.) has allowed the United States to make a strong transition to a clean energy future.

Supply chain vulnerabilities remain, especially as critical minerals and rare earth elements needed for essential intermediates like semiconductors and advanced batteries are concentrated in geopolitical adversaries like China or Russia. Two ways the United States can address these vulnerabilities are to diversify its sources of mineral and energy supply to trusted allies and strategic partners, and also to support sustainable sources of affordable energy in its domestic production as well as its purchasing contracts with international energy suppliers and collaborators in sustainable energy projects.

Question 2. How, if at all, do climate considerations factor into your analysis of developing a critical materials supply chain?

Answer. By all indications, climate change is occurring even more rapidly than most climate scientists expected. In North America, record heat waves, forest fires, and tropical storms are reaching unprecedented extremes, and the melting of polar ice and the breakup of enormous ice shelves in Greenland portend an even higher than expected sea level rise that could flood major coastal cities and agricultural deltas in the United States and many low-lying regions around the world (from northern Europe to South Asia).

As analyzed in the White House report on *Building Resilient Supply Chains* (June 2021), climate change underscores the centrality of strategic and critical minerals supply chains in two fundamental (and potentially cross-cutting) ways: (1) the performance of many environmentally friendly "green" technologies, such as electric vehicles, wind turbines, and advanced batteries to store and distribute energy from clean technologies, is more vital than ever to combat climate change; and (2) these same technologies are heavy users of critical mineral inputs (such as lithium, rare earth elements, and others) that are needed to make and operate the clean technologies that could help to attenuate the impact of climate change. Thus, making critical mineral supply chains more "resilient" is imperative in addressing this double challenge.

Pharmaceutical Supply Chain. In your testimony, you discussed how COVID-19 illustrated the supply chain vulnerabilities the United States faces in regards to medical supplies and pharmaceutical ingredients.

Question 3. How many pharmaceutical manufacturers do you estimate had their international operations curtailed as a result of the COVID-19 pandemic? What options were then available to American patients to obtain their prescriptions? Did prescription drug costs to patients increase as a result?

Answer. I have not seen any information that would allow me to estimate how many U.S. pharmaceutical companies had their international production operations curtailed due to COVID-19 or how much prescription drug prices to patients increased as a result. However, in the pharmaceutical industry chapter in the White House report of June 2021 on *Building Resilient Supply Chains*, there are concrete recommendations to lessen U.S. dependence on foreign nations for the supply of key essential medicines—both finished dosage forms (FDFs) and active pharmaceutical ingredients (APIs)—by creating investment and financial incentives to boost domestic production of selected products, and to promote international cooperation with allies and strategic partners to diversify U.S. sources of supply for these medicines.

Question 4. What steps could Congress take to encourage pharmaceutical companies to return their manufacturing operations to America and reduce their international supply chain vulnerabilities?

Answer. The White House's 100-day supply chain review report listed a variety of specific near-term and medium-term incentives to promote greater U.S. production and to develop new technologies to reduce costs and increase the resilience of U.S. and allied production (pp. 242–243). However, the report also stressed that intense cost pressures, especially on the mature U.S. generic drug market that accounts for 90 percent of all prescription medications filled but only 20 percent of total prescription drug spending in the United States, have not only driven pharmaceutical manufacturing overseas in pursuit of lower production costs, but also led to an intense concentration of the manufacturing and distribution of prescription drugs in the United States (pp 213, 226–228). This makes the survival of relatively small U.S. drug companies more difficult.

Question 5. Drug manufacturers were able to adjust to COVID–19 by implementing masking and social distancing procedures. What are the risks if a manufacturer's operations were halted for several months because of a natural disaster or security concerns? How quickly can manufacturers obtain additional capacity for their operations?

Answer. Factory closures or slowdowns because of COVID–19 have been happening across a large portion of U.S. industries in the manufacturing sector, even when safety measures have been introduced. The best way to mitigate this risk or more severe problems due to natural disasters is to diversify production by identifying actual or potential sources of supply in the event of significant supply-chain disruptions.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN HICKENLOOPER TO
DR. GARY GEREFFI

Supply Chains & Technology Advancement. Your testimony highlights the rapid pace technology advances increases the risk of “technological lock-in” for R&D-intensive sectors of the economy. As Chairman of the Subcommittee on Space & Science, I am monitoring how semiconductor shortages may impact mission timelines for Federal space programs or the commercial space sector.

Question 1. Could you discuss how technology-intensive sectors, such as space, can reduce their supply chain vulnerabilities once semiconductor production stabilizes?

Answer. Unfortunately, I do not have any information about the role of semiconductor shortages in relation to Federal space programs or the commercial space sector. However, in my written testimony, I note that recent research on “massive modularity” highlights significant vulnerabilities in the distributed international technology systems for an ubiquitous high-tech product like smartphones,¹¹ and thus potential cybersecurity risks and the nationality of lead firms and their suppliers can matter a great deal.

Supply Chains & Telecommunications Networks. Your testimony highlights the telecommunications sector as the largest end-market for semiconductors. Mobile networks require many components such as semiconductors, antennas, routers, hardware and software components. Within USICA, legislation I wrote with Ranking Member Wicker, the Telecommunications Supply Chain Diversity Promotion Act, was included to establish a testbed at NTIA to evaluate various interoperable network architectures and increase vendor diversity within our telecommunications supply chains.

Question 2. Could you discuss the importance of vendor diversity as a component of supply chain resiliency?

Answer. Senator Hickenlooper, vendor diversity indeed is a key component of supply chain resiliency for several reasons. First, we need more detailed and accurate supply-chain maps to indicate which companies are supplying components and other inputs at different tiers of complex supply chains in advanced-technology industries such as semiconductors, aerospace, and pharmaceuticals. We need to know not only

¹¹Eric Thun, Daria Taglioni, Timothy J. Sturgeon and Mark P. Dallas, “Why policy makers should pay attention to the concept of massive modularity: The example of the mobile telecom industry,” *Let's Talk Development*, World Bank blog, June 18, 2021, available at <https://blogs.worldbank.org/developmenttalk/why-policy-makers-should-pay-attention-concept-massive-modularity-example-mobile>; and Joonkoo Lee and Gary Gereffi, “Innovation, upgrading, and governance in cross-sectoral value chains: The case of smartphones,” *Industrial and Corporate Change* (2021), available at <https://academic.oup.com/icc/article/30/1/215/6215046?guestAccessKey=e382e42f-4a31-46f7-b144-636c78979d69>.

how many suppliers there are at crucial nodes in U.S. and global supply chains, but also their nationalities, their intellectual property rights status, and asset ownership, which is not currently possible with official economic statistics. For example, on May 7, 2021, the CEO of Pfizer, Albert Bourla, stated that the company's Covid-19 vaccine "requires 280 different materials and components that are sourced from 19 countries around the world."¹² This illustrates the magnitude of the problem. Without greater supply-chain transparency, the risks of future supply-chain disruptions increase.

Second, firms have developed several types of "switching strategies" to mitigate the risks of policy-related or other disruptions to their activities in global supply chains: (1) *production switching*—moving production to other countries not affected by policy restrictions or supply-side disruptions like natural disasters; (2) *supplier switching*—changing sourcing partners to circumvent restrictions (such as the U.S. ban against Huawei and its suppliers); and (3) *market switching*—the strategy of selling products in alternative countries not affected by restrictions.¹³ While these firm-level options are predictable, the ability to carry them out depends on the current organizational and geographic configuration of global supply chains, and frequently our information about these features of contemporary industries is inadequate or out of date.

Third, policy tools are in place to evaluate the impact of certain foreign direct investment (FDI) transactions on U.S. national security, such as the Committee on Foreign Investment in the United States (CFIUS), an interagency committee chaired by the Secretary of the Treasury authorized to review FDI transactions that produce or deal with inputs critical to U.S. supply chains. However, a former U.S. Under Secretary for Industry and Security who has been involved as a decision-maker in CFIUS deliberations cautions that not all FDI transactions or prospective foreign buyers involve the same risks, and thus advises to use this tool judiciously and "resist a reflexive, sweeping approach that could undermine long-term U.S. security interests."¹⁴

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL TO
DR. JAMES A. LEWIS

Preparing for Supply Chain Disruptions. In your testimony, you emphasized the need to strengthen the industrial analysis and support functions at the Department of Commerce. Impact Washington, the Manufacturing Extension Partnership (MEP) center in my state, helps small-and medium-sized manufacturers to better understand their supply chain vulnerabilities, to improve their cybersecurity posture, and to identify new opportunities, among other responsibilities.

Question 1. What role should supply chain mapping at the Department of Commerce play in helping the United States predict and prepare for supply chain disruptions, and what historical Commerce functions can be leveraged?

Answer. Commerce needs to start by identifying key technologies whose supply are vital for national security and economic health. Every shortage is not a strategic problem. It then needs to identify potential chokepoints in the supply of those technologies, which often turn out to be surprisingly fragile and dependent on only two or three producers. As part of this, it needs to consider how reliant these supply chains are to just-in-time production and how much has been stockpiled. The answers will point to potential vulnerabilities, since just-in-time and small stockpiles reduce resilience in supply.

Commerce used to have a "Technology Administration," headed by an Undersecretary. It needs to bring this back. Right now, the Commerce offices that have some insight into supply chain are scattered around the building and there are significant lacunae in their coverage, since the focus is often on export controls or trade promotion. The tech policy function will have to be rebuilt almost from scratch.

Question 2. In your view, how can additional resources at the Department of Commerce, including for cybersecurity support at the Manufacturing Extension Partner-

¹²Kevin Breuninger, "Pfizer CEO opposes U.S. call to wave Covid vaccine patents, cites manufacturing and safety issues," CNBC News, May 7, 2021, available at <https://www.cnbc.com/2021/05/07/pfizer-ceo-biden-backed-covid-vaccine-patent-waiver-will-cause-problems.html>.

¹³Gary Gereffi, Hyun-Chin Lim, and Joonkoo Lee, "Trade policies, firm strategies, and adaptive configurations of global value chains," *Journal of International Business Policy* (2021), <https://link.springer.com/article/10.1057/s42214-021-00102-z>.

¹⁴Mario Mancuso, "CFIUS and China in the post-COVID environment," *Columbia FDI Perspective*, No. 310, July 26, 2021, available at <https://cesi.columbia.edu/content/columbia-fdi-perspectives>.

ship program, help to prepare small-and medium-sized businesses for disruptions and bolster the Nation's supply chain resiliency?

Answer. Commerce can help small-and medium-sized businesses (SME) by reinforcing market mechanism for supply chain resilience. To use chips as an example, there are brokers in that market who know their segments and the state of supply better than anyone else. Commerce needs to find ways to take advantage of these deep pools of knowledge and identify if there are areas where this deep knowledge is lacking. Written surveys under the Defense Production Act are not adequate. Commerce can act as an intermediary to connect small-and medium-sized businesses to these pools of knowledge, and that means commerce must know the market and the players the same way an analyst on Wall Street knows them (and that means a lot of time on the phone, plant visits, etc.).

On cybersecurity, while it is not in the Committee's jurisdiction, the best way to help small-and medium-sized businesses is to connect them to DHS's Cybersecurity and Infrastructure Administration (CISA). Commerce does not have the expertise for this area and it would be redundant for it to develop it. The best support function might be to advise companies on foreign cybersecurity and privacy requirements that affect exports, particular the requirement of the European Union, where Commerce's ITA probably has expertise.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JACKY ROSEN TO
DR. JAMES A. LEWIS

Impact of semiconductor shortage on the tourism economy. The COVID-19 pandemic, which has created shifts in global demand, including a severe downturn in the travel and tourism industry, which in turn dramatically decreased demand for rental cars. Rental car companies sold off close to half of their fleets last year when travel halted, and are now struggling to restock fleets as auto manufacturers are idled by the global semiconductor shortage.

Now, as travel and tourism rebounds for places like Las Vegas, visitors are unable to find available rental cars or face extremely high prices. This directly impacts whether or not individuals and families choose to travel at all—particularly for outdoor recreation destinations in states like Nevada that can only be reached by car, even after arriving in the state by air.

The White House's 100-day Supply Chain Review recommends addressing such issues by building a diverse and accessible talent pipeline for jobs in the semiconductor industry through significant investments in the STEM talent pipeline.

Question 1. Dr. Lewis, could you please elaborate on the benefits of investments in the STEM talent pipeline to improve our domestic semiconductor capacity and discuss some ways in which Congress might support that effort?

Answer. Semiconductor manufacturing requires a high tech workforce. The American STEM workforce is strong, but there are persistent shortages in some areas. The U.S. has an advantage in that its universities remain the most attractive for STEM graduate education, but in many cases, the majority of students are fairing (often Chinese) because of the cost to American students. Increasing the number of American STEM students would benefit innovation and economic growth across the board.

The best way to build a STEM workforce in the U.S. is to provide students with financial incentives to get STEM degrees. The motto for this is "pay them and they will come." The need to create financial incentives to build the STEM workforce has been a consistent theme for more than a decade. The intent is to duplicate success that began in the Eisenhower administration with the 1958 National Defense Education Act, which created and sustained America's high -tech workforce for decades. Funding university research will also help, as graduate students from these programs will populate the high tech industry.

Supply chain risk management. Recent, unprecedented breaches have revealed the cyber risks to our information and communications supply chain. If a product could be compromised and go unnoticed for months, as in the case of the SolarWinds attack, how many more software supply chain compromises are out there at this very moment?

To address cyber risks to our supply chains, President Biden directed the Secretaries of Commerce and Homeland Security—through CISA—to submit a report on supply chains for critical sectors and subsectors of the information and communications technology industrial base within 100 days.

Question 2. How can the Department of Commerce better collaborate with CISA to track and resolve known cyber vulnerabilities in our information and communications technology supply chain before an attack takes place?

Answer. Collaboration between NIST and CISA is essential for better cybersecurity. NIST maintains the National Vulnerability Data Base. Legislation passed in November 2020 (the Internet of Things Cybersecurity Improvement Act) also requires it to work with the Department of Homeland Security to develop and publish guidelines on vulnerability disclosure and remediation for Federal IT systems. CISA has the authority to issue binding operational directives that require agencies to address vulnerabilities. . In combination, this can be effective. While this system works well, areas of improvement include timeliness, ensure broad dissemination, and improve the ability to integrate input on vulnerabilities from private sector researchers.

Question 3. And in your view, would supply chain risk management standards, like the one published by the Department of Commerce via NIST, have prevented the SolarWinds breach?

Answer. SolarWinds was the result of 1) hostile Russian action and 2) poor coding practices. A more assertive diplomatic policy is the best response to the first. Sanctions or petulant letters to the Kremlin are insufficient. The May 2021 Executive Order, which tasked NIST to develop standards for secure coding which would then become mandatory for software products and service sold to the Federal government, is the best answer to the second. Companies, often unwittingly, sell vulnerable IT products and mandatory standards can begin to change this.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. KYRSTEN SINEMA TO
DR. JAMES A. LEWIS

Federal Investment in Semiconductors. In your written testimony, you describe how other nations have subsidized their own domestic industries for decades, while the United States has not.

Question. Why is it important that Congress support domestic semiconductor manufacturing in the U.S. Innovation and Competition Act?

Answer. Companies make business decisions on where to locate or expand facilities, based on the cost of different locations and access to resources (like a skilled workforce or a good educational system). Semiconductor production provides real economic benefits to jurisdictions where it is located and semiconductors are a growth market that justify investment. Countries compete for a facility by offering tax breaks, educational support, infrastructure and land guarantees and other subsidies. They have assumed, correctly, that the net gain justifies the cost of these subsidies.

The United States still has a dominant position in the semiconductor industry when measured by overall market share, but not in all segments of it. It leads in design and in the production of semiconductor manufacturing equipment, but not in fabrication (fabs). This was not a concern until China became a hostile competitor. In his celebratory speech for the 100th anniversary of the founding of the Chinese Communist Party, Xi Jinping said China is “good at destroying the old world” and those who oppose it “will find their head broken and blood flowing against a great wall of steel built with the flesh and blood of more than 1.4 billion Chinese people!” Rhetorical flourishes to be sure, but a good indicator of China’s intent and the need to offset any potential vulnerability in the supply of this key technology. Additionally, many commentators have pointed to the strategic risk of depending on Taiwan as the primary source for advanced chip fabrication, given its proximity to China and China’s intent to do to Taiwan what it did to Hong Kong. All of this points to the need to incentivize an increased chip-making capacity in the United States.

Chip production in the U.S. has decline from 35 percent to 10 percent over two decades. The goal is to rebuild this share by having fabs locate in the United States. To do this, the U.S. will need to provide incentives if it is to compete against other countries who also want fabs on their territory. Arguments against subsidies are that they distort the market or that the semiconductor industry does not need funding. This does not recognize competition with China and the use of subsidies by many nations. There is fierce competition. These subsidies by other governments make it more expensive to build a fab in the U.S. than in other countries. A decision by Congress not to fully fund the semiconductor industry will keep the United States at a disadvantage and harm national security. Semiconductors are the foundational technology of the 21st century. They drive economic and military digi-

talization. The United States needs reliable and assured access to semiconductor and it can no longer safely rely on a supply chain connect to China.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. RAPHAEL WARNOCK TO
DR. JAMES A. LEWIS

Supply chain threats are not only a result of specific national security components built overseas, but also a result of the failure or inability for domestic industries here at home to grow. Just last year, Congress directed the Department of Defense to assess cybersecurity threats to the defense industrial base and the ability of the Department's industrial base and private sector partners to meet software development needs for our national security. I recently visited Project Synergy in Warner Robins, Georgia, a cutting-edge software laboratory built on a partnership between Robins Air Force Base's software depot maintenance and the regional Mercer College's engineering and computer science schools. One of their top requests was increased investment in STEM education and a strong workforce pipeline to ensure they can grow to meet their current needs and the threats of the future.

Question 1. What is the role of investments in domestic human capital, education, and workforce development as a component of supply chain resiliency—particularly as we invest in critical growth industries like cybersecurity and computing?

Answer. In 1983, Deng Xiaoping looked around China and found it lagging far behind in technology. To remedy this, he created programs to build the STEM workforce by subsidizing education and research. He knew that technological strength and innovation capabilities require a strong workforce. Deng was inspired in part by the US's National Defense Education Act (NDEA). This is ironic because in recent decades, the U.S. has seen the number of STEM student decline while China's continues to grow. We all know anecdotally of STEM programs at U.S. universities where foreign students make up the majority of a class. The ration of U.S. to foreign is moving in the wrong direction and support for STEM can change this. Regional and two-year colleges play an important part in this effort, since they are often best suited to building the technology workforce.

The easy fix to this is to spend on STEM education by subsidizing student tuition. A good motto is "if you pay them, they will come." A program focused on STEM and offering full or partial tuition coverage for students to obtain degrees in math, physics, material sciences, computing, and other related disciplines would increase the workforce. NDEA also supported the study of foreign languages, but a new effort should focus first on STEM.

Question 2. How can Congress support these efforts?

Answer. Congress can usefully support these efforts in two ways. The first, as noted above, involves subsidizing students to allow them to choose the school and the program. The second is more difficult, but the rate of increase in tuition far outpaces inflation. A badly designed tuition subsidy program could contribute to this, and it may be necessary to impose tuition caps or limitation on what courses will be supported, Congress can mandate attention to how to increase the productivity and rein in costs in higher education, but this is a long-term problem, and the immediate need is to increase the size of the STEM workforce

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. SHELLEY MOORE CAPITO TO
DR. JAMES A. LEWIS

Question. On June 16th, I wrote a letter to Federal Maritime Commission (FMC) Chairman Maffei regarding the ongoing shipping crisis. I appreciate Chairman Maffei's expeditious and thorough response to my letter and the FMC's commitment to doing whatever it can—within their jurisdiction—to address the issue.

In Chairman Maffei's response, he noted that most ocean containers and chassis are manufactured in China. It is only recently that other nations—like India, Vietnam, and Korea—are considering policies to develop or expand their manufacturing capabilities of intermodal equipment. You mention in your testimony that one of the U.S.'s advantages in securing a resilient supply chain are our allies.

In your opinion, what strategies should we take to support a multinational commercial innovation base?

Answer. Not all products made in China create security risks. To assess this, we might want to ask how easy it would be to duplicate the item if China blocked supply, whether there are movements in pricing that indicated intentional interference with a supply chain or predatory trade practices, and whether China's share of the market provides it with an opportunity such interference.

In many instances, manufacturing moved to China because of its low cost labor, government subsidies, and in some cases, the weak regulatory structure (as in environmental protections). Labor costs have risen in China, but as we discovered during the pandemic with personal protective equipment, a supply chain dominated by China creates security risks and raises issues with quality and reliability. Supply chain security requires that we ask in what industries do we need to reduce dependence on China and what can we continue to safely export or import from China (recognizing that this is a shrinking space).

We are not alone in having these concerns and a first step is to work with similarly inclined nations to respond to China's predatory trade practices. Low labor costs alone do not explain why industries moved to China, which has displayed a general disregard for its WTO commitments since it was admitted. Second, we need to invest domestically and find new ways to cooperate with security partners to accelerate the ability of private entrepreneurship to create new technologies.

In many ways, reducing reliance on supply chains that originate in China is inevitable. China is not interested in global supply chains, unless it can dominate them. To do this, it will use any means regardless of its WTO obligations. Distrust of China continues to grow in the U.S. and elsewhere. While price may dictate continued purchases from China, both trade and security policy may require limiting purchases from China. This will probably be incremental, first affecting with the most sensitive (from a security perspective) acquisitions. The issue for the U.S. is to identify where the security risk are low and continued reliance on China is appropriate. The best approach for contained would be to encourage other suppliers to enter the market and penalize China for predatory trade practices.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. MARIA CANTWELL TO
RICHARD ABOULAFIA

Aviation Workforce. Workforce shortages are known causes of supply chain disruptions. Maintaining a highly-skilled workforce in the multi-tiered aviation supply chain helps ensure that firms can meet future demand for valuable U.S. exports and compete with international firms. In your testimony, you indicated that market factors such as fuel, financing, and availability are creating the "perfect formula" for renewed large aircraft orders.

Question. After the COVID-19 pandemic caused smaller tier suppliers to close manufacturing facilities and consolidate their employees, do you think the aerospace manufacturing supply chain is prepared to meet demand? Would you recommend investing further in any existing Federal programs, such as the Department of Transportation's Aviation Workforce Development Grants, to strengthen the ability of the aviation sector to deter long-term risks of workforce shortages?

Answer. First, while I am still optimistic that the market for single-aisle jetliners is coming back, the arrival of the Covid Delta variant is clearly putting pressure on aviation recovery indicators. We could easily see a longer-than-expected slump in air travel demand, leading to a significantly delayed recovery in new aircraft demand, and in demand for maintenance, repair, and overhaul services for the existing fleet. This, in turn, puts pressure on suppliers, who were just starting to recover from the worst aviation market downturn in history.

But also importantly, many smaller U.S. aviation industry suppliers came through, and are still coming through, the crisis by reducing costs to the greatest extent possible. They did everything they could to raise money—selling assets, taking on debt, furloughing workers, cutting headcount, and of course reducing hiring to a bare minimum. Since this process is unfolding over at least two or three years, that represents a significant reduction in the number of new employees entering the industry.

In short, whether or not the market recovers, securing the next generation of aviation workers remains a key concern.

To me, workforce development and training grants represent the best use of government dollars to help the aviation industry compete in the long run. The Department of Transportation's Aviation Workforce Development Grants is a very strong program. Since funding for vocational training has fallen markedly over the past few decades, it would be good to see additional funding enacted to support vocational training institutions for a broad variety of aerospace functions (CNC operations, machining, Airframe & Powerplant mechanics, etc.). One option would be Federal matching grants to the states, educational institutions, community colleges, and other entities providing this training. These programs and initiatives will play a key role in the aviation industry supply base's future competitiveness and health.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL TO
WILLIAM "LEX" TAYLOR III

Supply Chain Resiliency. Other hearing witnesses noted the importance of promoting supply chain resiliency from the bottom up, with a focus on companies or groups of companies, universities, and government united by a common goal. By example, Washington state has cultivated technology and innovation clusters around the maritime, timber, and aerospace sectors.

Question 1. How can the Department of Commerce integrate smaller, innovative companies into its supply chain planning activities?

Answer. A suggestion for the Commerce Dept. is to direct NIST to give more focus toward supporting each State's industry association partnerships to more directly assist the small and medium companies to advance and increase their output to the supply chain. An example of this in Mississippi is the Manufacturing Extension Partnership (MEP) program administered by the Mississippi Manufacturers Association. The MEP is giving focused support to small manufacturers for services that they could ill afford from consulting firms.

The Dept. of Commerce should also work in conjunction with the EPA to streamline the permitting process for green field and additional floorspace expansion projects. For instance, develop a secure web portal to upload required documentation rather than letters, e-mails and faxes. This would allow for faster permit approvals from that one portal.

Question 2. What lessons can the Nation take from the private sector on building resilient supply chain infrastructure in a way that supports sustainable growth for small-to large-size suppliers?

Answer. The private sector generally will promote discounts or warranty extensions to entice their customers or prospective customers to increase business with them. Likewise, the government can do the same with tax incentives programs and liability protections to entice manufacturers to invest in America for job growth and facility expansion to improve the supply chain.

The private sector makes strategic plans for alternative supply in anticipating interruptions of their main supply sources. The government should do the same by not limiting strategic reserve contracts to union only shops or lowest price only contracts.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. SHELLEY MOORE CAPITO TO
WILLIAM "LEX" TAYLOR III

Question. Dr. Gereffi and Mr. Taylor, you both mentioned the need to be wary of unintended consequences before implementing policy. I agree and believe that our current market system has been relatively dynamic when addressing supply disruptions and pulling us out of the pandemic, especially when given additional flexibility from Federal regulations. Are there any consequences you believe Congress should be mindful of? What have been some examples of unintended consequences your companies has dealt with during the pandemic?

Answer. One of the biggest unintended consequences of government implementing policy on the current market system is on the procurement of steel. Within the last year, the average price of hot-rolled coil (HRC) has tripled from \$464/short ton to \$1,491/short ton. Spot hot-rolled coil prices has continued to rise as limited sales and offers pushed prices above \$1,800/short ton earlier this month. The Section 232 tariffs originally put in place to counter Chinese overcapacity of steel production but were implemented in a way that created numerous problems for U.S. manufacturers and disrupted North America's critical supply chains that are critical to our Nation's economic recovery from the COVID-19 pandemic. The Section 232 tariffs on steel have resulted in increased production costs, extended lead times, product scarcity, decreased exports, and workforce shortages that have become detrimental to domestic manufacturers and a boon to our foreign competitors.

Even with near record steel prices and diminished foreign competition, U.S. steel mills refuse to operate at full capacity, and recent consolidation within the industry has resulted in fewer domestic producers. Our national economic recovery depends on U.S. companies creating more family-sustaining jobs, not price gouging domestic steel consuming manufactures. Congress and the Administration need to remove the Section 232 tariffs on our trading partners and allies, and compel U.S. steel mills to bring more capacity online and hire more American workers.

One final example of unintended consequences is the government stipend to unemployment benefits. While giving much needed help to those individuals placed on layoff during the early uncertain days of the COVID pandemic; the lack of fore-

thought for what to do as the economy recovers has caused a lingering problem for employers to bring back on that labor force as their respective business recovers. This has greatly exacerbated the ability to bring the supply chain back on line.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JACKY ROSEN TO
DR. DARIO GIL

Impact of semiconductor shortage on the tourism economy. The COVID-19 pandemic has created shifts in global demand. This includes a severe downturn in the travel and tourism industry and a dramatic decrease in demand for rental cars. Rental car companies sold off close to half of their fleets last year when travel halted, and are now struggling to restock as auto manufacturers are idled by the global semiconductor shortage.

As a consequence, despite travel and tourism rebounding in places like Las Vegas, visitors are unable to find available rental cars or face extremely high prices. This directly impacts whether or not individuals and families choose to travel at all—particularly for outdoor recreation destinations in states like Nevada that can only be reached by car, even after arriving in the state by air.

The White House’s 100-day Supply Chain Review recommends addressing such issues by building a diverse and accessible talent pipeline for jobs in the semiconductor industry through significant investments in the STEM talent pipeline.

Question. The White House’s report also suggests that to rebuild our industrial base and hopefully prevent supply chain disruptions, like the semiconductor shortage, the Federal government should work with industry and labor to create and support registered apprenticeship programs and skilled workers. Dr. Gil, can you discuss ways in which Congress can help companies like IBM support workforce development?

Answer. Thank you for the question, Senator Rosen. Semiconductor supply chain disruptions will impact nearly 169 industries in the United States by year-end, including tourism and hospitality.¹ A lack of semiconductors has caused a shortage of point-of-sale machines in restaurants and bars, hobbling our post-pandemic jobs recovery.² Ultimately, semiconductor ecosystems are driven by the diverse and constantly evolving talents of American workers. We propose four ways for Congress to help IBM support workforce development:

1. Support the CHIPS Act and the creation of the National Semiconductor Technology Center (NSTC). The NSTC should be a force for inclusive, good-paying jobs across the United States. To this end, the NSTC should collaborate with universities, community colleges, workforce agencies, and the private sector to build skills pathways to jobs in the semiconductor industry that result in long-term outcomes for all Americans.
2. Increase funding for registered apprenticeships and reduce obstacles to the use of apprentices in Federal contracts. In order to proactively address skills gaps and support continued skills development among workers, IBM launched the New Collar Jobs program, which uses registered apprenticeship programs to create skills pathways for workers without advanced degrees.³ IBM has 25 registered apprenticeship roles in 16 states and 24 cities, and we have hired 500 apprenticeship graduates as full-time IBMers. IBM has partnered with the American Association of Community Colleges and the Department of Labor to launch the Expanding Community College Apprenticeships initiative, which aims to train an additional 16,000 apprentices over three years.
3. As it builds the NSTC, encourage the Department of Commerce to again convene stakeholders to resolve governance issues in the electronic exchange of credentials between educators and employers. Improving the technical infrastructure to better support the electronic exchange of education and skills-based credentials would significantly ease the management and exchange of these certifications, empower learners with trusted skills-based information, and align their skills to in-demand jobs. In 2020, IBM joined with other employers, education institutions—including community colleges—and education service organizations to demonstrate an education and employment record ex-

¹“The Semiconductor Shortage of 2021,” *Goldman Sachs*, March 17, 2021. <https://www.goldmansachs.com/insights/pages/the-semiconductor-shortage-of-2021.html>.

²“No Chips, No Tips: How the computer Chip Shortage threatens Thousands of Restaurant Service Jobs,” *The Washington Post*, June 11, 2021. <https://www.washingtonpost.com/business/2021/06/11/restaurant-workers-computer-chip-shortage/>.

³“IBM New Collar Programs,” IBM, <https://www.ibm.com/us-en/employment/newcollar/>.

change. The Department of Commerce played a critical convening role in that demonstration.

4. Modernize pathways to STEM fields. To maintain our global competitiveness, we must dramatically increase the number of individuals from underrepresented communities in STEM fields, as noted in the National Science Board's Vision 2030 report.⁴ IBM has committed to investing \$100 million in technology, assets, resources, and skills development through partnerships with historically black colleges and universities (HBCUs) through the IBM Skills Academy Academic Initiative. In addition, the IBM-HBCU Quantum Center includes twenty-three of the Nation's HBCUs.⁵ And IBM supports National Science Foundation (NSF) scholarships in baccalaureate education at Minority Serving Institutions (MSI) focused upon quantum science and applied quantum technologies.

But, while the private sector devotes significant funding to STEM education, we need to do more to collaboratively address urgent areas of need, share resources, and bring the combined weight of the government and industry together to ensure increased diversity in STEM fields. As a start, Congress could reform the Higher Education Act (HEA) including loosening Federal work study restrictions to accommodate off-campus work experience in the private sector; expanding Pell Grants to cover skills education for part-time students and mid-career professionals; and making career-oriented education beyond bachelor's and other traditional education degrees eligible for Federal student loans.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. KYRSTEN SINEMA TO
DR. DARIO GIL

Federal Investment in Semiconductors. The Senate passed the U.S. Innovation and Competition Act in June, which builds on the CHIPS for America Act by providing \$50 billion for American semiconductor manufacturing.

Question. How will this Federal funding for CHIPS Act grants support American semiconductor manufacturing and enable domestic manufacturers to develop state-of-the-art semiconductor technology?

Answer. Thank you for the question, Senator Sinema. To build semiconductor supply chain resilience and ensure that next-generation semiconductor breakthroughs occur in the United States, we must manufacture *and* invest in research and development. One cannot happen without the other. This requires a robust investment in the United States, and therefore we strongly support CHIPS Act funding for semiconductor manufacturing grants, as well as the creation of the National Semiconductor Technology Center (NSTC). Together, they address short-term supply chain challenges, and long-term research and development needs by leveraging existing semiconductor ecosystems.

As outlined in my written testimony, a well-structured and governed public-private NSTC could address immediate shortfalls by building on billions of dollars in previous and existing semiconductor infrastructure investments. In addition, the NSTC would promote collaboration between industry, academia, and government in advanced development, prototyping and packaging, and advanced manufacturing capabilities, serving as an important link between academic research, government R&D labs and programs, company specific R&D, and product manufacturing. Such an approach would help spur new capacity and job creation in America, enabling American innovators, big and small, to move semiconductor designs to any manufacturing plant. And it would provide needed flexibility in the United States manufacturing supply chain to support both government and commercial needs.

Furthermore, to deliver outcomes long into the future, the NSTC should leverage existing, proven ecosystems for semiconductor research and development with strong track records of leading-edge innovation. IBM has a track record of semiconductor breakthroughs: in May, we unveiled the world's first 2 nanometer chip, which could quadruple cell phone battery life, cut the carbon footprint of data centers, and drastically speed up a laptop's functions. This was achieved by IBM at the Albany Research Center, an existing multi-company semiconductor ecosystem with over 20 industry and university partners. Work on advanced photo-lithography capability including EUV (Extreme Ultra-Violet Lithography), advanced logic pathfinding, AI

⁴National Science Board Vision 2030," *National Science Board*, May 2020. <https://www.nsf.gov/nsb/publications/2020/nsb202015.pdf>.

⁵"The IBM-HBCU Quantum Center grows rapidly in scope," IBM, February 22, 2021. <https://www.ibm.com/blogs/research/2021/02/ibm-hbcu-quantum-center-expands>.

hardware research, and the development of new semiconductor materials is already underway at the Center, in New York. It offers an ideal environment from which to build and scale the NSTC. Fully funding the CHIPS Act, including the NSTC, will create a rising tide that will lift all boats.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JOHN HICKENLOOPER TO
DR. DARIO GIL

Tech Apprenticeships & Credentials. In your testimony you advocated for technical apprenticeships and credential systems in order to grow our high-tech workforce and support the semiconductor industry. As Governor of Colorado, we started the National Cybersecurity Center in Colorado Springs to provide students and local governments with hands-on cyber training and skills.

Question. What role should these programs play in supporting mid-career transitions and creating new professional pathways?

Answer. IBM supports the creation of multiple education and training pathways that lead to good jobs. The National Cybersecurity Center (NCC) in Colorado Springs provides in-demand cybersecurity skills and training. Graduates often enter local government, where they deploy their skills to protect highly sensitive information and systems. Educational pathways, such as those offered by the NCC, improve equity, jobs, and pay. Making them more widely available is an economic imperative that our country cannot afford to ignore. IBM urges three additional steps to support mid-career transitions and the creation of new professional pathways:

- 1) *Better connect pathways to existing education and training systems:* Nationally, only 13 percent of students who enrolled in community college in 2010 earned a bachelor's degree by 2016. In most states, reducing obstacles to transferring credits would significantly improve those outcomes while reducing taxpayer and student costs. An example of good practices in Colorado is Pikes Peak Community College (PPCC), which offers AAS and Certificates in Cyber Security. Transferring credits to the University of Colorado at Colorado Springs (UCCS) is possible and the courses that transfer from PPCC to UCCS are clearly defined.¹ PPCC and UCCS are to be commended on the clarity of their transfer pathway. Reducing obstacles to educational pathways could also bolster the value of NCC training.
- 2) *Use industry recognized certifications:* For example, NCC awards certifications to completers but may not award the most valuable industry recognized certifications in the Colorado employment marketplace. CIO Magazine lists 10 top IT certificates, including cybersecurity.² NCC should ensure that its training (and the certificates awarded) best align with the needs of the Colorado job market. IBM is working with employers on a Learning Credential Network to ease the management and exchange of these kinds of credentials—providing a secure and trusted source for all skills-based credentials.
- 3) *Increase apprenticeship funding:* Apprenticeships can be a valuable pathway to jobs for Colorado and NCC students and help create a more diverse workforce. In October 2017, IBM launched its first of a kind technology focused Department of Labor Registered Apprenticeship Program. The program grew nearly twice as fast as expected in its first year. IBM apprenticeships focus on building skills in rapidly growing fields, such as cybersecurity and cloud network management. This 12–24 month earn while you learn program pairs apprentices with an IBM mentor to work through real-world projects and provides traditional classroom learning in technology's fastest-growing fields. IBM is partnering with the American Council on Education (ACE) to increase transfer of credit from apprenticeship programs. To achieve this goal, ACE will evaluate selected apprenticeship programs for college credit and workplace competencies based on input from schools and employers. Higher education partner institutions will receive support to articulate the apprenticeship credits into degree programs.

¹ <https://transfer.uccs.edu/sites/g/files/kjihxj1551/files/inline-files/BC%20CSBA-Cyber%2021-22.pdf>

² <https://www.cio.com/article/3562331/top-15-it-certifications-in-demand-for-2021.html>

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. KYRSTEN SINEMA TO
JOHN S. MILLER

Federal Investment in Semiconductors. In your written testimony, you describe the importance of the \$50 billion authorized by the Senate in the CHIPS Act and funded in the U.S. Innovation and Competition Act for the semiconductor industry.

Question. In addition to direct investment, what other options would you recommend either the Commerce Department or Congress pursue to further increase the capacity of American semiconductor manufacturing?

Answer. Thank you for the question, it is an important one given the importance of U.S. semiconductor leadership to both economic competitiveness and national security, and also due to the reality that increasing domestic manufacturing capacity will take time. There are several options we recommend the Commerce Department and Congress pursue to address this issue.

First, it will be important to utilize tax policy to encourage and enable greater investment in the U.S. semiconductor ecosystem, such as through maintaining a competitive corporate tax environment, offering investment tax credits (ITCs) to further incentivize building new and modernizing existing semiconductor manufacturing facilities in the United States, and ensuring companies may continue to deduct research and development (R&D) expenses in the year incurred.

Second, the U.S. should enhance cooperation with global partners and allies to ensure stability of the global semiconductor supply chain by convening formal supply chain reviews and other efforts to minimize damaging interruptions. The U.S. should also deepen trade and investment relationships and address unintended trade barriers that restrict supply chain resilience by organizing tech-sector specific dialogues, increasing digital trade partnerships, enhancing regulatory compatibility, and reducing barriers to trade through increased bilateral, regional, and multilateral engagement with partner economies. The newly launched EU–U.S. Trade and Technology Council provides an excellent venue for pursuing international cooperation on semiconductor supply chain issues.

Third, the U.S. needs to strengthen public-private partnerships by convening industry and government experts to enable a holistic view of the semiconductor supply chain and risks, and utilize such partnerships to develop a coherent, streamlined, holistic, coordinated long-term approach to address ICT supply chain security.

Fourth, the U.S. should support semiconductor R&D through innovation-forward economic policies, such as those that open markets and minimize burdens on U.S. overseas sales to ensure continued robust R&D funding and market leadership.

Fifth, the U.S. should advance policies to ensure that America has the highly-skilled technology workforce necessary to support increased semiconductor manufacturing capacity, including providing funding for science, technology, engineering, and mathematics (STEM) and computer science education and advancing legislative proposals for immigration reforms.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. RAPHAEL WARNOCK TO
JOHN S. MILLER

Supply chain threats are not only a result of specific national security components built overseas, but also a result of the failure or inability for domestic industries here at home to grow. Just last year, Congress directed the Department of Defense to assess cybersecurity threats to the defense industrial base and the ability of the Department's industrial base and private sector partners to meet software development needs for our national security. I recently visited Project Synergy in Warner Robins, Georgia, a cutting-edge software laboratory built on a partnership between Robins Air Force Base's software depot maintenance and the regional Mercer College's engineering and computer science schools. One of their top requests was increased investment in STEM education and a strong workforce pipeline to ensure they can grow to meet their current needs and the threats of the future.

Question 1. What is the role of investments in domestic human capital, education, and workforce development as a component of supply chain resiliency—particularly as we invest in critical growth industries like cybersecurity and computing?

Answer. Addressing America's workforce shortage must be at the top of the list when tackling the cybersecurity and technology challenges this Nation faces. The global cybersecurity workforce shortage is particularly acute, and impacts companies and governments alike. Projections as of a few years ago estimated there would be approximately 3.5 million open cybersecurity jobs globally in 2021, with the United States accounting for roughly a half-million of those open positions. My guess is that the actual numbers today may well be higher.

Investment in education and training of the U.S. workforce is a part of the solution, and many ITI member companies partner with universities in support of science, technology, engineering, and mathematics (STEM) education initiatives. Additionally, the workforce shortage provides a good reminder of one of the reasons ITI has long advocated for a collaborative, public-private approach to resolving cybersecurity and supply chain challenges; the partnership model enables both government and industry to leverage shared cybersecurity resources they would otherwise not have access to.

Question 2. How can Congress support these efforts?

Answer. ITI and our member companies appreciate the U.S. Innovation and Competition Act's (USICA) sponsors for their attention to the workforce issue, by addressing STEM education which is foundational to training workers needed to enable the technologies of the future as well as the diversity pipeline. The United States operates at maximum global competitiveness when our workforce is both well-equipped in terms of both knowledge and skills and diverse. ITI is supportive of numerous pieces of legislation which, if passed, would promote cultivating a proficient workforce, including the Advanced Technological Manufacturing Act sponsored by Senators Cantwell and Wicker. Other legislation that ITI has been supportive of that address the workforce challenge include the Rural STEM Education Act sponsored by Senators Wicker, Rosen, Cornyn, and Hassan; and the and the Institutional Grants for New Infrastructure, Technology, and Education for (IGNITE) HBCU Excellence Act sponsored by Senators Coons and Scott.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. SHELLEY MOORE CAPITO TO JOHN S. MILLER

Question 1. I believe the significant investments and priorities that were included in the United States Innovation and Competition Act (USICA) will keep the United States competitive now and into the future. A critical component was the funding needed to implement provisions of the CHIPS Act. However, a number of these provisions may take years to implement and even longer to bear fruit. What are some short-term measures that should be taken to address the current semiconductor shortage? Can those measures be handled by the private sector or are there recommendations for the Department of Commerce in order to address the shortage?

Answer. Thank you for the question, it is an important one given both the significance of the semiconductor challenge facing the U.S., but also due to the reality that increasing domestic manufacturing capacity will take time.

First, it is important to identify opportunities to utilize tax policy in the near-term to encourage and enable greater investment in the U.S. semiconductor ecosystem, such as through maintaining a competitive corporate tax environment, offering investment tax credits (ITCs), and ensuring companies may continue to deduct research and development (R&D) expenses in the year incurred.

Second, the U.S. has the opportunity now to enhance cooperation with global partners and allies to ensure stability of the global semiconductor supply chain by convening formal supply chain reviews and other efforts to minimize damaging interruptions. Deepen trade and investment relationships and address unintended trade barriers that restrict supply chain resilience by organizing tech-sector specific dialogues, increasing digital trade partnerships, enhancing regulatory compatibility, and reducing barriers to trade through increased bilateral, regional, and multilateral engagement with partner economies.

Third, the private sector has significant expertise on supply chain management that can benefit U.S. government stakeholders including the Department of Commerce. The U.S. needs to strengthen public-private partnerships by convening industry and government experts to enable a holistic view of the semiconductor supply chain and risks, and utilize such partnership to develop a coherent, streamlined, holistic, coordinated long-term approach to address ICT supply chain security.

Question 2. I agree with the sentiments in your testimony about the inclusion of Regional Technology Hubs in the USICA. I believe that geographic diversity of supply chains are not only beneficial to producers, but especially important to the economic development of more rural communities. Could you elaborate on how supporting such hubs will support innovation, especially among smaller players?

Answer. ITI welcomes funding for the regional technology hubs to help increase the geographic diversity of supply chains across the U.S., and I appreciate your point that such hubs will also support innovation among smaller players, particularly as the presence of such hubs should help spur workforce development and attract the highly skilled workforce of the future to rural and underserved communities that smaller players will need to support innovation. Maintaining a trained

domestic workforce is key to ensuring a resilient semiconductor supply chain in the United States, and is a necessary precursor to ensure the talent is available to support the Regional Technology Hubs.

Policymakers should support significant funding for science, technology, engineering, and mathematics (STEM) and computer science education through these technology hubs, which should consist of technical training opportunities and new advanced hardware for teachers; expanded access to high-quality instructional materials and rigorous STEM and computer science coursework; hands-on practical experience for students; and effective regional partnerships. Moreover, policymakers must ensure that all students have access to high-caliber STEM and computer science education, including underrepresented minorities and girls.

Developing Regional Technology Hubs will also provide an additional strategic benefit for the United States: improving the resiliency of U.S. semiconductor and other supply chains. The ICT SCRM Task Force's study of the impacts from COVID-19 on ICT supply chains underscored the need for an approach to improving supply chain resiliency that was already underway over the last six years: diversifying supply chains to a broader array of locations and away from single source/single region suppliers. While the study was focused on the impacts of single source/single region suppliers outside the U.S., there are a variety of reasons why increasing the geographic diversity of supply chains within the U.S. can also improve resiliency, for example, by broadening supplier networks and lessening the overall potential impacts of natural disasters such as hurricanes, floods, and wildfires on manufacturing, logistics, transportation and other elements of supply chains.

Question 3. You mention in your testimony that the Department of Commerce should be asked which bureau, office, or entity is best equipped to coordinate supply chain resiliency strategies. In your opinion, which bureau, office, or entity should Commerce consider to be the lead?

Answer. What is more important than identifying which bureau, office or entity is designated as the lead is ensuring that whichever entity is so designated is fully resourced, equipped with a sound Commerce-wide strategy, and empowered to lead and coordinate on behalf of all Commerce Department entities to execute on that strategy. The Bureau of Industry and Security could potentially serve as the convening force to coordinate supply chain resiliency strategies and activities at Commerce, based on its recent track record of working closely with industry and demonstrated expertise in delivering the 100-day review report. However, it is important to point out that BIS did not execute that report alone, and worked with ITA and other entities within the Department of Commerce, and also that BIS has a substantial number of other priorities including in the expansive area of export controls.