HEARING ON U.S.-CHINA COMPETITION IN GLOBAL SUPPLY CHAINS

HEARING

BEFORE THE

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

ONE HUNDRED SEVENTEENTH CONGRESS
SECOND SESSION

THURSDAY, JUNE 9, 2022

Printed for use of the
United States-China Economic and Security Review Commission
Available via the World Wide Web: www.uscc.gov

UNITED STATES-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

WASHINGTON: 2022

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

ALEX WONG, *CHAIRMAN*
KIMBERLY T. GLAS, *VICE CHAIR*

Commissioners:

CAROLYN BARTHOLOMEW
BOB BOROCHOFF
ROBIN CLEVELAND
JEFFREY FIEDLER
AARON FRIEDBERG
HON. CARTE P. GOODWIN
JAMES MANN
RANDALL SCHRIVER
DEREK SCISSORS
MICHAEL R. WESSEL

The Commission was created on October 30, 2000 by the Floyd D. Spence National Defense Authorization Act of 2001, Pub. L. No. 106–398 (codified at 22 U.S.C. § 7002), as amended by: The Treasury and General Government Appropriations Act, 2002, Pub. L. No. 107–67 (Nov. 12, 2001) (regarding employment status of staff and changing annual report due date from March to June); The Consolidated Appropriations Resolution, 2003, Pub. L. No. 108–7 (Feb. 20, 2003) (regarding Commission name change, terms of Commissioners, and responsibilities of the Commission); The Science, State, Justice, Commerce, and Related Agencies Appropriations Act, 2006, Pub. L. No. 109–108 (Nov. 22, 2005) (regarding responsibilities of the Commission and applicability of FACA); The Consolidated Appropriations Act, 2008, Pub. L. No. 110–161 (Dec. 26, 2007) (regarding submission of accounting reports; printing and binding; compensation for the executive director; changing annual report due date from June to December; and travel by members of the Commission and its staff); The Carl Levin and Howard P. ''Buck'' McKeon National Defense Authorization Act for Fiscal Year 2015, Pub. L. No. 113–291 (Dec. 19, 2014) (regarding responsibilities of the Commission).

The Commission's full charter and statutory mandate are available online at: https://www.uscc.gov/charter.

CONTENTS

THURSDAY, JUNE 9, 2022

HEARING ON U.S.-CHINA COMPETITION IN GLOBAL SUPPLY CHAINS

Panel I: China's Position in Global Supply Chains

Panel II: U.S. Policies to Bolster Supply Chain Resilience

Administration Panel: Administration Views on Securing Defense-Critical Supply Chains

Panel III: Safeguarding U.S. Defense-Critical Supply Chains

QUESTIONS FOR THE RECORD

HEARING ON U.S.-CHINA COMPETITION IN GLOBAL SUPPLY CHAINS

THURSDAY, JUNE 9, 2022

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

Washington, D.C.

The Commission met in Room 430 of Dirksen Senate Office Building, Washington, DC and via videoconference at 9:30 a.m., Commissioner Bob Borochoff and Commissioner Carte Goodwin (Hearing Co-Chairs) presiding.

OPENING STATEMENT OF COMMISSIONER CARTE GOODWIN HEARING CO-CHAIR

COMMISSIONER GOODWIN: Good morning, and welcome all to the sixth hearing of the U.S.-China Economic and Security Review Commission's 2022 Annual Report cycle. I want to extend my appreciation to our witnesses for joining us today and for all the effort that they put into their testimony. We are certainly looking forward to the discussion.

China's emergence in manufacturing and international trade has resulted in serving a dominate role in global supply chains. As with much of China's economic rise, the Chinese Communist Party has sought to put its finger on the scale in multiple harmful ways through various subsidies, market access restrictions, and broader strategic moves designed to encourage the localization and concentration of global value chains and supply networks in mainland China. Indeed, today many of our most critical materials and consumer goods -- from pharmaceuticals, to rare earths, to smartphones and laptops -- are sourced almost exclusively from China.

Likewise, many other critical supply chains such as those for semiconductors run through East Asia. And China's centrality in this increasingly integrated region means that many of our supply networks are closely interconnected with China and Beijing's increasing aggressiveness and willingness to weaponize its economic position. This concentration of critical U.S. supply chains in and around China's borders presents growing risk to the United States.

Obviously, many in government industry today are increasingly prioritizing efforts to secure critical supply chains. As we'll hear today, gaining visibility into and a better understanding of these global supply chains is a necessary first step to building resilience. Part of this of course includes gaining a better understanding of the multitude of factors that contributed to the concentration of supply chains in East Asia.

In addition to certain structural features of China's economy and CCP policies, some western companies' short-term pursuit of lower cost and increased efficiencies has also encouraged production supply lines to migrate across the globe. Unfortunately, this shift has often come at the expense of security and economic concerns. And as the past two years have made us all painfully aware, complex and far flung supply chains can be highly vulnerable to disruption. And now with growing geopolitical threats from authoritarian countries, the U.S.

must act urgently to build resilience into our supply chain.

As other countries reconsider their own exposure to China's economy, CCP leaders are attaching increased importance to protecting their position in global supply chains. General Secretary Xi himself has stated that China's supply chains cannot be broken at critical moments. Our hearing today will evaluate CCP leader's strategy and tactics to strengthen supply chain security and assess their impact on the U.S. world economies. We are joined today by an impressive collection of witnesses, and we all look forward to hearing their recommendations.

I want to extend a special thanks to Assistant Secretary of Defense Deborah Rosenblum for her time later today. Her team, the Office of Industrial Base Policy, plays a crucial role in ensuring that the Defense Department has an industrial base and is always prepared to support its critical mission. I'd also like to extend my appreciation to the Senate Health, Education, Labor, and Pensions Committee for securing this room for our use today. Before turning to introduction of the witnesses, I want to turn the floor to my colleague and co-chair for this hearing, Commissioner Bob Borochoff.

PREPARED STATEMENT OF COMMISSIONER CARTE GOODWIN
HEARING CO-CHAIR

Hearing on "U.S.-China Competition in Global Supply Chains"

Opening Statement of Commissioner Carte Goodwin

June 9, 2022

Washington, DC

Good morning, and welcome to the sixth hearing of the U.S.-China Economic and Security Review Commission's 2022 Annual Report cycle. Thank you to our witnesses for joining us today and the effort they have put into their testimony. We are looking forward to the discussion.

China's emergence in manufacturing and international trade has resulted in it serving a dominant role in global supply chains. As with much of China's economic rise, the Chinese Communist Party has sought to put its finger on the scale in multiple harmful ways, through various subsidies, market access restrictions, and broader strategic moves designed to encourage the localization and concentration of global value chains and supply networks in mainland China. Today, many of our most critical materials and consumer goods—from pharmaceuticals, to rare earths, to smart phones and laptops—are sourced almost exclusively from China. Many other critical supply chains, such as those for semiconductors, run through East Asia. China's geographic centrality in an increasingly integrated East Asian region means many of these supply networks are closely interconnected with China. With Beijing's increasing aggressiveness and willingness to weaponize its economic position, concentration of critical U.S. supply chains in and around China's borders presents growing risk to the United States.

Many in government and industry are increasingly prioritizing efforts to secure critical supply chains. As we will hear today, gaining visibility into and understanding of global supply chains is the necessary first step to building resilience. Part of this includes gaining a better understanding of the multitude of factors that have contributed to the concentration of supply chains in East Asia. In addition to certain structural features of China's economy and CCP policies, western companies' short-term pursuit of lower costs and increased efficiencies has encouraged production and supply lines to migrate across the globe. Unfortunately, this shift has often come at the expense of national security and economic concerns and, as COVID has made us all painfully aware, complex and far-flung supply chains can be highly vulnerable to disruption. And now with the growing geopolitical threats from authoritarian countries, the United States must act urgently to build resilience into our supply chains.

As other countries reconsider their exposure to China's economy, CCP leaders are attaching increased importance to protecting their position in global supply chains. General Secretary Xi

Jinping himself has stated Chinese supply chains “cannot be broken at critical moments.” Our hearing today will evaluate CCP leaders’ strategy and tactics to strengthen supply chain security and assess their impact on the United States and world economies.

We are joined today by impressive group of witnesses, and I look forward to hearing their recommendations. I would like to especially thank Assistant Secretary of Defense Deborah Rosenblum for her time today. Her team, the Office of Industrial Base Policy, plays a crucial role in ensuring the Department of Defense has an industrial base that is always prepared to support its mission. I would also like to thank the Senate Health, Education, Labor, and Pensions Committee for securing this room for our use today.

I will now turn the floor over to my colleague and co-chair for this hearing, Commissioner Bob Borochoff.

OPENING STATEMENT OF COMMISSIONER BOB BOROCHOFF
HEARING CO-CHAIR

COMMISSIONER BOROCHOFF: Thank you very much. Good morning, everyone. Welcome to the sixth hearing of the U.S.-China Economic and Security Review Commission's 2022 Annual Report cycle. And I want to thank you again to our witnesses for joining us today and for their invaluable testimony.

This hearing comes at a pivotal moment as global supply chains continue to face disruptions and affect everything from parts for your dishwasher to microchips used to manufacture new automobiles to the military supply of anti-aircraft missiles. It's not a secret that American families and businesses are experiencing firsthand the consequences of a diminished manufacturing base of the United States which instead depends on foreign suppliers, including China for some of the most critical materials and parts. Globalization has lowered costs for consumers throughout sourcing production while also creating more complex and vulnerable supply chains that rely heavily on China.

China is now the world's largest manufacturer. And although some companies have relocated their supply lines to neighboring countries such as Vietnam, businesses are still lured to China by its robust and usually less expensive manufacturing ecosystem. The decrease in homeland manufacturing has diminished the opportunities for businesses, small and large, to innovate new products. And it's hurt the employment opportunities of Americans of all ages, from the apprentice to the semi-retired.

As I'm sure we have all experienced, the last several years of lockdowns, port closures, shipping delays have tested the resilience of our supply chains and revealed keen vulnerabilities in how we move goods from supplier to consumer. I personally have worked and owned restaurants and other small businesses for over four decades. And I have seen and personally experienced how crucial it is to have strong supply chains in place.

Restaurants are the second largest private employers in America. According to the National Restaurant Association's analysis of Bureau of Labor Statistics data, the restaurant industry currently employs 15 million Americans directly. And it represents 1 in 10 American workers.

Half of these businesses are family owned. And each and every one of them depends on regular and reliable shipments of supplies, paper goods, replacement parts, everything from air conditioners and fryers to cash registers and forks and knives. Virtually all businesses in America rely in some fashion, either directly or indirectly, on the ability to purchase goods and rely on prompt deliveries, be it by road, rail, sea, or air.

Importantly, overreliance on Chinese manufacturing presents serious national security concerns. For instance, China dominates portions of the supply chain for key materials in U.S. defense systems which we'll hear more about from our witnesses today. The U.S. defense industrial base plays a vital role in ensuring our military has everything it needs to be successful in wartime and prepared in peacetime and cannot afford to have weak supply chains or domestic capacity.

As the U.S. continues to respond to the current crisis in Ukraine, U.S. weapons stockpiles need thoughtful attention. A depleted stockpile in addition to the delayed delivery of defense system parts has serious effects on the military's operational readiness. The United States must restore its robust manufacturing base at home and judiciously coordinate with allies to build more diverse and secure supply chains.

I hope our hearing today can help us identify weaknesses in U.S. supply chains and determine the best approach for restoring U.S. domestic manufacturing capacity in the most important sectors. I too am excited and thankful to have the experts and distinguished representative of the Department of Defense appear before us today. Before we begin, I would like to remind you all that the testimonies and transcript from today's hearing will be posted on our website.

Please also mark your calendars for the Commission's upcoming hearing on U.S.-China relations in 2022 which will be on August 3rd. So we'll now begin today's hearing with our first panel which will examine China's position in global supply chains and China Committee Party leaders' views of supply chain security. Commissioner Goodwin?

PREPARED STATEMENT OF COMMISSIONER BOB BOROCHOFF
HEARING CO-CHAIR

Hearing on "U.S.-China Competition in Global Supply Chains"

Opening Statement of Commissioner Bob Borochoff

June 9, 2022

Washington, DC

Thank you, Commissioner Goodwin, and good morning everyone. Welcome to the sixth hearing of the U.S.-China Economic and Security Review Commission's 2022 Annual Report cycle. Thank you again to our witnesses for joining us today and for their invaluable testimony.

This hearing comes at a pivotal moment as global supply chains continue to face disruptions and effect everything from parts for your dishwasher, to microchips used to manufacture new automobiles, to our military's supply of anti-aircraft missiles. It's no secret that American families and businesses are experiencing firsthand the consequences of a diminished manufacturing base in the United States, which instead depends on foreign suppliers, including China, for some of the most critical materials and parts.

Globalization has lowered costs for consumers through outsourcing production, while also creating more complex and vulnerable supply chains that rely heavily on China. China is now the world's largest manufacturer and although some companies have relocated supply lines to neighboring countries such as Vietnam, businesses are still lured to China by its robust, and often less expensive, manufacturing ecosystem. The decrease in homeland manufacturing has diminished the opportunities for businesses, small and large, to innovate new products and has hurt the employment opportunities of Americans of all ages from the apprentice to the semi-retired. As I am sure we have all experienced, the last several years of lockdowns, port closures, and shipping delays have tested the resiliency of our supply chains and revealed keen vulnerabilities in how we move goods from supplier to consumer. I have worked in and owned restaurants and other small businesses for over four decades and have seen and personally experienced how crucial it is to have strong supply chains in place. Restaurants are the second largest private employers in America. According to the National Restaurant Association's analysis of Bureau of Labor Statistics data, the restaurant industry employs 15 million Americans directly, representing one in ten American workers. Half are family owned and each and every one depends on regular and reliable shipments of supplies, paper goods, and replacement parts for everything from air conditioners and fryers to cash registers and forks and knives. Virtually all businesses in America rely in some fashion either directly or indirectly on the ability to purchase goods, and rely on prompt deliveries be it by road, rail, sea, or air.

Importantly, overreliance on Chinese manufacturing presents serious national security concerns. For instance, China dominates portions of the supply chain for key materials used to build U.S. defense systems. This includes cast and forged products used in U.S. defense systems, which we will hear more about from our witnesses today. The U.S. defense industrial base plays a vital role in ensuring our military has everything it needs to be successful in wartime and prepared in peacetime and cannot afford to have weak supply chains or domestic capacity. As the U.S. continues to respond to the crisis in Ukraine, U.S. weapons stockpiles need thoughtful attention. A depleted stockpile, in addition to delayed delivery of defense system parts, has serious effects on the military's operational readiness.

The United States must restore its robust manufacturing base at home and judiciously coordinate with allies to build more diverse and secure supply chains. I hope our hearing today can help us identify weaknesses in U.S. supply chains and determine the best approach for restoring U.S. domestic manufacturing capacity in the most important sectors.

I, too, am excited and thankful to have the experts and distinguished representative of the Department of Defense appear before us today. Before we begin, I would like to remind you all that the testimonies and transcript from today's hearing will be posted on our website. Please also mark your calendars for the Commission's upcoming hearing on U.S.-China relations in 2022, which will be on August 3.

We'll now begin today's hearing with our first panel, which will examine China's position in global supply chains and Chinese Communist Party leaders' views of supply chain security.

PANEL I INTRODUCTION BY COMMISSIONER CARTE GOODWIN

COMMISSIONER GOODWIN: Thank you, Commissioner. As Commissioner Borochoff said, this first panel review is China's dominant position in global value chains and assesses the party's supply chain objectives.

We'll begin with Dr. David Bulman, the Jill McGovern and Steven Muller Assistant Professor of China Studies and International Affairs at the Johns Hopkins University School of Advanced International Studies.

Next, we'll hear from Dr. Willy Shih, the Robert and Jane Cizik Professor of Management Practice in Business Administration at Harvard Business School. And finally, we're pleased to welcome Dr. Mark Dallas, Associate Professor of Political Science and Director for Asian Studies at Union College, the International Affairs Fellow for Tenured International Relations Scholars at the Council on Foreign Relations.

Thank you all for your testimony and your presence here today, and the Commission is looking forward to your remarks. I remind you to try to keep your initial remarks to seven minutes. Dr. Bulman, we'll begin with you.

OPENING STATEMENT OF DAVID BULMAN, JILL MCGOVERN AND STEVEN MULLER ASSISTANT PROFESSOR OF CHINA STUDIES AND INTERNATIONAL AFFAIRS, JOHNS HOPKINS UNIVERSITY SCHOOL OF ADVANCED INTERNATIONAL STUDIES

DR. BULMAN: Thank you very much for that introduction and thank you to the Commission for inviting me to speak today. It's an honor to be here. My testimony explains China's global manufacturing dominance and supply chain integration through an analysis of the efficacy of China's industrial policies with specific attention to policy implementation by local governments.

Broadly, I argue that China's dominance in many global supply chains has been driven by comparative advantages and market liberalization rather than by intention industry policy. Industrial policy itself has limited effectiveness to the mismatched incentives between central policymakers and local implementers. The key policy recommendation arising from this analysis is actually that the U.S. should not base policy on overestimation of the supply chain threat from China.

Let me flesh out these points briefly with details, of course, available in the written testimony. Looking first at China's emergence as the world's largest manufacturer and exporter, I argue that China's integration into global supply chains prior to the financial crisis was enabled by a mix of serendipitous timing, East Asian geography, and most importantly, China's natural comparative advantages and trade and market liberalization, not by industrial policy. In terms of timing, China's entry into the global trading system in the 1980s coincided with a new wave of globalization enabled by the ICT revolution and declining transport costs.

China's geography also helped as East Asia led the way globally in terms of explicit support for developing regional value chains with low tariffs, intermediate goods, and also because of the extensive regional Chinese diaspora which drove early FDI into China. More importantly, China had the world's largest labor force. And this labor force was relatively well educated and healthy as a result of Mao-era policies, particularly compared with countries at China's level of per capita income.

Even more importantly, trade liberalization spurred market liberalization and unleashed massive productivity gains. China moved from an export plan to an open current account with policies encouraging foreign investment and export processing. These reforms and China's low-cost labor force along with competition between local government to attract investment paved the way for foreign firms to drive China's export explosion.

Foreign investment enterprises grew, account for 80 percent of China's processing trade and over 80 percent of China's high-tech exports. American firms were definitely a part of this, but they were not the key players. Trade liberalization's most important contribution was inducing competition that forced deep reforms to China's enterprise system.

Industrial sectors that liberalized furthest in terms of reduced tariffs were those that experienced the most subsequent private sector entry, SOE reform, and productivity gains. These factors drove China's rise as a global manufacturing powerhouse deeply integrated into global supply chains. But following the global financial crisis, Chinese policymakers became concerned that China was stuck in low value-added production and asymmetrically dependent on foreign technologies leading to an increasing emphasis on techno-industrial policy.

But although central industrial policy has become increasingly rigorous, mismatched local government incentives have often undermined implementation. China has a highly decentralized system. And most of the key elements of Chinese industrial policy are implemented locally, including preferential credit, below value land sales, government guidance fund investments, and direct subsidies.

But local officials have strong short-term growth incentives. And this is true even after recent cadre management reforms under Xi. These incentives are highly compatible with investments promotion and with attracting foreign firms, but they are less compatible with industrial policy that aims to boost long-term productivity growth.

Available academic evidence including my own research suggests that local investment patterns, firm subsidies, and R&D tax breaks are often misallocated and do not match central industrial policy goals. They instead tend to target large incumbent low productivity and often loss making firms, often state owned which might fail without such support. Yet China's industrial sector exhibit wide variation in terms of both central policy support and China's level of global supply chain centrality causing us to need to look at sectors individually.

And my piece leads to three key sectorial patterns that I think we can identify. The first pattern is supply chain dominance without central policy support based on China's comparative advantages and local competition. One perhaps surprising example is rare earth production which China has come to dominate as a consequence of local incentives for overproduction with limited environmental regulation and relatively high natural reserves.

Rare earth dominance emerged despite central policy which is generally sought to eliminate illegal production and reduce overcapacity. Recent efforts, in fact, to centralize control through new state enterprise management groups have coincided China's share of global production of rare earth falling from 98 percent to only 58 percent in the past decade.

The second pattern I identify is central industrial policy support without emerging supply chain dominance. And high-tech sectors with global incumbents, Chinese industrial policy has had quite underwhelming results. Semiconductors might be the prime example.

High-end chips have been consistently targeted by China's central policymakers and yet the sector continues to lag. Given local incentives to get money out the door fast, most semiconductor policy funding has targeted top first rather than long-term R&D. And in just the past three years, at least ten different local multi-billion-dollar chip projects have imploded, often with considerable evidence of fraud.

The third sectoral pattern are those cases where central policy support has indeed successfully helped China achieve supply chain dominance. China has had success particularly in new emerging industries with no dominant incumbents that have relatively low technological requirements and surging levels of demand. A good example here is high capacity batteries predominantly manufactured for use in electric vehicles.

Protectionist policies here have been important. But even more important are demand side policies supporting EVs, including consumer subsidies and government procurement. Yet even here, China's future success is not guaranteed. Subsidies have had to be absolutely massive in order to sustain demand. And China's all out approach based on this artificial demand has concentrated production in relatively low-tech batters that may soon be superseded by foreign firms.

So what policy recommendations arise from this analysis? The broadest recommendation is to not overestimate the threat. There may be very good reasons to engage in domestic industrial policy. But the threat from China should not be one for four broad reasons.

First, China's low-cost production benefits the U.S. leading to considerable welfare gains.

And even China's subsidization of emerging clean tech has served as a global public good. For instance, resulting in the cost of both solar and lithium-ion energy becoming cheaper than coal and gas.

Second, the biggest risk for America companies is losing China as an export market, not being denied Chinese inputs. Policies to seek to reduce economic interdependence work both ways and could lead to harmful retaliation. Third, China remains more vulnerable to U.S. economic coercion than vice versa, particularly in financial and high-tech fields.

China has become increasingly quick to use economic tools for political purposes but generally only does this when China is asymmetrically favored and the expected economic impacts are small. Fourth, changes in risk perceptions and rising costs in China given our shrinking workforce have already altered China's comparative advantages and encourage companies to move production away from China. And this is without any policy encouragement, and that trend is likely to continue.

Although policymakers should not overestimate the threat, in the written testimony, I also lay out three additional policies in the short and long term. First, where the U.S. depends on a single source for critical inputs, be that from China or elsewhere, U.S. policymakers should address key vulnerabilities through targeted support, potentially including efforts to spur domestic production, increase stockpiles, or design emergency diversion plans. This depends on the nature of the sector.

Second, the U.S. should pursue greater global trade integration and renewed efforts at WTO reform in order to incentivize Chinese adherence to international trade norms. And finally, the U.S. must maintain its own innovative edge which has been weakened by recent policies that make it more difficult for Chinese nationals to study and stay in the U.S. and policies that make Chinese scientists feel unwelcome. The U.S. needs to stay open to Chinese students and encourage these students to work in the U.S. after graduation. Thank you very much for the opportunity to testify. I look forward to all of your questions.

PREPARED STATEMENT OF DAVID BULMAN, JILL MCGOVERN AND STEVEN MULLER ASSISTANT PROFESSOR OF CHINA STUDIES AND INTERNATIONAL AFFAIRS, JOHNS HOPKINS UNIVERSITY SCHOOL OF ADVANCED INTERNATIONAL STUDIES

China's Position in Global Supply Chains: Understanding the Effectiveness of Industrial Policy

David J. Bulman

Johns Hopkins School of Advanced International Studies

Testimony presented to the U.S-China Economic and Security Review Commission

June 9, 2022

I. Introduction

China has become a central actor in global value chains (GVC), accounting for nearly 20% of global manufacturing trade and a far greater share of many intermediate GVC inputs that are essential for modern production. As China's position in global value chains has strengthened, so have concerns about America's domestic vulnerabilities.

The following testimony seeks to explain China's supply chain dominance through an understanding of the efficacy of China's industrial policies, with specific attention to policy implementation by local governments and firms themselves. Broadly, I argue that China's dominance in global supply chains has been driven by China's comparative advantages regarding size, geography, and human capital rather than by intentional industrial policy (Section II). Industrial policy, which has become increasingly important in the past 10-20 years in China, has had limited effectiveness due to mismatched incentives between central government policymakers and local government policy implementers (Section III). Yet in certain sectors, particularly emerging industries without global incumbents, Chinese policy has found more success. This variation in sectoral outcomes is explored through examples drawn from the Biden Administration's Executive Order 14017 exploring U.S. supply chain resilience, including rare earth elements, semiconductors, and high-capacity battery production (Section IV).

The testimony concludes with a set of policy recommendations for the U.S. government based on the preceding analysis (Section V). Most importantly, U.S. policymakers should not base policy on overestimation of the threat from China: China's low-cost production has benefits for the US; China remains more vulnerable to U.S. economic coercion than vice versa, and is thus unlikely to use supply chain disruptions for political gain; the biggest risk for American companies is losing China as an export market, *not* being denied Chinese inputs; and, most importantly, changes in risk perceptions and rising costs in China have already altered China's comparative advantage and encouraged companies to move production away from China without policy encouragement. Beyond this broad conclusion, however, U.S. policymakers should address emerging vulnerabilities through limited and highly targeted supply chain support; greater global trade integration and renewed efforts at WTO reform to pressure reforms to Chinese trade practices; and continued societal openness to ensure that China's best and brightest minds continue to study and work in the United States.

II. China's supply chain evolution

From 1978 until the global financial crisis in 2008-2009, China transitioned from a nearly autarkic country to the world's largest manufacturer and goods exporter. China's deep integration into global supply chains in this period was enabled by serendipitous *timing* given concurrent global developments, East Asian *geography*, natural *comparative advantage*, and *policy choices*, particularly trade and market liberalization. During this period, industrial policies to strengthen China's position in global supply chains were limited in scope and effectiveness.

Timing

China's entry into the global trading system from 1978 through 2008 coincided with a new wave of globalization and global value chain development driven by the information and communications technology (ICT) revolution and declining transportation costs. The ICT revolution significantly lowered costs of outsourcing and related services, including financial services, computer and information services, and other business services, which could increasingly be traded internationally. Technological developments in transportation led to lower costs for air and ocean shipping.[1] These declining costs helped to spur firm de-verticalization and outsourcing. Rather than fully integrated vertical firms, business shifted towards lead firms with core competencies, with production increasingly moving out-of-house in the 1980s and 1990s. Declining costs also led to a "death of distance." Previously, countries predominantly traded with their neighbors, e.g., intra-regional trade in Africa and the Middle East, or with large geographic players, e.g., the U.S. in Latin America and Russia in Eastern Europe, but lower costs and integrated value chains defied this "gravity"-based explanation for trade.

Based on these trends, goods trade in the 1980s and 1990s soared, outpacing global GDP growth two-fold. China was particularly well-positioned to capitalize on these trends given the concurrent launch of China's opening and reform period in 1978.

East Asian geography

China's centrality in an increasingly integrated East Asian region facilitated China's entry into global supply chains. East Asia has led the way globally in terms of explicit support for developing regional value chains, as trade policies have consistently ensured low tariffs on intermediate goods through a rapid increase in regional preferential trade agreements (PTA), which expanded from 3

[1] Hummels, D. 2007. "Transportation Costs and International Trade in the Second Era of Globalization." *Journal of Economic Perspectives* 21(3):131–54.

in 2000 to 37 a decade later, with a further 72 under negotiation.[2] China took full advantage of these PTAs, implementing 13 PTAs with 21 individual economies and negotiating at least 10 more, including the 16-member Regional Comprehensive Economic Partnership (RCEP). And GVC complementarities have been an important factor in determining China's choice of PTA partner.[3]

China's geographic centrality within Asia also played an important role given the extensive regional Chinese diaspora. Early foreign direct investment (FDI) into China in the 1980s and 1990s was driven by investment from Hong Kong, Taiwan, Singapore, and other Asian neighbors with large ethnic Chinese populations, constituting a "China circle." As industrial production in the East Asian "tigers" moved up the value chain, China became the natural destination for outsourcing given these language and cultural ties.[4] In this sense, much of China's rising GVC integration should be considered as relocated intra-Asian Asian trade. As one potential indication of this, the U.S. total goods trade deficit with Asia in 2000 was 2.6% of U.S. GDP, of which nearly 2 percentage points were accounted for by non-China Asia and less than 1 percentage point was accounted for by China; by 2016, the total U.S. goods trade deficit with Asia was 2.8% of U.S. GDP, but China accounted for nearly 2 percentage points of this deficit and non-China Asia accounted for less than 1 percentage point.

Comparative advantage: a relatively educated low-cost workforce

Centrality in East Asia only mattered given China's comparative advantages: most importantly, a large, relatively well-educated, and low-cost workforce. Mao era (1949-1976) policies, despite causing economic inefficiency and human disasters, also led to considerable increases in human capital: life expectancy rose from 40 years to 68 years and literacy rose from 10% to 90%, both well above other countries at China's level of per capita income, and the population itself grew from 540 million to nearly one billion.[5] Consequently, China entered the 1980s with a massive and relatively well-educated work force. Additionally, Mao policies restricting urbanization beginning in the late 1950s resulted in over 80% of the population remaining underemployed in rural areas, leading to a huge surplus rural labor population that could migrate for work to urban areas without driving up wage pressures.[6] Along with an urban workforce with higher levels of education, China thus had an ideal combination of supervisory manpower and a vast pool of

[2] Kimura, F., and A. Obashi. 2011. "Production Networks in East Asia: What We Know So Far." ADBI Working Paper 320, Asian Development Bank Institute; Escaith, H., and S. Inomata. 2013. "Geometry of Global Value Chains in East Asia: The Role of Industrial Networks and Trade Policies." In *Global Value Chains in a Changing World*, edited by D. Elms and P. Low, 135–57. Geneva: World Trade Organization.
[3] Cheng, D., X. Wang, Z. Xiao, and W. Yao. 2016. "How Does the Selection of FTA Partner(s) Matter in the Context of GVCs? The Experience of China." Working Paper, Fudan University, Shanghai.
[4] Naughton, B. 1997. *The China Circle: Economics and Electronics in the PRC, Taiwan, and Hong Kong*. Washington, DC: Brookings Institution Press
[5] Jowett, A. J. 1984. "The Growth of China's Population, 1949-1982 (With Special Reference to the Demographic Disaster of 1960-61)." *The Geographical Journal* 150(2): 155–70.
[6] China's "Lewis Turning Point"—the point at which surplus rural labor disappears and wage pressures start to grow more rapidly—did not occur until the past decade, although estimates of the exact transition timing vary.

unskilled workers. As a sign of the importance of low-cost labor, China's labor-intensive exports as a share of total exports rose from 37% in 1984 to 54% in 1994.[7]

In addition to China's well-educated yet cheap labor force, China's huge size and relatively well-developed infrastructure (see below) also provided firms with the option to relocate production within the country. This was particularly important given that GVC development and firm de-verticalization partially reshuffled global comparative advantages in trade, as GVCs required the capacity for inter-industry reallocation of inputs as well as the ability to support the operations of multinational firms.[8]

Policy choices: market liberalization and targeted support for export processing

Yet the single most important factor in China's global trade dominance has been the productivity gains enabled by state-owned enterprise (SOE) reform and private sector entry in the 1990s and 2000s, and this market liberalization was itself enabled by earlier trade liberalization. In this sense China's most important policy choices were to support market-driven growth.

On trade liberalization, in the 1980s China began to de-monopolize its Mao era foreign trade regime, under which the currency was entirely non-convertible, only 12 foreign trade corporations (FTC) were allowed to conduct cross-border trade, and an export plan covered all of China's exports. Gradually, ministries, local governments, and special economic zones were allowed to set up FTCs, and by the late 1990s China had granted direct export/import rights to 10,000 manufacturing companies.[9] By 1991, only 15% of exports were covered in the plan. And from a highly overvalued currency, China in the mid-1990s moved to a market-based currency convertible on the current account. At the time, China replaced non-tariff administrative barriers to trade with high tariffs, but over the course of the 1990s these high tariffs were reduced below the developing country average to pave the way for WTO liberalization.

Trade liberalization also included explicit policy choices to attract FDI and engage in export processing, but for the most part these policies were broad-based and not targeted at the development of specific industries. Policymakers established four SEZs in Guangdong and Fujian in 1979– enclaves that did not threaten China's system of domestic production—followed by 14 open cities in 1984 and a 1986 Coastal Development Plan with explicit support for export processing that brought SEZ-type policies to China's entire coastal region, with hundreds of millions of potential workers. Export processing was exempt from duties on imported inputs, providing an important cost advantage. And foreign invested enterprises (FIE) did not have to go

[7] Naughton, B. 1996. "China's Emergence and Prospects as a Trading Nation." Brookings Papers on Economic Activity, No. 2. Washington, DC.
[8] Amador, J. and S. Cabral. 2016. "Global Value Chains: A Survey of Drivers and Measures." *Journal of Economic Surveys*, 30: 278-301.
[9] See discussion in Naughton, B. 2018. *The Chinese Economy: Adaptations and Growth, Second Edition.* Cambridge, MA: MIT Press.

through FTCs to import, while also receiving special tax concessions. China's export processing trade subsequently reached as high as 56% of total exports by 1996.[10]

Beyond SEZs and export processing tax break policies—policies which China learned from Asia and the rest of the world—explicit attention to infrastructure development and to decentralization helped to attract FDI. China spent lavishly on infrastructure, including roads, railways, ports, and telecommunications; by the mid-2000s, despite remaining a lower middle income country, China's infrastructure stock was similar to advanced economies, and China's logistics performance rose well ahead of other middle income countries.[11] Part of this infrastructure performance was driven by competition between local governments to attract investment: in the 1980s, China developed a regionally decentralized form of authoritarianism in which local officials were incentivized to attract FDI to boost economic growth and thus their career prospects. Localities competed with each other by providing preferential policies including cheap land and tax breaks, and also by improving local institutions. This led to uncoordinated competition, as well as intra-national cross-border protectionism. But it also led to institutional improvements, as foreign firms were attracted to Chinese cities with more reliable contract enforcement and faster customs clearance.[12]

These policy reforms paved the way for foreign firms to help drive China's initial export explosion. The FIE share of exports rose from nothing in the late 1970s to 58% in 2005.[13] FIEs grew to account for 80% of processing trade and over 80% of China's high tech exports. American firms have been part of this process, but they have not been the key players, and their role has diminished in the past two decades. Although U.S. firms accounted for over 10% of China's inward FDI in 2000, this share has been below 2% since 2011,[14] partially due to the sectoral transformation away from manufacturing, whose share of manufacturing fell from 70% in 2005 to 25% in 2017, and partially because an increasing share of FDI is for domestic sales within China: domestic sales of FIEs surpassed export revenues in 2005 and were 2.7 times exports by 2013.[15]

FDI helped drive China's growth,[16] but trade liberalization's most important contribution was inducing international competition that forced deep reforms to China's enterprise system, enabling the entry of private sector firms and the closure of inefficient SOEs. During China's China's most rapid period of economic growth in the early 2000s, productivity gains across manufacturing sub-sectors were systematically correlated with levels of tariff reductions; sectors with greater tariff reduction experienced more private sector entry and greater competitive pressures that resulted in

[10] Ibid.

[11] Arvis, J.-F., M. Alina Mustra, J. Panzer, L. Ojala, and T. Naula. 2007. *Connecting to Compete 2007: Trade Logistics in the Global Economy--The Logistics Performance Index and Its Indicators.* Washington, DC: The World Bank.

[12] World Bank Group, IDE-JETRO, OECD, UIBE, and World Trade Organization. 2017. *Global Value Chain Development Report 2017: Measuring and Analyzing the Impact of GVCs on Economic Development*. Washington, DC: The World Bank.

[13] Lardy, N.R. 2014. *Markets over Mao: The Rise of Private Business in China*. Washington, DC: Peterson Institute for International Economics.

[14] Based on data from China Statistical Yearbooks, National Bureau of Statistics, various years.

[15] Enright, M.J. 2017. *Developing China: The Remarkable Impact of Foreign Direct Investment*. Abingdon and New York: Routledge.

[16] For a meta-analysis of FDI's contribution to Chinese growth, see: Gunby, P., Y.H. Jin, and W.R. Reed. 2017. "Did FDI Really Cause Chinese Economic Growth? A Meta-Analysis." *World Development* 90: 242-255.

improved SOE performance.[17] Trade liberalization also helped to improve China's institutions, as WTO accession spurred China to abolish, revise, or introduce more than 300 national laws and nearly 200,000 local regulations; such institutional reforms further helped to provide secure property rights for private and foreign firms. Consequently, in the late 1990s and early 2000s, SOEs shed approximately 40 million workers. SOEs accounted for over two-thirds of China's exports as late as 1995, but by 2016 accounted for only 10% of exports as the domestic private sector took off.[18]

III. The effectiveness of sector-specific industrial policy

The factors described above drove China's rise as a global manufacturing powerhouse deeply integrated into global supply chains. China went from autarky to the world's biggest exporter (2009), with a trade share of GDP over 65% in 2006, compared to 21% for the US.

But beginning in the mid-2000s and especially following the global financial crisis, Chinese policymakers became concerned that China was stuck in low-value-added production and subsequently devoted more explicit attention towards techno-industrial policy, including intentional positioning of China in GVCs with a focus on "indigenous innovation." Increasingly over the past decade, China's policymakers rolled out centrally-formulated industrial policies for industrial upgrading and reducing supply chain vulnerability. These policies included trade/investment restrictions, new tax policies and subsidies, direct investment through state-owned guidance funds, regulations and pricing support, ownership policies, and overseas acquisitions. And industrial policy formulation itself became increasingly standardized and rigorous.[19]

Yet mismatched local government and firm incentives and capabilities have often undermined implementation of these central industrial policies and investment plans. Although China's sector-specific industrial policies are often highlighted as effectively driving China's new technological innovation and GVC dominance, the actual efficacy of China's central industrial policy toolkit is determined by the incentives and capabilities of the local government officials who implement industrial policy. China has a five-tier administrative system—center, province, prefecture/city, county, and township—and is highly decentralized within this structure, with 85% of fiscal expenditure at the sub-national level. In a vast country with country-sized provinces, delegation to local officials is key, and in China local officials have high degrees of autonomy given that local enforcement agencies often lack autonomy from local leadership and information asymmetries between central and local governments make monitoring and evaluation of local enforcement practices challenging.

[17] Brandt, L., J.V. Biesebroeck, L.H. Wang, and Y.F. Zhang. 2017. "WTO Accession and Performance of Chinese Manufacturing Firms." *American Economic Review* 107(9): 2784-2820.
[18] Based on data from China Statistical Yearbooks, National Bureau of Statistics, various years.
[19] Chen, L. and B. Naughton. 2016. "An Institutionalized Policy-making Mechanism: China's Return to Techno-industrial Policy." *Research Policy* 45(10): 2138-2152.

Local officials thus implement industrial policies with considerable discretion, both as a consequence of *de jure* delegation of policymaking authority and *de facto* policy implementation autonomy. Locally-adapted industrial policies proliferate sub-nationally and define China's formal industrial policy landscape. With over 300 prefecture/city-level units and nearly 3000 county-level units, this is a very varied landscape. Additionally, Chinese policies are often based on broad central guidance with wide scope for local implementation, and industrial policy is no exception.[20] Most of the key elements of Chinese industrial policy are thus locally determined and implemented, including preferential credit, below-value land sale, government guidance fund investments, direct subsidies, and, to some extent, tax breaks.[21] The "central" share of investment itself declined from 13.3% in 2003 to 4.7% in 2015.[22]

Given local government discretion in industrial policy implementation, it is essential to understand local officials' incentives. China's local officials are upwardly accountable to superiors at the next administrative level who determine their career prospects—county officials are accountable to city officials, city officials to provincial officials, and provincial officials to central officials. This hierarchical principal-agent system relies on designing rules that align local incentives with central goals and priorities.

Two characteristics of this hierarchical cadre management system help to explain industrial policy implementation: simple targets (economic growth and social stability) and short tenures (generally less than three years). China's central priority has been economic development, proxied by GDP growth, and "tournament promotion competition" in which only local cadres who generate the best economic outcomes receive promotions, has successfully incentivized local leaders to promote growth.[23] This competition played a role in incentivizing local officials to compete for foreign and domestic investment as well as "local developmental state" type policies in which the government seeks to help firms grow.[24] Yet local officials must achieve growth while avoiding

[20] As documented by the "fragmented authoritarianism" literature, China's local authorities have a long history of "implementation bias" in a wide variety of policy areas. See: Lieberthal, K. G., and D.M. Lampton (Eds.). 1992. *Bureaucracy, politics, and decision making in post-Mao China*. Berkeley: University of California Press.

[21] A recent report estimates these industrial policy categories as a share of China's GDP: direct taxes/subsidies (0.8% of GDP), below market credit (0.5% of GDP), below-market land sales (0.3%), and state investment funds (0.1%). See: DiPippo, G., I. Mazzocco, and S. Kennedy. 2022. *Red Ink: Estimating Chinese Industrial Policy Spending in Comparative Perspective*. Washington, DC: Center for Strategic and International Studies. Regarding the role of local governments, local governments control land sales and help direct local credit. They are also responsible for over 80% of government guidance funds. See: Naughton, B. 2021. *The Rise of China's Industrial Policy, 1978 to 2020*. Universidad Nacional Autónoma de México.

[22] "Central" investment refers to investment by enterprises and administrative units subordinate to the CCP Central Committee, the National People's Congress, and the State Council. See: Holz, C.A. 2019. "Industrial Policies and the Changing Patterns of Investment in the Chinese Economy." *The China Journal* 81: 23-57.

[23] See: Li, H., and L. Zhou. 2005. "Political turnover and economic performance: the incentive role of personnel control in China." *Journal of Public Economics* 89: 1743–1762.

[24] 16 percent of private firms received government help securing loans, and 35 percent receive government help getting information. Cull, R., L. C. Xu, X. Yang, L. Zhou, and T. Zhu. 2017. "Market facilitation by local government and firm efficiency: Evidence from China." *Journal of Corporate Finance* 42: 460–480. See also: Bai, C.E., C.T. Hsieh, and Z.M. Song. 2020. "Special deals with Chinese characteristics." *NBER Macroeconomics Annual* 34: 341–379; Oi, J. C. 1992. "Fiscal reform and the economic foundations of local state corporatism in China." *World Politics* 45: 99–126.

social instability,[25] and they must achieve rapid short-term growth given short tenures: local leaders are generally appointed from other localities and only serve 2-3 year terms, on average.

These short-term growth incentives can result in suboptimal behavior from the central government's perspective. For instance, local officials may be incentivized to increase local debt to unsustainable levels, or to keep uncompetitive firms open in order to reduce unemployment, preventing creative destruction. This local government sub-optimal support may help to explain the rise of 'zombie firms,' those with consecutive years of losses and access to subsidized credit, which account for 15% of industrial firm credit.[26] Local officials may also choose to ignore or only partially implement central regulations that could undermine short-term growth, including environmental regulations or industrial capacity reductions. Incentives for close state-firm relations also lead to collusive state-business relations and corruption that result in misallocation of government support, with politically connected local firms receiving preferential treatment[27] and firms without connections resorting to bribery to receive these favors.[28]

The cadre management system may therefore face challenges in incentivizing local leaders to pursue industrial policy that aims to boost sustainable long-term productivity growth, and available evidence suggests poor local implementation of central industrial policies. Looking at six major central industrial policies, including the 12th and 13th Five-Year-Plans and Made in China 2025, Carsten Holz finds that these policies do not determine actual investment patterns in China: private entrepreneurship determines sectoral investment patterns rather than industrial policy, and the central government has very limited direct impact on investment.[29] Instead of targeting high-potential firms in targeted sectors, local officials may target politically connected firm or those whose closure would negatively affect short-term growth and thus promotion prospects. My own work with Xun Yan and Qiong Zhang uses a tax and subsidy database to show that financial support for firms has targeted low productivity, old, large, and loss-making firms rather than new, productive firms in emerging industries.[30] We show that these patterns are driven by local officials' career incentives—providing more subsidies and tax breaks to large loss-making firms helps city-level officials win promotions.

Poor implementation suggests that although government support may help individual firms, support as implemented also generates economy-wide market distortions that prevent creative

[25] In China, 'stability overrides everything' (稳定压倒一切) and preventing local social instability is therefore a 'veto target' (一票否决) that when triggered eliminates the possibility for promotion. See Edin, M. 2003. "State capacity and local agent control in China: CCP cadre management from a township perspective." *The China Quarterly* 173: 35–52.

[26] Lam, W.R., A. Schipke, Y. Tan, and Z. Tan. 2017. "Resolving China's zombies: Tackling debt and raising productivity." IMF Working Paper No. 17/266. Washington, DC: International Monetary Fund.

[27] Chen, T., and J.K. Kung. 2019. "Busting the 'princelings': The campaign against corruption in China's primary land market." *Quarterly Journal of Economics* 134: 185–226; Liu, N., L. Wang, and M. Zhang. 2013. "Corporate ownership, political connections and M&A: Empirical evidence from China." *Asian Economic Papers* 12(3): 41–57.

[28] Fang, H., Z. Li, N. Xu, and H. Yan. 2018. "In the shadows of the government: Relationship building during political turnovers." NBER Working Paper 25300. Cambridge, MA: National Bureau of Economic Research.

[29] Holz, "Industrial Policies"

[30] Bulman, D.J., X. Yan, and Q. Zhang. 2022. "Picking Losers: How Career Incentives Undermine Industrial Policy in Chinese Cities." *The Journal of Development Studies*.

destruction.[31] And indeed, our paper shows that these subsidies and tax breaks have large distorting effects: the more government financial support in a given city and sector, the lower productivity growth is and the fewer firms enter. In this sense, the rapid rise in local subsides in China may help to explain China's declining levels of firm entry and productivity.[32]

These findings help provide an understanding for the vast firm-level misallocation of innovation funding in China. Private and foreign firms are considerably more innovative than SOEs: for every 10 million RMB of firm-level R&D investment, private firms generate 6.5 patents, foreign firms generate 7.6 patents, and SOEs generate only 2.2 patents. And smaller firms are considerably more innovative than larger firms, regardless of ownership: the smallest quintile private sector firms produce 3.2 times as many patents per R&D expenditure than the largest quintile private sector firms; for SOEs, this ratio rises to 6.3 times.[33] Yet R&D subsidies and tax breaks predominantly target large firms, and particularly large SOEs,[34] likely for the same career-related reasons and political connection reasons discussed above.[35] This helps to explain massive misallocation of R&D spending,[36] along with firm incentives to take advantage of R&D tax breaks by artificially inflating actual R&D spending.[37]

Change under Xi?

Xi Jinping has attempted to change China's governance and cadre management over the past ten years, with explicit attention towards a move away from "GDP worship" as well as an anti-corruption campaign and environmental inspections to limit problems stemming from excessive local discretion. Institutional reforms have attempted to recentralize central authority by:

[31] Aghion, P., and P. Howitt. 1992. "A model of growth through creative destruction." *Econometrica* 60: 323–351.

[32] Brandt, L., J. Litwack, E. Mileva, L. Wang, Y. Zhang, and L. Zhao. 2020. "China's productivity slowdown and future growth potential." World Bank Policy Research Working Paper 9298. Washington, DC: World Bank Group; Tan, Y., Y. Huang, and W.T. Woo. 2016. "Zombie firms and the crowding-out of private investment in China." *Asian Economic Papers* 15(3): 32–55.

[33] Based on data in Wei, S.J., Z. Xie, and X.B. Zhang. 2017. "From 'Made in China' to 'Innovated in China': Necessity, Prospect, and Challenges." *Journal of Economic Perspectives* 31(1): 49-70.

[34] SOEs account for 10.9% of R&D expenditure but 21.5% of government R&D funding support. See: Liu, X.L., S..S. Serger, U. Tagscherer, and A.Y. Chang. 2017. "Beyond catch-up—can a new innovation policy help China overcome the middle income trap?" *Science and Public Policy* 44(5): 656–669.

[35] Cheng, Fan, Hoshi, and Hu find that China's innovation subsidies are targeted at politically connected firms, helping to explain why firms that receive these subsidies are not more productive or more profitable. See: Cheng, H., H.B. Fan, T. Hoshi, and D.Z. Hu. 2019. "Do Innovation Subsidies Make Chinese Firms More Innovative? Evidence from the China Employer Employee Survey." NBER Working Paper 25432. Cambridge, MA: National Bureau of Economic Research.

[36] Konig, Song, Storesletten, and Zilibotti find that less productive firms have too much R&D spending, while more productive firms do not have enough, and that if China allocated R&D spending efficiency to that of Taiwan, aggregate manufacturing productivity from 2001-2007 could have grown by up to one-half. See: König, K.D., K. Storesletten, Z. Song, and F. Zilibotti. 2020. "From Imitation to Innovation: Where Is All That Chinese R&D Going?" Cowles Foundation Discussion Papers 1.

[37] Chen, Liu. Suarez Serrato and Xu find that a large share of firms respond to R&D tax incentives by simply relabeling non-R&D expenditures as R&D expenses. See: Chen, Z., Z.K. Liu, J.C. Suárez Serrato, and D.Y. Xu. 2021. "Notching R&D Investment with Corporate Income Tax Cuts in China." *American Economic Review* 111(7): 2065-2100.

strengthening vertical supervision of subnational bureaucracies;[38] revising cadre appointment guidelines to put more emphasis on ideology and political loyalty;[39] emphasizing obedience to central party decisions;[40] and establishing a new National Supervisory Commission to investigate and monitor subnational officials' behavior.[41]

But while Xi has recentralized power, the effects on local governance and implementation are unclear. Indeed, there is emerging evidence that at the local level promotion processes are less transparent with fewer objective criteria and more influence of top party leaders, leading to more scope for clientelism.[42] Under Xi, term lengths for local leaders have shrunk even further, and there are also fewer local cadres with stronger intrinsic motivations and ties to their locality. In work with Kyle Jaros, I find that despite the appointment of many more "central" cadres to provincial leadership positions, local implementation of central policies remains problematic.[43] And although there is some evidence that the anti-corruption campaign has made local officials somewhat more responsive to central policy,[44] local officials in charge of allocating resources have increasingly shirked responsibility, leading to less local dynamism and slower economic growth.[45]

In sum, then, China has increasingly relied on sector-specific industrial policies, but these policies are predominantly implemented by local governments whose incentives are not aligned with the long-term growth objectives pursued by the center. These officials instead seek to maximize short term growth and minimize creative destruction and attendant unemployment, and Xi's institutional reforms have not altered this calculus. Consequently, industrial policy as implemented is much less effective than U.S. policymakers often assume. This is not to say that all of China's industrial policies fail, but rather that their efficacy and explanatory power regarding broader industrial and exporting trends in China is overstated.[46]

[38] See, for instance, the discussion of centralization in the environmental policy realm in Kostka, G., and J. Nahm. 2017. "Central–Local Relations: Recentralization and Environmental Governance in China." *The China Quarterly* 231: 567-582.

[39] Xinhua. 2019. 中共中央印发《党政领导干部选拔任用工作条例》. March 17. Accessed June 2, 2022: http://www.xinhuanet.com/politics/2019-03/17/c_1124245012.htm.

[40] Li, L. 2019. "Politics of Anticorruption in China: Paradigm Change of the Party's Disciplinary Regime 2012–2017." *Journal of Contemporary China* 28(115): pp. 47-63.

[41] Ibid.

[42] Doyon, J. 2018. "Clientelism by Design: Personnel Politics under Xi Jinping." *Journal of Current Chinese Affairs* 47(3): 87-110.

[43] Bulman, D.J., and K.A. Jaros. 2021. "Localism in Retreat? Central-Provincial Relations in the Xi Jinping Era." *Journal of Contemporary China* 30(131): 697-716,

[44] For instance, Fang, Lerner, Wu, and Zhang find that R&D subsidies become better targeted after removal of government innovation officials following anti-corruption investigations. See: Fang, L.H., J. Lerner, C.P. Wu, and Q. Zhang. 2018. "Corruption, Government Subsidies, and Innovation: Evidence from China." NBER Working Paper No. w25098.

[45] For instance, a 2015 survey by the China Executive Leadership Academy in Shanghai found that 62% of leading cadres attributed the problem of "official neglect of duties" (为官不为) to fear of being held liable for problems, while 42% blamed strict discipline with unclear "red lines." For the anti-corruption campaign's negative growth effect, see: Qu, G.J., K. Sylwester, and F. Wang. 2018. "Anticorruption and growth: Evidence from China." *European Journal of Political Economy* 55: 373-390.

[46] For instance, the relocation of component manufacturing to China itself—imports of components as a share of assembled products fell from 90% in 2005 to 60% in 2017—is more of a consequence of domestic strength in

IV. Sectoral variation

The previous sections highlight that (1) in general terms, China's supply chain dominance has arisen from natural comparative advantages; (2) China's policymakers have nevertheless employed targeted industrial policies to achieve dominance or reduce vulnerability in specific sectors; and (3) these targeted measures have only been partially effective given implementation challenges. Consequently, industrial sectors exhibit wide variation in terms of both central policy support and China's level of global supply chain centrality/dominance. These two dimensions combine to create a 2x2 matrix, seen in Table 1 below.

Table 1. China's central industrial policy support and supply chain dominance

		Central industrial policy support	
		Low	*High*
Supply chain dominance	*High*	Pattern 1: Comparative advantage *Examples: ITC, rare earth elements, textiles*	Pattern 2: Emerging low/medium-tech industries *Examples: solar cells, high-capacity batteries*
	Low	Not applicable	Pattern 3: Incumbent high-tech industries *Examples: semiconductors, passenger aircraft*

The following three subsections look at the three key patterns identified in Table 1, taking as examples three of the four sectors highlighted in the Biden Administration's Executive Order 14017 on building resilient supply chains: rare earth elements (REE) as an example of supply chain dominance *without* central policy support; high-capacity batteries as an example of supply chain dominance *with* central policy support; and semiconductors as an example of supply chain weakness *despite* central policy support. I ignore sectors with neither policy support nor market dominance.

manufacturing than targeted industrial policy. Similarly, the decline in FIE share of domestic manufacturing has more to do with domestic private sector growth than policies that harm foreign enterprise or prevent FDI.

Pattern 1. Supply chain dominance without central policy support (example: rare earth elements)

As highlighted above, China's trade liberalization and broad market liberalization along with natural comparative advantages including a well-educated and low-cost labor force were the most important factors behind China's emergence as the world's largest manufacturer and a central hub in global value chains. Consequently, China has come to dominate many manufacturing sectors without targeted industrial policies.

One perhaps surprising example of a sector that China has come to dominate without effective central support is rare earth elements (REE) mining and production. E.O. 14017 directed the government to focus on REE given their centrality to modern manufacturing and the fact that China controlled 55% of REE mining capacity in 2020 and 85% of refining.[47] Yet although the E.O. 14017 review concludes that China's non-market activities "contributed to the erosion and then elimination of U.S. production in the global market," the cited policies—a 2003 acquisition by a Chinese-invested conglomerate of a loss-making NdFeB magnet producer and VAT rebates for rare earth exports beginning in 1985—had little to do with China's actual dominance.

Instead, China's REE dominance should be seen as a consequence of local incentives for overproduction with limited environmental regulation and relatively high REE reserves;[48] REE dominance emerged *despite* central policy, which has sought to reduce local overcapacity and improve environmental regulation implementation. And while China was building capacity in the 1980s and 1990s, advanced economies were shutting down polluting mines.[49]

REE mining and production took off in the 1980s and 1990s based on proliferation of dispersed local mines and illegal production that took advantage of rising profits. These firms and local governments did not internalize environmental costs, with deleterious results.[50] As early as the 1990s, central policy makers attempted to shut down illegal mines and limit environmental damage, but failed to gain control.[51] Failure led to a system of export quotas in 1999, followed by production quotas and new taxes, all attempting to rein in local production, but these central measures had the unintended consequence of incentivizing *more* illegal production, as only illegal producers could avoid taxes and the quota system.[52] Throughout this period, local governments cooperated with illegal REE mines to support local employment and growth.[53] Consequently,

[47] The White House. 2021. *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth.* 100-Day Reviews under Executive Order 14017. Accessed June 2, 2022: https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.
[48] According to the U.S. Geological Survey, China's REE reserves are approximately 44 million tons, accounting for 37% of world reserves.
[49] Shen, Y., R. Moomy, and R.G. Eggert. 2020. "China's public policies toward rare earths, 1975–2018." *Mineral Economics* 33: 127–151.
[50] Yang, X.J., A. Lin, X.L. Li, Y. Wu, W. Zhou, and Z. Chen. 2013. "China's ion-adsorption rare earth resources, mining consequences and preservation." *Environmental Development* 8:131–136.
[51] Shen, Moomy, and Eggert, "China's public policies toward rare earths"
[52] Ibid.
[53] Packey, D.J., and D. Kingsnorth. 2016. "The impact of unregulated ionic clay rare earth mining in China." *Resources Policy* 48:112–116.

illegal REE mining has been rampant, with estimates ranging from 30% of all production during 2005-2012 to 50% after 2017, implying a continued failure of central efforts to halt illegal local production, even in recent years. [54]

This is not to say that China has not since attempted to re-assert central control to make REE a more centrally-planned industry and potential coercive foreign policy tool. In 2010, China's use of quotas led to sharp export reductions at a time of political conflict with Japan, and China planning agency suggested China could use REE quotas for leverage in the U.S.-China trade war.[55] In 2016, China consolidated rare earth production into six large SOE groups in an effort to make production quotas more binding,[56] and in late 2021 China announced the creation of a new REE SOE (China Rare Earth Group).[57] But these measures have had limited—and often unintended—effects. For instance, when quotas were limited in 2010, domestic REE prices shot up 10-fold, leading to both more imports in the short-term and more incentives for illegal production in the medium-term.[58] And central consolidation and industrial policies over the past decade have coincided with China having *less* control over global REE production: China's share of world REE mine production fell from 98% in 2010 to 58% in 2020 as other countries increased production.[59]

Pattern 2. Supply chain dominance with central policy support (example: high-capacity batteries)

Recent central policy failure in the REE sector does not imply complete impotence of central industrial policy, but suggests that such industrial policy may require certain conditions to succeed. When central goals (e.g., limiting environmental damage and curbing illegal production) contradict local incentives for rapid short-term growth, these central policies are likely to fail. In the case of emerging industries with no dominant incumbent domestic or foreign players, broad demand-side policies and local protectionism have proven to be more aligned with local incentives, making them more effective.

China's industrial policies have sought to identify emerging industries that will become important, with attention to "alternative routes" and "overtaking on a curve" (弯道超车), and China has had particular success in fields with a combination of low/medium technological requirements, surging demand, and extensive labor needs. Solar cell production constituted one early case of successful

[54] See discussion in Shen, Moomy, and Eggert, "China's public policies toward rare earths."
[55] Zheng, S. 2019. "China will not rule out using rare earth exports as leverage in trade war with US." *South China Morning Post*. 29 May. Accessed June 2, 2022: https://www.scmp.com/news/china/diplomacy/article/3012199/china-will-not-rule-out-using-rare-earth-exports-leverage.
[56] Consolidation had been proposed since 2002, but local governments resisted handing control of a profitable industry to SOEs outside of their province. See Yang, D. 2015. *中国稀土产业发展与政策研究 [Research on China's rare earth industry development and policies]*. Beijing: China Social Sciences Publishing House.
[57] Zhai, K. 2021. "China Set to Create New State-Owned Rare-Earths Giant." *The Wall Street Journal*. 3 December. Accessed June 2, 2022: https://www.wsj.com/articles/china-set-to-create-new-state-owned-rare-earths-giant-11638545586.
[58] Yu, S., and T. Mitchell. 2020. "State interference threatens China's control of rare earth production." *Financial Times*. 28 October. Accessed June 2, 2022: https://www.ft.com/content/b13a3c4e-e80b-4a5c-aa6f-0c6cc87df638?segmentId=114a04fe-353d-37db-f705-204c9a0a157b.
[59] USGS. Rare Earths Statistics and Information. Mineral Commodity Summaries, various years.

policy in China. Today, China produces 80% of global solar cell output, and the U.S. has almost no domestic capacity.[60]

Perhaps the best example of successful policy is high-capacity batteries, predominantly manufactured for use in electric vehicles (EV).[61] China played catch-up for years attempting to generate competitiveness in internal combustion engine (ICE) automobiles, with little success. But China became the largest market for EVs as a consequence of government policy, and as a direct consequence of this policy-generated EV demand, along with protectionism and infrastructure investment, China now commands 75% of advanced cell fabrication capacity for high-capacity batteries globally and is home to two of the top four battery makers in the world (CATL and BYD).[62] In terms of protectionism, China's EV subsidy scheme has supported domestic battery producers, and China has required technology transfers for EV companies looking to invest in China. In terms of infrastructure, China pushed forward to develop charging stations throughout the country.[63]

But the most effective policies for creating a domestic battery market were demand-side policies supporting EVs, including consumer subsidies, mandated government purchases, and various forms of local government support for EV purchases, including lower license plate fees and free parking. The subsidy policy itself, with average local and central subsidies of approximately $10,000 per vehicle,[64] were extremely successful at incentivizing EV purchases: after their rollout nationwide in 2013, EV sales growth in 2014 and 2015 was over 300% annually, and China has been the largest market for plug-only and plug-in hybrid EVs since 2015.[65] And as a result of local procurement policies, China now has 421,000 electrically-powered buses, compared to only 300 in the U.S.

Despite China's success creating EV demand that spurred high-capacity battery production, China's industrial policy story should not be seen as an unmitigated success, nor is future success in the sector guaranteed. With relatively weak ICE incumbents, local governments in China were very supportive of EVs and high-capacity batteries. But this support has resulted in considerable waste and cost-ineffective investment and subsidies. Between 2009 and 2017, China's central and local governments spent approximately $50 billion on consumer subsidies and sales tax

[60] Though even in solar, subsidies did not play as important a role as China's large labor force and local government industrial parks. See: Ball, J., D. Reicher, X.J. Sun, and C. Pollock. 2017. *The New Solar System: China's Evolving Solar Industry and Its Implications for Competitive Solar Power in the United States and the World*. Stanford. Accesed June 2, 2022:: https://law.stanford.edu/wp-content/uploads/2017/03/2017-03-20-Stanford-China-Report.pdf.

[61] EVs account for 80-85% of high-capacity batter use. See White House, *Building Resilient Supply Chains*.

[62] The White House, *Building Resilient Supply Chains*

[63] See: State Council. 2018. "提升新能源汽车充电保障能力行动计划 [Action Plan for Enhancing the Guaranteed Charging Capacity for Electric Vehicles]." Notice No. 1698.

[64] Electric buses could receive subsidies of up to $87,000. See: Mazzocco, I. 2020. "Electrifying: How China Built an EV Industry in a Decade." *MacroPolo*. July 8. Accessed June 2, 2022: https://macropolo.org/analysis/china-electric-vehicle-ev-industry/.

[65] Du, J.Y., and D.H. Ouyang. 2017. "Progress of Chinese Electric Vehicles Industrialization in 2015: A Review." *Applied Energy* 188: 529–46. Teece, D.J. 2019. "China and the Reshaping of the Auto Industry: A Dynamic Capabilities Perspective." *Management and Organization Review* 15(1): 177–199.

exemptions,[66] over one-quarter of total EV sales. With large subsidies, there has unsurprisingly been considerable evidence of corruption and fraud.[67] And access to easy money led the number of registered EV firms to explode to over 400 by 2018, even though only 15% appear to actually manufacture any cars, with many of these cars of low quality.[68] And China's all-out approach based on artificially-manufactured demand has concentrated production in relatively low-tech batteries that may soon be superseded by foreign firms, with Chinese average battery capacity growth lagging behind the global average over the last decade.[69]

Finally, despite recent ambitions to remove subsidies and move towards a more market-based approach to incentivizing EV sales and production, announced as early as 2016,[70] it is unclear if EV demand can survive subsidy removal. Indeed, after sales plummeted following the removal of most subsidies in 2019, the government quickly re-introduced the subsidies.[71] Europe in the past year emerged as the world's largest EV market based on a more market-based regulatory approach, without requiring China's scale of government subsidization, putting the future of China's EV market and high-capacity battery dominance in question.

Pattern 3: Central industrial policy support without supply chain dominance (example: semiconductors)

Although China has had industrial policy success in several emerging industries, in many other sectors Chinese industrial policy has been expansive and expensive with underwhelming results. Generally, these sectors appear to have high capital and technological requirements as well as large existing global markets/demand and foreign incumbents. In these sectors, China's ability to pick winners has proved limited, leading to waste as subsidies and investments have been distorted while traveling through the prism of China's hierarchical system. Demand-side subsidies, so important in the case of emerging industries, have been ineffective given preexisting high levels of global demand.

Semiconductors may be the prime example in which policy has not produced hoped-for results. High-end chips have been consistently targeted by China's central policy makers for financial support. In the late 1990s and early 2000s, China utilized bureaucratic processes to attempt to

[66] Kennedy, S. 2018. *China's Risky Drive into New-Energy Vehicles*. Washington, DC: Center for Strategic and International Studies.
[67] Ai, L.M., and C. Feng. 2017. "China Pulls Plug on Electric Vehicle Fraud." *Caixin Global*. 6 February. Accessed June 2, 2022: https://www.caixinglobal.com/2017-02-06/china-pulls-plug-on-electric-vehicle-fraud-101050629.html.
[68] Mazzocco, "Electrifying."
[69] ICCT. 2021. "Race to Electrify Light-Duty Vehicles in China, the United States and Europe: A Comparison of Key EV Market Development Indicators," The International Council on Clean Transportation. February 4. Accessed June 2, 2022: https://theicct.org/wp-content/uploads/2021/06/china-green-future-ev-fs-feb2021-01.pdf.
[70] See discussion in Mazzocco, "Electrifying."
[71] See: Ministry of Finance. 2020. 关于《财政部 工业和信息化部 科技部 发展改革委关于调整完善新能源汽车补贴政策的通知（财建〔2020〕86 号）》的解读. Accessed June 2, 2022: http://www.gov.cn/zhengce/2020-04/23/content_5505506.htm.

create large semiconductor firms, with little to show.[72] In the mid-2000s, central planners attempted to use more sophisticated industrial policy support to encourage both state and private sector chip development through new incentives.[73] But the Hanxin 1 scandal and SMIC's intellectual property theft case demonstrated how far behind China remained, leading to massive amounts of new funding beginning with the 12th Five Year Plan.[74] The National IC Industry Development Fund created in 2014, with a second phase in 2018, led to approximately 500 billion RMB in funding, mostly for fabrication.[75] And local governments have provided more than 300 billion RMB in guidance funds.[76] Yet China's semiconductor sector continues to lag, with most high-end design still controlled by foreign firms and most Chinese companies only supplying mid-to-low-end design and fabrication.[77] The Trump Administration's decision to put ZTE on the entity list in April 2018 was China's "Sputnik moment," indicating how far behind China remained and how dependent its economy remained on foreign technology and production.[78]

China's failure to break through in semiconductors is a result of failed industrial policy: assessing firm quality and picking winners is difficult given information asymmetries in highly technical fields, and local governments may be especially vulnerable to incentives to get money out the door fast. Most semiconductor policy funding was intended to target top firms in each category of production,[79] but included very little investment in long-term R&D. Guidance funds sought to follow market rules for equity investments, but the incentives facing bureaucrats and officials in charge of allocation remain short-term, leading to investments in lagging (known) technologies.[80]

Targeting firms with local governments controlling the levers can lead to massive failures. Local governments have provided at least 300 billion RMB to support local semiconductor industries, but in just the past three years at least 10 different multibillion RMB chip projects failed, prompting

[72] Jiang Zemin argued that China needed to "develop China's semiconductor industry at all costs" after vising a Samsung factory in Korea, leading to Project 908 and Project 909. See: He, A. 2021. "China's Techno-Industrial Development: A Case Study of the Semiconductor Industry." CIGI Papers No. 252. Accessed June 2, 2022:: https://www.cigionline.org/sites/default/files/documents/no.252%20web.pdf.
[73] Ibid.
[74] For the Hanxin 1 scandal, see: Lemon, S. 2006. "An elaborate chip fraud unravels in China." *Computerworld*. 15 May. Accessed June 2, 2022: https://www.computerworld.com/article/2549655/an-elaborate-chip-fraud-unravels-in-china.html. For the SMIC lawsuit, see: Keating, G. 2009. "California jury finds SMIC stole trade secrets." *Reuters*. 3 May. Accessed June 2, 2022: https://www.reuters.com/article/us-smic-lawsuit/california-jury-finds-smic-stole-trade-secrets-idUSTRE5A26CA20091103.
[75] Xinhua. 2014. "国家集成电路产业投资基金正式成立 [National IC Industry Investment Fund formally established]. *Xinhua*. October 14. Accessed June 2, 2022: www.gov.cn/xinwen/2014-10/14/content_2764849.htm; Li, N., and S.S. Lai. 2019. "国家大基金二期落地 两千亿投向何方 [The second phase of the National IC Fund has arrived; where will the 200 billion RMB fund invest]." *Yicai*. October 28. Accessed June 2, 2022: www.yicai.com/news/100380063.html.
[76] Zhang, J. 2021. "China's semiconductors: How Wuhan's challenger to Chinese chip champion SMIC turned from dream to nightmare." *South China Morning Post*. 20 March. Accessed June 2, 2022: https://www.scmp.com/tech/tech-trends/article/3126124/chinas-semiconductors-how-wuhans-challenger-chinese-chip-champion.
[77] He, "China's Techno-Industrial Development."
[78] Ibid.
[79] Ibid.
[80] Ibid.

China's central planners to promise to clean up the "chaotic" industry.[81] The HSMC scandal was perhaps the most high-profile, after an entrepreneur with only an elementary school education convinced the Dongxihu district government to put up 200 million RMB and the Wuhan city government to commit over 15 billion RMB to build a semiconductor production company that never got off the ground.[82] Other examples of local governments ploughing money into failed semiconductor projects include Nanjing Dekema and Shaanxi Kuntong Semiconductor Technology.[83] The underlying problem is clear to industry insiders. As one analyst in Shanghai notes: "Some local governments that are eager to launch hi-tech projects lack relevant experience and clear understanding of project risks. They simply use generous subsidies and large amounts of capital to attract projects."[84]

V. Conclusions and policy recommendations

This testimony has argued that China's supply chain dominance has arisen largely from natural comparative advantages. China's central policymakers increasingly employ targeted industrial policies to achieve dominance or reduce vulnerability in specific sectors, but these policies have only been partially effective given distorted implementation by local governments.

The broadest recommendation for U.S. policymakers that arises from these conclusions: *do not overestimate the threat that China's GVC dominance poses*. There may be very good reasons to engage in domestic industrial policy, impose taxes on outsourcing, or directly pay firms to "reshore" and bring manufacturing production back to the United States. These good reasons could include concerns about American job creation and climate change. But the threat from China should not be a key motivation. There are four broad reasons why U.S. industrial policy with the explicit goal of reducing reliance on China may be misguided, in increasing order of importance:

First, China's entry into GVCs has been and continues to benefit the US. China's entry into GVCs has led to considerable welfare gains from price decreases, despite documented job losses from import competition.[85] Additionally, China's subsidization can serve as a global public good: the cost of solar energy fell by over 80% over the past decade, becoming cheaper than either coal or natural gas in 2018, as has the cost per kilowatt-hour of lithium-ion batteries, enabling growth of the EV market. Neither of these price reductions would have been possible without China's non-market interventions.

[81] Lee, A. 2020. "China to curb 'chaos' in semiconductor industry and hold bosses accountable for risky, loss-making projects." *South China Morning Post*. 20 October. Accessed June 2, 2022: https://www.scmp.com/economy/china-economy/article/3106307/china-curb-chaos-semiconductor-industry-and-hold-bosses?module=inline&pgtype=article.
[82] Zhang. "China's semiconductors."
[83] Cortese, A.J. 2021. "Semiconductor squander: China's chip drive leaves unqualified projects languishing." *KrAsia Insights*. 11 June. Accessed June 2, 2022: https://kr-asia.com/semiconductor-squander-chinas-chip-drive-leaves-unqualified-projects-languishing.
[84] Zhang, "China's semiconductors."
[85] China's WTO entry reduced the U.S. manufacturing price index by 7.6 percent between 2000 and 2006. See: Amiti, M., M. Dai, R.C. Feenstra, and J. Romalis. 2017. "How Did China's WTO Entry Affect U.S. Prices?" Federal Reserve Bank of New York Staff Report No. 817.

Second, any effective measures to convince companies to leave China would be very expensive and could lead to harmful retaliation given the importance of the Chinese market to American industry. Policies intended to dis-incentivize outsourcing to China are difficult, long-term, and costly, as indicated by the limited effectiveness of the trade war tariffs. Part of this is because GVCs break down effectiveness of bilateral measures as well as links between relative prices and trade performance. More importantly, the largest U.S. supply chain vulnerability vis-à-vis China is getting cut off from exporting to and selling in China. This is clear in Biden supply chain report in references to semiconductors: "Heavy reliance on sales to China provides the Chinese Government with economic leverage and the potential to retaliate against the United States." [86]

Third, China's economy is more vulnerable to U.S. economic coercion than vice versa, making China's aggressive use of coercive supply chain disruptions aimed at the U.S. unlikely. Most of China's economic coercion—which China has become increasingly quick to use for political purposes—is limited in scope and impact. China's use of coercive economic tools is special for several reasons, including willingness to use trade as a short-term coercive measure;[87] the role of SOEs, which serve as a the channel for trade shocks following "political incidents" with China's trade partners;[88] the role of state media and propaganda to drive consumer boycotts;[89] and, most importantly, China's overall asymmetric trade importance to large set of countries.[90] But China's use of trade as a political tool is generally ineffective, and China has been loath to implement these tactics when they can harm China itself. In the case of the U.S.-China bilateral economic relationship, China remains considerably more asymmetrically dependent on the U.S. than vice versa, as indicated by China's financial vulnerabilities (i.e., potential for exclusion from Swift) and dependence on U.S. technology, as seen in the recent ZTE and Huawei cases.

Fourth, and most importantly, many companies are *already* leaving China as China's comparative advantage shifts and supply chain risks emerge; policy support would be a waste of taxpayer money. There are many reasons that China's comparative advantage is eroding and shifting, most importantly rising costs given a shrinking labor force as well as greater environmental and labor taxation. Additionally, the environment for foreign firms has deteriorated in Xi's state-led economy. According to AmCham China, approximately one in five U.S. firms based in China have already moved or are considering moving capacity outside of China; tariffs played a role, but

[86] See White House, *Building Resilient Supply Chains*. U.S. semiconductor chip makers rely heavily on China for sales given that China is the largest market for semiconductors: Qualcomm generates two-thirds of its revenue in China and Micron generates 57% of its revenue in China.
[87] For example, countries that officially receive Dalai Lama visits experience reduced exports to China as a result. Fuchs, A., and N.-H. Klann. 2013. "Paying a visit: The Dalai Lama effect on international trade." *Journal of International Economics* 91(1): 164-177.
[88] Davis, C.L., A. Fuchs, and K. Johnson. 2019. "State Control and the Effects of Foreign Relations on Bilateral Trade." *Journal of Conflict Resolution* 63(2): 405-438.
[89] Vekasi, K., and J. Nam. 2019. "Boycotting Japan: Explaining Divergence in Chinese and South Korean Economic Backlash." *Journal of Asian Security and International Affairs* 6(3): 299-326.
[90] This asymmetric dependence can lead to political alignment. For instance, developing countries become more aligned with Chinese voting patterns at the UN as they become more dependent on trade with China. Flores-Macias, G.A., and S.E. Kreps. 2013. "The Foreign Policy Consequences of Trade: China's Commercial Relations with Africa and Latin America, 1992–2006." *The Journal of Politics* 75(2): 357-371.

not as big a role as rising labor costs and slowing Chinese growth.[91] Shifts out of China have been especially apparent in labor intensive industries. Most recently, city-wide lockdowns in China as part of a "zero-Covid" policy and supply chain disruptions stemming from Russia's invasion of Ukraine (both countries far less integrated in the global economy than China), have made firms further consider duplicating or relocating their China-based supply chains. As early as May 2020, as a result of the pandemic, a McKinsey survey of global supply chain and business leaders found that 93% already planned to increase supply chain resilience, and 44% planned to do so at cost of short-term savings.[92]

Although policymakers should not overestimate the supply chain threat from China, America remains vulnerable as a consequence of dependence on concentrated Chinese production. An optimal response should: (1) address key vulnerabilities at a minimal cost in the short term; (2) incentivize Chinese adherence to international trade norms in the medium-term; and (3) ensure U.S. innovative advantages in the long-term. The following three policy recommendations address these three areas in turn:

1. Identify vulnerable sectors and generate targeted policy responses. Key policy and business communities should develop lists of key inputs that have no domestic sourcing, as DOD has already done.[93] There is no reason to focus solely on China: any single sourced product is a potential risk. Where the U.S. depends on a single source for *critical* inputs, efforts should be made to spur domestic production. As a good example of a cost-effective strategy: given that only half of vital pharmaceutical products have any U.S. production, $60 million has been allocated from the Defense Production Act to onshore 50-100 critical drugs on the FDA's essential medicines list. As an alternative to generating domestic production, policymakers could also consider increasing stockpiles and designing emergency diversion plans.

2. Use trade pressure and trade carrots to shape Chinese policy: WTO reform and regional PTAs. In the medium term, the U.S. and the world would benefit from China's greater adherence to international trade norms. The 2018 U.S.-China trade war undermined the stated U.S. commitment to fair trade while also demonstrating that unilateral approaches to changing China's trade behavior are doomed to fail. Nevertheless, China has responded positively to regional and global trade carrots in the past given the importance of trade to the Chinese economy. The lack of a functioning dispute resolution body at the WTO does not make the U.S. stronger, and the U.S. should continue to work with like-minded countries to pursue WTO reform. Additionally, the U.S. should consider joining regional trade agreements, including the CPTPP. The recently mooted Indo-Pacific Economic Framework lacks public details, but does not appear to open the U.S. to greater imports, making it relatively ineffective and unattractive to potential trade partners.

[91] American Chamber of Commerce in China. *Business Climate Survey 2020*. Summary accessed June 2, 2022: https://www.amchamchina.org/press/2020-business-climate-survey-released/.
[92] McKinsey Global Institute. 2020. *Risk, resilience, and rebalancing in global value chains.* August.
[93] Department of Defense. 2018. *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States*. Report to President Donald J. Trump by the Interagency Task Force in Fulfillment of Executive Order 13806.

3. Maintain the U.S. innovation edge: stay open to Chinese students and scientists. Human capital is the most important advantage the U.S. has in high-tech, innovation-based sectors. Our universities are the best in the world, and attract the greatest minds from abroad, including from China. Consider artificial intelligence (AI): the U.S. employs 60% of the world's top-tier AI researchers, six times more than China, but two-thirds of these researchers immigrated to America after college (mostly to attend graduate school), and more than one-quarter are Chinese. Indeed, only one-third of Chinese top AI researchers stay in China, with 56% working in the U.S.[94] Recent policies that make it more difficult for Chinese nationals to study in the U.S.[95] and policies that make Chinese scientists feel unwelcome, including the Department of Justice's recently concluded China Initiative,[96] weaken American innovative capacity. The U.S. needs to stay open to Chinese students and do more to encourage these students to stay and work in the United States after graduation.

[94] Banerjee, I., and M. Sheehan. 2020. "America's Got AI Talent: US' Big Lead in AI Research Is Built on Importing Researchers." *MacroPolo*. 9 June. Accessed June 2, 2022: https://macropolo.org/americas-got-ai-talent-us-big-lead-in-ai-research-is-built-on-importing-researchers/?rp=m.

[95] The Trump administration shortened the duration of Chinese student visas for those studying aviation, robotics, and advanced manufacturing. See Mervis, J. 2018. "More restrictive U.S. policy on Chinese graduate student visas raises alarm." *Science*. 11 June. Accessed June 2, 2022: https://www.science.org/content/article/more-restrictive-us-policy-chinese-graduate-student-visas-raises-alarm. Additional policies restricting Chinese students from particular universities could reduce Chinese STEM graduate students in the U.S. by one-quarter. Hua, S. 2021. "Visa Restrictions on Chinese Students Endanger U.S. Innovation Edge, Universities Say." *The Wall Street Journal*. 2 November. Accessed June 2, 2022: https://www.wsj.com/articles/visa-restrictions-on-chinese-students-endanger-u-s-innovation-edge-universities-say-11635856001

[96] Gilbert, N., and M. Kozlov. 2022. "The controversial China Initiative is ending — researchers are relieved." *Nature*. 24 February. Accessed June 2, 2022: https://www.nature.com/articles/d41586-022-00555-z.

OPENING STATEMENT OF WILLY SHIH, ROBERT AND JANE CIZIK PROFESSOR OF MANAGEMENT PRACTICE IN BUSINESS ADMINISTRATION, HARVARD BUSNIESS SCHOOL

COMMISSIONER GOODWIN: Thank you, Dr. Bulman. Dr. Shih?

DR. SHIH: Hearing Co-Chairs Borochoff and Goodwin, commission members, staff, distinguished guests, good morning, and thank you for the invitation to speak with you today. During my 15 years at the Harvard Business School and 28 years in industry, I watched China rise from an impoverished nation to become a formidable manufacturing powerhouse. First decade of the 21st century was a period of spectacular growth for China, as well as one of the hollowing out of substantial parts of the manufacturing infrastructure of the United States.

Some of you may know that a lot of my thinking on the impact on the U.S. was laid out in a paper published in the Harvard Business Review in 2099 and a subsequent book. But let me start by addressing your questions. First, China was late to industrialize, relative to other countries. In that regard, it had what some people called the late comers' advantage.

When it built its electric grid, its communications network, a fair amount of this manufacturing capacity, it didn't have a lot of existing and older infrastructure that was already paid for and fully depreciated. Since it was looking to catch up, it could start fresh with the newest technologies, and this was a huge advantage. Let me illustrate.

I used to teach with the late Clayton Christensen, who was famous for his model of disruptive innovation and how the steel mini mills caused havoc for domestic integrated steel producers. I asked him once, Clay, the question you should ask is how did the American steel makers get in trouble in the first place because at the end of World War II, they were the king of the hill. Partly, that was because all of their competitors lay in ruins.

But as a consequence of that, competitors in Europe and Japan were the first to use basic oxygen. They were the first to use continuous casting. They were first to use a lot of near-net-shape methods. They were the first to use an electric arc.

Now they weren't hobbled by older, less efficient, but fully paid for and depreciated facilities. American firms feared excess capacity. So why add more even if it made better product at lower cost? Now during China's industrialization, companies invested -- imported the latest production technologies. I point out in my written testimony how the knowledge embodied in theses production tools was of great value.

China's position in global supply chain is much more pervasive than many people realize. It is combined what seem like a virtually unlimited low-cost workforce that had both the discipline and the ambition to get ahead. Its position is durable though not insurmountable because they have both the capacity and the capabilities.

Next, what economic advantages has that conveyed? Chinese companies use learning and economies of scale to cement their positions. They've been able to take advantage of the tradeability of their output and combine the gigantic export market with its own growing domestic market. This is something the United States took advantage of during the 20th century.

But the growth of the tradeable sector has helped China immensely. Its firms have been able to build extraordinary positions as low cost producers. Process learning is essential. When a firm starts making a product, it might not be as good as international competitors. But it's good enough for many buyers in the local market.

It's able to get practice and move down the learning curve. Customers pay for this learning by buying the firm's output. The way I describe that is somebody is paying my tuition while I learn and improve.

Next, is China's international competitiveness eroding? I believe so for the following reasons. First, increasing logistic cost and transit times are eroding tradeability. As Dr. Bulman has said, China's population dividend has peaked and labor costs are rising. Heightened trade tensions have made manufacturing some products that are too high risk and manufacturers hate risk. And China's zero-COVID policy has made business much harder to conduct and inject to a major degree of risk and uncertainty.

Lastly, the Chinese government's willingness to disrupt some of its own industries through policy and regulation have injected even more uncertainty. Meaningful shifts in production have already begun and continue to take place. But I'm not willing to write China off.

Fourth, what should the U.S. government do? We should engage in some long-term planning beyond one or two election cycles to identify the strategic capabilities that we believe we and our allies need to possess or can scale rapidly under times of duress. I believe the focus should be on platform capabilities upon which others rest. We should watch for step-change innovations in manufacturing process technologies that can change the game and obsolete existing process methods, just like basic oxygen did for the steel makers.

I see a number of these opportunities, and they're outlined in my written testimony. At the same time, I believe it's crucial that our country invest and maintain leadership in the fields that will be important in this century, life sciences in particular, new energy technologies, advanced tool making. Lastly, recommendations for Congress, I think we need to adopt a challenger mindset.

We need to stop wasting emotional energy about how we've been wrong in the past and poor it into what we are going to do to, number one, strengthen where we are still strong so we don't mess those areas up and then create strategic plans that grab the lead in areas that we decide are really important. Part of the first system is to do an honest assessment of where are free market system is having trouble competing. The question is what makes a company operating in a strategic sector more attractive to investors and what are the impacts of different tax and incentive regimes on financial metrics above and below the EBITDA line. I talk about more of that in my written testimony.

Finally, let me conclude with a few thoughts to go beyond your questions. I believe in America. I believe in our system of market-based competition. Importantly, we foster a competition of ideas.

We can accept failure and the idea that people should be given another chance. We have long been that shining light on the hill that has attracted the best and brightest to come here to be all that they can be. My parents came here with that belief as did countless others. And this country has been good to us.

If you believe, as I do, that we have a superior system, then let's address some of the imbalances that occur at the interfaces. China's leadership believes in their system. There's a side of me that says we should just step aside and see how their top-down model will work facing the challenges of the years ahead.

Their zero-COVID strategy and the way they have treated their private education industry and their tech sector tells us a lot. We need to address our weaknesses and penchant for watered-down short-term solutions. I have told this Commission before that a little long-term planning would benefit all of us. Thank you for the opportunity to address the Commission.

PREPARED STATEMENT OF WILLY SHIH, ROBERT AND JANE CIZIK PROFESSOR OF MANAGEMENT PRACTICE IN BUSINESS ADMINSTRATION, HARVARD BUSINESS SCHOOL

Willy C. Shih
Robert & Jane Cizik Professor of Management Practice in Business Administration
Harvard Business School

Testimony before the U.S. - China Economic and Security Review Commission

Hearing on Supply Chains

June 9, 2022

Hearing Co-Chairs Borochoff and Goodwin, commission members, staff, and other distinguished guests, good morning, and thank you for the invitation to speak with you today.

I am on the faculty of the Harvard Business School, where I have taught for the past 15 years. Prior to that I spent almost 28 years in industry, a time that saw a dramatic expansion of the tradable sector, and the rise of China from an impoverished nation to a formidable manufacturing powerhouse. I spent a lot of time in China from the late 1990s onward, and I watched its rise. The first decade of the 21st century was a period of spectacular growth for China, as well as one of the hollowing out of substantial parts of the manufacturing infrastructure of the United States. Some of you may know that a lot of my thinking on the impact on the U.S. was laid out in a paper published in the *Harvard Business Review* in July–August 2009 on "Restoring American Competitiveness" and a subsequent book.

Let me start by addressing your questions.

1. **Describe how China has utilized process innovation to develop and occupy a leading role in global production networks. What makes China's position in global supply chains unique? How durable is China's position on this score?**

China was late to industrialize, relative to the U.S., Europe, and other East Asian countries. In that regard it had what some authors call the "late comers' advantage." When it built its electric grid, its communications network, and a fair amount of its manufacturing capacity, it didn't have a lot of existing (and older) infrastructure that was already paid for and fully depreciated, or maybe State-owned Enterprises (SOE) didn't have to worry about concepts like depreciation schedules. In either case, since it was looking to catch up, it could start fresh with the newest technologies, and this was a huge advantage. Some of the old Mao era manufacturing legacy was pretty archaic, but firms weren't afraid to invest in a lot of new capacity. They planned for vast growth with the domestic market and increasing access to global markets.

Let me illustrate this point. I used to teach with the late Clayton Christensen, who was famous for his model of disruptive innovation – and how the steel minimills caused havoc for the domestic integrated steel producers. I asked him once, “Clay, the question you really should ask is how did American steel manufacturers get in trouble in the first place?”

At the end of World War Two, American steel manufacturers were the king of the hill. U.S. Steel, Bethlehem, Jones & Laughlin, others. I remember those names from when I was young. Their competitors in Germany and Japan lay in ruins. But when those countries rebuilt, they were the first to use newer technologies like the basic oxygen process, they were the first to use continuous casting, they weren’t hobbled by older open hearth furnaces that were less efficient but fully paid for and depreciated. American firms were fearful of the financial costs of excess capacity, so why add more even if it made better product at lower cost? In the late 1910s, American firms were also late adopters of electric motors distributed in factories for the same reason. The old centralized power was already paid for. I can extend this example to numerous other industries: castings, LCD display panels, vehicle assembly lines, the telephone network. As I’m sure you know, China largely skipped fixed wireline and went right to wireless.

In China during the 1990s and 2000s, a period of rapid industrialization, both Chinese and foreign invested companies imported a great deal of production equipment. Some of this was the result of “lift and shift” strategies in which production equipment was moved from the U.S. or Europe, but there were also many instances where the latest production technologies and equipment were purchased, largely from abroad. The equipment generally comes with training, as it is in the interest of the toolmakers to provide it. They therefore received a lot of know-how embedded in those production tools. I have written about this phenomena in the *MIT Sloan Management Review*, and I am incorporating that article by reference.[1] That is something everybody in every country does, but if you are a latecomer, it helps when you don’t have to go through a lot of learning that is abstracted and presented to you.

Let me add that China historically engaged in a unique combination of centralized planning with experimentation. In addition to its five year plans, it engages in longer term programs as well. I would like to highlight in particular the National High-tech R&D Program, also known as the “863 Program” named for the year and month (March, 1986) when four scholars proposed a plan to accelerate the country’s high tech development. It sought to boost innovation capacity in named strategic sectors like information technologies and infrastructure, biological and pharmaceutical technologies, nanomaterials and other materials, among others. I have to admit the first time I saw this program, I was impressed by its ambition and well delineated scope.

China also has a fierce form of market competition, and it is driven by policy makers in provinces and cities who take plans handed down from Beijing and implement them with their own means and methods, competing fiercely with each other. For those leaders who are successful, this is a path to promotion within the Chinese Communist Party. Sometimes Beijing tries to tone down this hyper-competition and rationalize markets, deeming it a waste of resources. But it’s an interesting and powerful model that had delivered results.

China’s position in global supply chains is much more pervasive than many people realize. It has combined what seemed like (until a few years ago) a virtually unlimited low-cost workforce that

[1] Shih, Willy. "Why high-tech commoditization is accelerating." *MIT Sloan Management Review* 59, no. 4 (2018): 53-58

had both the discipline and the ambition to get ahead. Workers there were willing to do things that American workers were not, and they did it for a tenth the cost or sometimes even less. While many people focus on the high profile products like lithium ion batteries, computers, communications equipment, or pharmaceuticals, we actually have broad dependencies that run much deeper than most Americans realize. Do you shop at the big box home improvement stores or retailers? All you have to do is look at who the largest importers from China are. In the midst of the supply chain crisis that we have been living through for the past two years, imports from China have posted records month after month, because we don't have anywhere else to go to for a lot of manufacturing capacity. The pandemic revealed a lot of surprise dependencies, and I guarantee there are many more.

China's position is durable, though not insurmountable, because they have both the capacity and the capabilities. If you want to assemble 10 million iPhones in preparation for a launch weekend, there is only one place where you can marshal the labor, enjoy the labor flexibility, and do it at a reasonable cost, at scale.

2. **What economic advantages has China's leadership in process innovation conferred on China? To what extent can other economies realize similar advantages?**

As described above, Chinese companies have been willing and able to apply the latest process innovations. They then use learning and economies of scale to cement their positions. Economies of scale and process learning as exemplified by the learning curve play a crucial role. These effects overlap of course, but let me start with scale economies.[2]

Economies of scale are cost decreases that result from expanding production. If the cost per unit of output rises more slowly than the costs of inputs in the same proportions, there are economies of scale (for example, if output doubles while the total cost of inputs less than doubles). The simplest scale economies arise when there are high setup costs and relatively low run costs per unit of output so that spreading setup over larger run volumes improves efficiency of labor and asset utilization.

Economies of scale are frequently found in industries that require large capital expenditures on plant and equipment, or the establishment of a large infrastructure prior to the ability to begin providing service. High fixed costs get apportioned across the entire product volumes, so larger production volumes mean a smaller per unit allocation.

China has been able to take advantage of the tradability of its output, and as a low cost provider combine the gigantic export market with its own growing domestic market. This is something that the United States was able to take advantage of during the 20th century, but the growth of the tradable sector enabled by low cost ocean container shipping from the late 1990s has helped China immensely. Thus its firms have been able to build extraordinary positions as low cost producers.

[2] This explanation comes from Shih, Willy, "Scale Effects, Network Effects, and Investment Strategy," HBS Case No. 611-082 (May 13, 2011)

Process learning is essential. The experience (learning) curve originated from the work of Theodore Wright, who studied aircraft production.[3] He observed that the more times a task was repeated, the less labor time was required in each subsequent iteration. Empirically this takes the form of:

$$C_x = C_1 \mathrm{x}^{\log_2(b)}$$

where C_x is the unit cost of producing the xth unit, C_1 is the cost of producing the first unit, and b is the progress ratio. ($1 - b$) is the proportionate reduction in unit cost with each doubling of cumulative production volume. Experience curve benefits can be attributed to improvements in labor efficiency as workers' dexterity improves, standardization, specialization and work method improvements, improved use of tools and equipment, product redesigns to improve assembly efficiency and productivity, material substitutions and more efficient use of inputs, and a shared experience effect when multiple products share usage of common resources.

One of the key benefits that I have observed Chinese manufacturers have been able to exploit is a market breadth and depth that facilitates this learning. When a firm starts out making a product, it might not be as good as international competitors but it is good enough for many buyers in its local market. Thus it is able to get practice and move down the learning curve. Customers pay for this learning by buying the firm's output, and this gives the manufacturer the cash flow to keep operating and improve. I describe this as "paying my tuition" while I learn and improve. China didn't invent this idea – it is a feature of market economies. Japan and other Asian economies leveraged this earlier, as did the U.S. in the 19th and 20th centuries. But a broad tradable sector with low cost shipping facilitates it.

3. **Is the international competitiveness of China-based manufacturing networks eroding, and if so, why? Is any such erosion significant enough to precipitate a meaningful shift of production outside of China?**

In my opinion the competitiveness of China is eroding, and I would attribute this to several factors:

- Increasing logistics costs and transit times, essentially eroding the tradability of many goods. If you don't have sufficient value density, it makes no economic sense to produce physical products that far away from where they are sold. Since 90% of global trade moves on water-borne trade lanes, the arrival of IMO 2023 regulations on shipping suggest to me that we are not going back to the days of the first 15 years of this century.
- China's population dividend has peaked, and demographic trends are not in its favor. China's workforce is no longer seemingly limitless, and workers are demanding more pay. That die was cast with the country's one-child policy, and there is no correcting that in the near term.
- Heightened trade tensions between the U.S. and China have made manufacturing some commodities too high risk, and we have already seen the beginnings of a lot of diversification.
- China's Zero Covid policy has made business much harder to conduct, and has injected a major degree of risk uncertainty. Manufacturers really dislike uncertainty.

[3] Wright, Theodore P., "Factors affecting the cost of airplanes," Journal of Aeronautical Sciences," 3, no. 4 (1936):122-128.

- The Chinese government's willing to disruptive some of its own industries through policy and regulation have injected more uncertainty. Until the Party Congress later this year, this uncertainty is likely to continue.

Meaningful shifts in production have already, and continue to take place. Countries like Vietnam, Malaysia, and Mexico have seen gains. Having said this, I am not prepared to write off China's long term capabilities or its ability to react and respond to these shifts.

4. **How should the U.S. government and industry work together to diversify sourcing and production away from China? Are there certain manufacturing processes the U.S. public and private sector should prioritize to reduce exposure to China-centric production networks? Where are the opportunities on this score?**

The U.S. Government should engage in long term planning, *i.e.,* beyond one or two election cycles, to identify strategic capabilities that we believe we and our allies need to possess or can scale rapidly under times of duress. I believe the focus should be on *platform capabilities* upon which others rest. For example the metalcasting industry is a critical part of the U.S. manufacturing ecosystem. Highly engineered castings are used to produce 90% of all durable goods and nearly all manufacturing machinery. If you cannot make metal castings efficiently and cost effectively in the quantities you need, you will have trouble making machine tools, plumbing and fluid handling devices, oil field equipment, motor vehicles, and countless other goods. We have experienced waves of offshoring in the metalcasting business, generally sending the high volume work overseas, leaving small volumes to domestic firms, including many SMEs. Thus the overseas manufacturers have been able to buy the latest tools, and they have the scale and learning curve benefits described above.

There is a lot of anxiety about our dependence on overseas sources for high capacity batteries. But again we are dependent on those sources for the manufacturing tools as well, and many of those tools depend on platform capabilities like coatings and fine chemical manufacturing.

Some of these capabilities will take a long time to restore or develop domestic capabilities. What we should watch for are step-change innovations in manufacturing process technologies that can change the game and obsolete existing processing methods, just like basic oxygen, continuous casting, and electric arc furnaces did it to the incumbent American steel makers. I see a number of these opportunities:

- Continuous flow and on demand process technology platforms for manufacturing of fine chemicals, medicines, and sterile injectables.
- New metal processing technologies, such as hydrogen assisted magnesiothermic reduction for the production of titanium spherical powders, to replace the energy intensive Kroll process.
- Additive manufacturing technologies such as binder jet printing coupled with computer modeling applied to the production of advanced metal castings.

At the same time, I believe it as crucial that our country invest to maintain leadership in the fields that will be crucial in this century:

- Life sciences, in particular manufacturing processes to support things like synthetic biology, and gene and cell therapy.
- New energy technologies, including hydrogen and derivative forms, green transition technologies, and compact modular nuclear technology.
- Advanced tool making, metrology, and packaging technologies in support of semiconductor manufacturing.

5. **The Commission is mandated to make recommendations to Congress. How should the United States restore its industrial competitiveness vis-à-vis China? What other policy recommendations would you make based on the topic of your testimony?**

I have been thinking a lot about this question lately. First, we need to adopt the mindset of the challenger who is trying to climb back into the ring. What I mean here is we should stop wasting emotional energy about how we have been wronged in the past and pour it into what we are going to do to (1) strengthen where we are still strong so we don't mess it up, and (2) create strategic plans to grab the lead in areas that we decide are important, leveraging many of the ideas I have mentioned above.

Part of the first suggestion is to do an honest assessment of where our free market system is having trouble competing. I have been thinking about one of these areas a lot lately, and have been interviewing numerous experts. I am decidedly NOT a tax expert, but I want to frame the issue. The question is what makes a company attractive to investors, and what are the impacts of different tax and incentive regimes on financial metrics above and below the earnings before interest, taxes, depreciation, and amortization (EBITDA) line of a company?

Why do I think this is a problem? When investors compare companies that are in capital-intensive manufacturing industries or ones where sophisticated technology investments may take years to earn a return, they often bet instead on the sectors with shorter horizons or the prospects of closer-in earnings and cash flow. Strategically critical industrial sectors, particularly capital intensive ones like most types of manufacturing have suffered in comparison. Deductions for capital investments are spread out over time, and the tax code creates a bias that favors services firms with higher labor costs and lower capital costs compared to manufacturing firms with high capital costs and lower labor costs. Investors also dislike long horizon risks associated with investments or projects that take many years to reach fruition. This is problematic for a company that has to make a large investment to stand up a new facility that may not be able to yield product for several years and turn a profit even further out – 10 years is not uncommon in some areas.

Tax policy in the U.S. is shifting with the upcoming expiration of certain deductions such as for investments. At the same time, other countries have enacted significant incentives to attract new manufacturing capacity. Incentives range from outright cash grants, concessions on land and buildings, as well as preferential tax treatment including reduced or zero corporate income taxes and exemptions from transaction taxes and import duties.

Refundable tax credits might be one vehicle to level the field a bit. Because they are refundable regardless of tax liability, under U.S. GAAP accounting rules they are treated as a grant equivalent, so they are above the EBITDA line. Thus it also contributes to cash flow, which means it results in a P&L benefit, *making the investment more attractive*.

Non-refundable tax credits, like the R&D tax credit require a firm to have sufficient tax liability in order to absorb the credits and the associated benefits, and therefore are treated as part of tax expense and are below the EBITDA line. France, to use one example, has a refundable R&D credit, so it is treated as an above the line reduction of R&D expense.

Investment tax credits are a similar vehicle. The Section 48 Investment Tax Credit allows project owners or investors a credit for installing designated renewable energy generation equipment placed in service during the period 2006 through 2024. This might be a tool to foster both new investment, and modernization of existing processes and technologies.

Another thing to consider is the treatment of R&D expense. This has been fully deductible on an annual basis since 1954, like every other country in the world except Belgium. But the Tax Cut and Jobs Act of 2017 included a provision that require capitalization and amortization over 5 to 15 years, beginning January 1, 2022. That moves an above the line impact to below the line. The R&D Tax Credit (Research and Experimentation Tax Credit) extended by the 2015 PATH Act provides a credit amount that equals the applicable credit rate times the amount of qualified research expenses (QRE) above a base amount, but this reduces the amount of deduction for R&D expense, so 90% of corporate taxpayers elect a reduced credit.

In my mind the advantage of using taxation as a tool is that we avoid picking winners and losers. Rather, we focus on ensuring that our playing field is at least a competitive venue for firms to want to field a team, play, and stay here.

Finally, let me conclude with a few thoughts that go beyond your questions. I believe in America, and I believe in our system of market-based competition. Importantly we foster a competition of ideas, we can accept failure and the idea that people should be given another chance. We have long been that shining light on the hill that has attracted the best and the brightest to come here to be all that they can be. My parents came here with that belief, as did countless others. And this country has been good to us. If you believe, as I do, that we have a superior system, then lets address some of the imbalances that occur at the interfaces with other less-than-market systems. As for China, their leadership believes in their system. There's a side of me that says step aside and see how their top-down model will work facing the challenges in the years ahead. Their zero Covid strategy provides a lot of insight, as does the way they have treated their private education industry and their tech sector.

That also means we need to address our weaknesses and penchant for watered-down short-term solutions. I have told this Commission before that a little long term planning would benefit us all.

Thank you for the opportunity to address the Commission.

OPENING STATEMENT OF MARK DALLAS, ASSOCAITE PROFESSOR OF POLITICAL SCIENCE AND DIRECTOR FOR ASIAN STUDIES, UNION COLLEGE; AND INTERNATIONAL AFFAIRS FELLOW FOR TENURED INTERNATIONAL RELATIONS SCHOLARS, COUNCIL ON FOREIGN RELATIONS

COMMISSIONER GOODWIN: Thank you. Dr. Dallas?

DR. DALLAS: Thank you. Hearing Co-Chairs Commissioner Borochoff, Commissioner Goodwin, other distinguished members of the Commission, and the very hardworking staff members, thank you for the opportunity to testify today. My comments today will focus on China, the complexity of supply chains, and American economic and national security.

Over the past few years, supply chains have taken on geopolitical significance. This has been due to a variety of causes, including supply chain weaponization, COVID-19, and most recently the broad sanctions against Russia. However, today's supply chains do not work well under these conditions.

This is because they were stitched together during an era of far less conflict, far less fear, and a more open, cooperative, and perhaps naive global environment. This era of openness created supply chains that have become incredible intertwined such that companies today are deeply interdependent. Over the past few years, this world seems to be shifting.

Today, all countries are trying to figure out where to draw the line between tolerable or benign interdependence and unacceptable supply chain risk. In my written testimony, I went into considerable empirical detail to give a sense of just how complex and intertwined supply chains are. Keep in mind that the data represented only a single product, the smartphone that's in everyone's pocket this morning, and in only a single industry, information communication technologies.

In fact, even that empirical deep dive was a gross simplification of the true complexity of supply chains. The purpose of doing this empirical exercise was not to be pedantic. Rather, the data lead to three conclusions. First, the U.S. has deep dependencies with many countries, not just China. And oftentimes, the dependency rests on only one, two, or three companies which capture enormous global market share at least in a single subsystem or component.

This extreme global concentration is repeated again and again at each deepening layer of the technology stack. This example hopefully illustrated the extreme challenges of any government effort to monitor, regulate, let alone positively shape supply chains. Thus, any government action should use a scalpel on a select few supply chains, not a machete, including when it comes to interdependencies with China.

This is not based on a belief that trade will create peace. I think China and especially Russia have both undermined that idea. Rather it's purely in our strategic interest.

Why do I say this? Because the second conclusion from the empirical deep dive is that while China possesses some key capabilities that expose America to vulnerabilities, China's dependency on the U.S. and U.S. ally countries is far greater. China's leading high-tech firms like Huawei are substantially dependent from top to bottom on the entire stack of technologies, machinery, hardware, software components, and standard setting processes which they do not control and which have their center of gravity firmly set in OECD countries.

What does this imply? For one, while businesses utilize supply chains to make profits from a purely geopolitical point of view, China's dependence on U.S. technology is a key point of leverage. In addition, Chinese industrial policy should be interpreted as defensive and reactive and derived from their perceptions of vulnerability.

China's sense of vulnerability is well reflected in the data that I presented from Chinese news media from 2005 to 2021. The news reports systematically show that U.S. actions not only have a strong bearing on Chinese perceptions but also that China creates new institutions and new policies that seek to counteract their threat perceptions. The U.S. government already has the resources to weaponize supply chains.

However, this should not be abused and we need to remain aware of Chinese reactions to our behavior and to utilize our powers carefully. Beyond Chinese media perceptions, however, China's deep-seated insecurities over technology also drive their longstanding goal of catching up in foundational technologies and more recently technological leapfrogging. Chinese increasing use of industrial policies began in the mid-200s, well before the era of Xi Jinping and before the global financial crisis.

My third and final point is that the complexity of supply chains means that China's most recent industrial policies are likely to fail even as they have become more ambitious and utilize more resources. Self-reliance simply is not possible if China wishes to catch up to the technological leading edge. Even so, in many cases, China's industrial policies will inflict damage on American innovation and our allies.

Thus, it is in our own national interest to find ways to reduce China's sense of insecurity while also enhancing overall U.S. security. Unequivocally, the goal of the American government is always to achieve American national security goals. However, American's sense of security is partly a function of China's sense of security.

Our relationship is like a circle. If China feels insecure, its policy choices will be reactive and harmful to U.S. interests such as its industrial policies. In turn, Chinese policies and political rhetoric will inflame American perceptions of China.

If, in reaction, American policy also becomes knee-jerk and unnecessarily bellicose, then we're all worse off. My written testimony offers some concrete policy suggestions. However, let me end by mentioning just a few broad principles.

First, it's critical for the government to focus on asymmetric interdependence with China, not all forms of interdependence. Defining this is a major challenge. Second, our supply chain goals should aim to achieve security and openness and prosperity. There's no law of nature which says that we must choose between them. And so policy making should at least attempt at all three.

Third, given the complexity of supply chains, governments need to be crystal clear about end goals and what it can and cannot achieve through supply chain policies. Fourth, to achieve this, we must reject counterproductive labels that brand policies as hawkish or dovish towards China such as the debate over maintaining or removed Trump-era tariffs. We should acknowledge that the CCP and Chinese leadership will pursue what is in their perceived interests.

Thus, U.S. policy should work hard along with our allies to shape China's external environmental and mold China's perceptions so that as much as possible, they naturally and willingly behave in ways that are in America's national interest. Both hawk-like and dove-like policies creatively mixed together will be needed to achieve this broader strategy. Thank you, and I look forward to your questions.

PREPARED STATEMENT OF MARK DALLAS, ASSOCIATE PROFESSOR OF POLITICAL SCIENCE AND DIRECTOR FOR ASIAN STUDIES, UNION COLLEGE; AND INTERNATIONAL AFFAIRS FELLOW FOR TENURED INTERNATIONAL REALTIONS SCHOLARS, COUNCIL ON FOREIGN RELATIONS

Testimony of

Mark P. Dallas, PhD

Associate Professor of Political Science & Asian Studies, Union College, NY
Director of Asian Studies, Union College, NY
Council on Foreign Relations, IAF-TIRS

Before the
U.S.-China Economic and Security Review Commission

Hearing on
"U.S.-China Competition in Global Supply Chains"

June 9th, 2022

Washington, DC

Table of Contents

1. Executive Summary

Supply chains raise thorny policy challenges for all countries. Not only are they complex, but they vary enormously across industries, with each product and production process having unique features. Furthermore, many of these features change rapidly. As such, it is often impossible to discuss 'supply chains' in generic terms, and impossible to create one-size-fits-all frameworks or policy solutions.

Supply chains also force countries to confront new vulnerabilities that have arisen as both innovation and production have become more globalized. Most fundamentally, these new realities compel us to seriously re-think some foundational concepts, including our understanding of 'economic and national security,' 'critical infrastructure,' 'dual-use,' and other commonly used policy concepts. As one small example, consider just one 'link' in the mobile telecommunications supply chain – mobile applications. Are the mobile apps installed on every American's smartphone a matter of national security? Are they a new form of critical infrastructure? These are new questions that remain unanswered, even as they regularly, and often unexpectedly, rise to the level of policy relevance.[1]

Obviously, China is deeply integrated with global supply chains, and this creates interdependencies between countries and new vulnerabilities. Our key task, as I see it, is not to cut China out of global supply chains that intersect with the United States, but to understand which circumstances create unacceptable risk, and which create tolerable or benign risk. For example, interdependency with China should not automatically be interpreted as vulnerability, even when Chinese companies possess large market shares in a particular link in a supply chain. We should worry about *asymmetric* interdependence, not all forms of interdependency. The best way to illustrate this is through data. As such, Section 2 of this testimony offers a brief, non-technical but deep-dive into one slice of the mobile telecommunications supply chain, based on very detailed studies I have carried out with many research collaborators.[2]

The purpose of this empirical deep-dive is, first, to demonstrate the complex trade-offs between benign interdependence and vulnerability. It is hard to fully appreciate the degrees of supply chain complexity and flexibility without engaging with their industry-specific idiosyncrasies through data. Second, the data also demonstrate the challenges of any future government efforts to monitor, regulate, let alone positively shape supply chains. Nevertheless, for critical supply chains, there still are many pragmatic actions governments can take to enhance economic and national security, as discussed in Section 4.

The empirical deep-dive also helps us to better understand China, the topic of Section 3. For China, information-communication technologies (ICTs) are somewhat paradoxical: it arguably is the sector about which the Chinese government feels the most vulnerability (based on policy documents and industrial policies), even when Chinese firms play important roles in the global industry, with Huawei as just one leading example. The reason is simple to state, but challenging to unravel empirically: China's leading firms, like Huawei, are substantially dependent on a host of technologies, machinery, hardware and

[1] For instance, the August 6, 2020 "Executive Order on the Threat Posed by TikTok" stated that "the spread in the United States of mobile applications developed an d owned by companies in the People's Republic of China (China) continues to threaten the national security, foreign policy, and economy of the United States." This assessment was based on perceived risks to data collection, disinformation and censorship because the app had been "downloaded over 175 million times in the United States and over one billion times globally." Tiktok is a video-sharing mobile app owned by the Chinese company, ByteDance. https://trumpwhitehouse.archives.gov/presidential-actions/executive-order-addressing-threat-posed-tiktok/

[2] Most of the data in Section 2 consist of statistics based on large-scale proprietary databases and are the result of two years of collaboration with Timothy Sturgeon (MIT), Daria Taglioni (World Bank) and Eric Thun (Oxford University). Additional open-source data was analyzed in conjunction with Jing-Ming Shiu (National Cheng Kung University in Taiwan). Detailed data in Section 3 on Chinese news media derive from collaborations with Yeling Tan (University of Oregon), Abraham Newman (Georgetown University) and Henry Farrell (Johns Hopkins University). This report would have been impossible to write without these collaborations, although the views expressed in them are solely my own.

software components, and standard-setting processes that they do not control, and which have their center of gravity firmly set, for now at least, in OECD countries. Understanding the structure and dynamic of the ICT sector helps explain this paradox. Thus, by examining the ICT sector, we can see where China's and America's sense of vulnerability through interdependency intersect and clash.

One conclusion from the empirical deep-dive is to illustrate that while China possesses some key capabilities that expose America (and our allies) to vulnerabilities, China's dependency on the US and US-allied countries is far greater. As such, China's sense of vulnerability and insecurity is substantially elevated. This is confirmed in Section 3 which offers some insights into China's *perceptions* of technological and supply chain vulnerability, as well as China's concrete *policy* actions. These include both longer term trends in Chinese industrial policies (since early 2000s), as well as more recent reactions to American policy and world events (since 2018).

Broadly speaking, Chinese policy should be interpreted as 'defensive' and 'reactive,' and derived from their perceptions of vulnerability. While mostly harmful, China's long-standing industrial policies are aimed as much at reducing vulnerabilities from dependency on foreign technology in critical supply chain links (e.g. semiconductors), as they are aimed at enhancing China's overall economic development, or solving particular political goals (stability) or social challenges (e.g. demographic, epidemiological or environmental). Of course, they also sometimes aim at very disturbing goals, like state surveillance which have human rights implications for China and other countries. Nevertheless, China's long-standing goal of 'catching up' in critical technologies, and even their more recent aims of technological 'leap frogging,' are driven by deep-seated insecurities around foreign control over technology-intensive supply chains.

Furthermore, China's insecurities have intensified since trade and technology frictions became elevated in 2018, followed by the massive supply chain disruptions of COVID-19 and interminable lockdowns in China, which have raised alarms in the United States about inflation and dependence on China's export manufacturing sector. Most recently, these have further heightened with the unprecedented coordination among allied countries to impose economic sanctions on Russia and Belarus. These events have reaffirmed China's sense of vulnerability, offered positive affirmation to the policy perspectives of security-oriented bureaucrats in China, and will likely lead China to double down on its already extensive industrial policies to achieve 'self-reliance' in key technologies and critical links in supply chains. While China certainly creates and amplifies these worries to the point of paranoia, the fact of the matter is that there is a deep sense of insecurity in China, which crosses over into techno-nationalism, and other forms of nationalism. Predictably, China's nationalism only makes their circumstances worse, but it can also distort America's foreign policy reactions.

The data on ICTs (Section 2) and analysis of Chinese policies and perceptions (Section 3) lead to another conclusion: China's more aggressive and autarkic industrial policies are likely to fail, though not without inflicting damage on its own economy, and more importantly, on America and our allies. Thus, it is in our own national interest to find a way to reduce China's sense of insecurity, while also enhancing overall US security. Unequivocally, the goal of the American government is always to achieve American national security goals. However, America's sense of security is partly a function of China's sense of security. If China feels insecure, its policy choices will be reactive and harmful to US interests, such as many of its value-destroying industrial policies. In turn, Chinese policies and political rhetoric will enflame American perceptions of China's policy goals. If, in reaction, American policy also becomes knee-jerk and unnecessarily bellicose, then we will all be worse off. In a word, we are interdependent with a rising power and we need to get our policies right. As Dr. Joseph Nye sagely writes, "Thucydides famously attributed the Peloponnesian war to two causes: the rise of a new power and the fear that an established power creates. Most analysts focus on the first half of his statement, but the second is more within our control."[3] While supply chains are incredibly complex and increasingly geopolitical, with appropriate policy nuance, there are positive-sum outcomes that can be accomplished by building institutions to promote transparency and confidence-building within critical supply chains. These will require the US to employ both carrots and sticks, both bilaterally with China as well as with our allies, as outlined in Section 4 on policy recommendations.

While I propose five specific policy recommendations, as a general rule, our supply chain goals should aim to achieve security *and* openness *and* prosperity. There is no law of nature which says that we must choose between them, and so policy making should at least attempt at a trifecta. Furthermore, to achieve this, we must eschew counterproductive labels that brand policies as 'hawkish' or 'dovish' towards China, such as the debate over maintaining or removing Trump era tariffs. We should acknowledge that the CCP and Chinese leadership will pursue what is in their perceived interests. Thus, US policy should work hard, along with our allies, to shape China's external environment and mold China's perceptions, so that they naturally and willingly behave in ways that are in America's national interests. Both hawk-like and dove-like policies will be needed to achieve this broader strategy.

2. Vulnerability, Security and the Supply Chain Challenge

Supply chains have become increasingly important objects of analysis for businesses, NGOs, governments and academics. However, there is no single definition or way to characterize them, and there is no common nomenclature, with even the term 'supply chain' itself contested.[4] While every analyst has their own research goal (and hence definition), broadly speaking, *supply chains are all of the activities performed by firms and workers in bringing a product from initial conception to final end-use.* This includes research and development (R&D), design, production, distribution, marketing, retail and even recycling. While this definition and the metaphor of a 'chain' may imply that they are always 'linear,' in fact, this is purely an artifact of the very high level of abstraction of this definition.[5] Others prefer 'network' metaphors,[6] and in the ICT sector, my collaborators prefer 'ecosystems.'[7] Below, I introduce the concept of 'massive modular ecosystems' which we developed to analyze ICTs, one focus of my testimony.

It is now clichéd to state that 'supply chains are complex.' What matters more is that each supply chain is complex *in its own way*, and so there is no one-size-fits-all way to analyze them or recommend policy. While there may be some broad similarities between supply chains at the sector-level (food, mining, transportation equipment, business services), it is usually more productive and insightful to dig deeper to the industry-level (wheat, copper, automobiles, legal services). Ultimately, however, each product is organized in its own way. This became evident during the COVID-19 pandemic when shortages of each type of PPE (medical masks, gowns, gloves, ventilators, etc.) had to be managed in different ways by hospitals and governments due to their unique supply chain structures.[8] Even within products, each 'lead'

[3] Nye Jr, J. S. (2020). Power and interdependence with China. *The Washington Quarterly*, *43*(1), 7-21, p. 14.
[4] For instance, 'supply chains' is often the term used in management and operations literatures that offer advice and analysis for companies to enhance efficiencies through improved 'supply chain management.' The term 'global value chains,' by contrast, is more expansive and more political in that it includes the strategic interactions between firms that determine how the division of labor between firms is constructed, and who creates and captures 'value.' For GVCs, see Gereffi, Humphrey and Sturgeon 2005.
[5] Given the sheer complexities of supply chains, this sort of abstraction and simplification is a necessity for insightful research.
[6] Coe, Neil M., and Henry Wai-Chung Yeung. *Global production networks: Theorizing economic development in an interconnected world*. Oxford University Press, 2015.
[7] Thun, Taglioni, Sturgeon and Dallas, "Massive Modularity: Understanding Industry Organization in a Digital Age," 2022.
[8] Dallas, Mark P., Rory Horner, and Lantian Li. "The mutual constraints of states and global value chains during COVID-19: The case of personal protective equipment." *World Development* 139 (2021); Gereffi, Gary. "What does the COVID-19 pandemic teach us about global value chains? The case of medical supplies." *Journal of International Business Policy* 3, no. 3 (2020): 287-301.

firm that manages a supply chain will vary in its size, organization, and business and governance practices. In a word, the closer to the ground that one looks, the more accurate one's understanding of supply chains and the more effective policy will be. However, this will require upgrading of government expertise.

Furthermore, many supply chains change fast, due to market forces, technology changes, government policy, and even the media (e.g. forced labor in Xinjiang cotton). The sheer diversity, complexity and speed of supply chains pose further problems for policy-makers, as discussed in the final section.

The remainder of this section briefly offers a non-technical but deep-dive into one segment of the ICT sector. There are three main takeaways:

(i) Supply chains have multiple and complex layers and links, each layer has its own distinct organization and they interlink with each other in varied ways. These details matter.

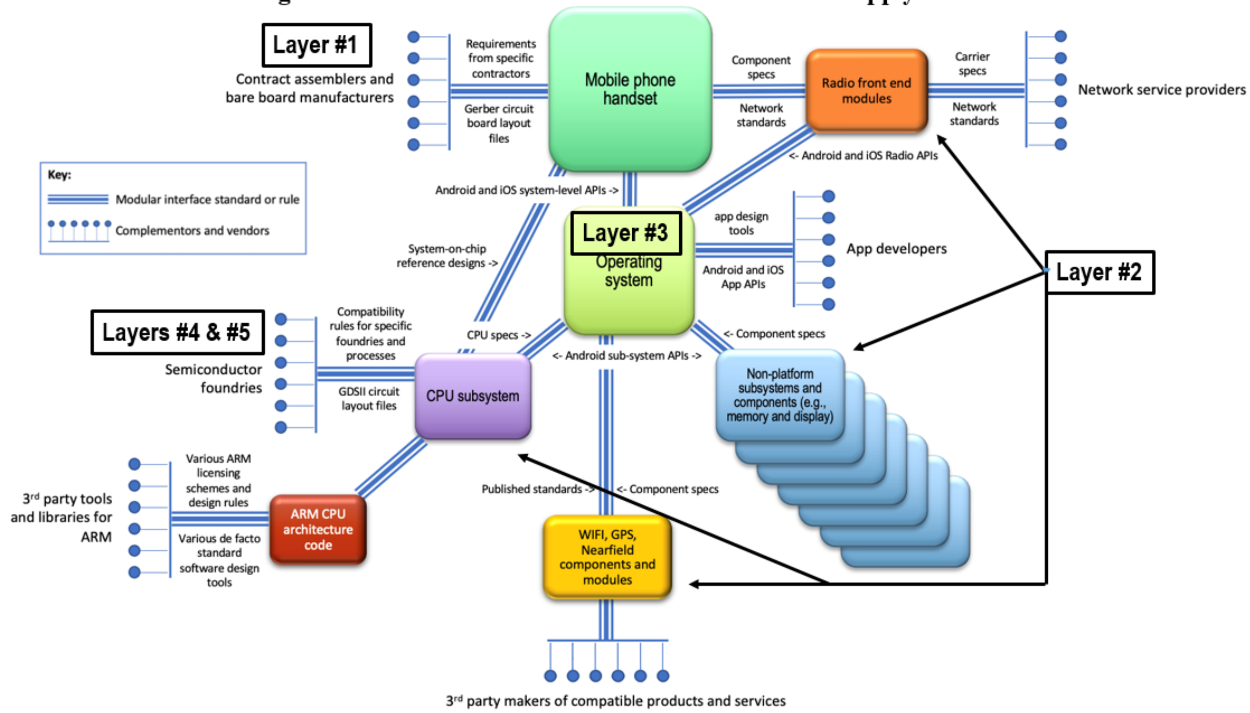
(ii) There can be extreme levels of country-level (and firm-level) specialization which generates interdependencies between countries and companies. Thus, the US is dependent on and possesses vulnerabilities with many countries and companies, not just Chinese ones.

(iii) China's position in supply chains is highly uneven, but in most ICT supply chains and layers, China's position is weak. This matches China's own sense of vulnerability in ICTs, which drives forward their industrial policies. But it is also paradoxical because this is the sector in which the US perceives China to be strongest, with Huawei as a prime example. The paradox is resolved because it depends on which layer and which 'link' within the layer one chooses to look. A strong argument can be made for Chinese strengths or weaknesses, depending on where one wishes to look. Again, the details matter.

Figure 1 is a simplified abstraction of a smartphone supply chain. For the purposes of this testimony, I will briefly focus on only five 'layers' in the ICT stack (labelled #1 to #5 in Figure 1), as well as the double-band links that connect the various boxes. On the outer edges of Figure 1, each 'branch' links to other dimensions and layers in the ever-expanding ICT ecosystem. Furthermore, Figure 1 represents only one device (smartphone), which itself is embedded within much larger systems, some of which consist of critical infrastructure. In other words, many more layers and links would need to be added to understand the full complexity of mobile telecommunications, something which my research collaborators call a 'massive modular system' (MME).[9] A very short list of additional layers might include telecommunications equipment and infrastructure, internet infrastructure, cloud computing (increasingly important in 5G era), among others, each of which would require their own simplified abstraction similar to Figure 1. Some fork-shaped branches also link to consumer platforms such as the Apple or Google app stores where everyone downloads apps, and innovation platforms, such as those offered by semiconductor foundries, like TSMC. These are massive modular ecosystems onto themselves, and not covered here.

[9] Thun, Taglioni, Sturgeon & Dallas, "Massive modularity: Understanding industrial organization in a digital age," 2022.

Figure 1: An Abstraction of a Mobile Phone Handset Supply Chain



Source: Thun, Taglioni, Sturgeon & Dallas, "Massive Modularity: Understanding Industry Organization in a Digital Age," 2022.

Very briefly, *modularity is the partial decomposability of a complex system into distinct sub-systems which interoperate through standard interfaces, and thereby maintains system-level coherence and functionality*. It is especially prevalent in ICTs due to digitization, and it can occur in large-scale systems (e.g. internet) and micro-systems (e.g. semiconductors). In terms of supply chains, massive modularity generates three paradoxes: (i) products can be both extremely complex *and* produced at scale; (ii) they create extreme market concentration *and* also fragmentation; (iii) they combine geographic agglomeration *and* dispersion. All of these characteristics are illustrated in the data below.

Since smartphones are familiar to everyone, it is as good a 'layer' to start as any. I will briefly 'descend' layer by layer into the phone following Figure 1, and I will only focus on one dimension – the distribution of *market share by country*, because of its clear policy relevance and to highlight China's position in the MME. The country-level data are constructed by aggregating together firm-level data, in most cases based on the location of the firm's headquarters. [10]

Two brief observations before our deep-dive. First, in general, hardware is much easier to monitor and quantify and so there is a hardware-bias to this exercise. Nevertheless, it should be kept in mind that various types of software interpenetrate every 'box' in Figure 1 and often bind boxes together. Below, we only offer evidence of software for mobile operating system. Second, as briefly discussed below, the double-band lines between boxes consist of interoperability standards which also serve as critical 'glue' holding the industry together. The important point to remember is that most standards extend far beyond the smartphone itself, whether telecommunications standards (e.g. 3GPP) or internet standards (e.g.

[10] This has implications for geopolitics as well because governments have authority over the headquarters of companies. Of course, policy tools like the direct product rule extends American law beyond US-headquartered and US-located companies. In terms of business capabilities, most companies have a large share of their key assets and resources in the country where they are headquartered. Furthermore, company headquarter also serves as a proxy for a range of critical supply chain activities, often including product design, R&D, supply chain management, and core governance decisions concerning what, how, where and to whom to outsource, among other key activities.

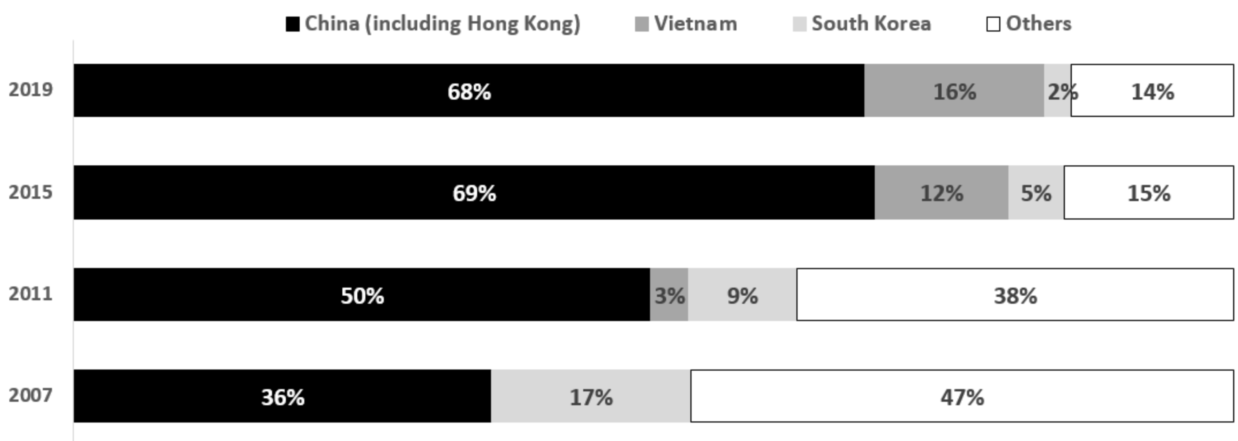
W3C). These are created in global, voluntary, consensus-based and industry-led organizations. But, other standards are created by dominant firms and thus are proprietary or semi-proprietary, such as Google Android operating system or ARM, the UK-based semiconductor IP company. Thus, standards are the invisible webs that not only tie the smartphone together, but ties the smartphone into many other ecosystems of equal complexity, and thus the following only scratches the surface. Interoperability standards are numerous and proliferating, and there is a risk they will become increasingly politicized.

Layer #1: Smartphone (system-level)

Figure 2 offers data on the locations where smartphones are manufactured and exported (2007-2019). That is, the countries where the smartphone assembly factories are located. I start with this layer because it is the perspective that is most commonly associated with China – a manufacturing and export powerhouse. Indeed, Figure 2 confirms this perspective: China's share of global mobile handset exports rose from 36% in 2007 to 68% in 2019. However Figure 2 does not represent the headquarters of the firms who own and manage the factories (such as Foxconn in Taiwan), nor the headquarters of the companies whose phones are being assembled (such as Apple in US). These data points would offer quite different perspectives on China's position in the supply chain.

Nevertheless, this still represents a significant vulnerability for firms (like Apple) who heavily rely on China-*located* factories. That said, due to interdependency, China is also vulnerable because the livelihood of millions of Chinese workers are reliant on assembly factories like these.

Figure 2: Layer #1 – Top mobile handset export shares by country, 2007-2019



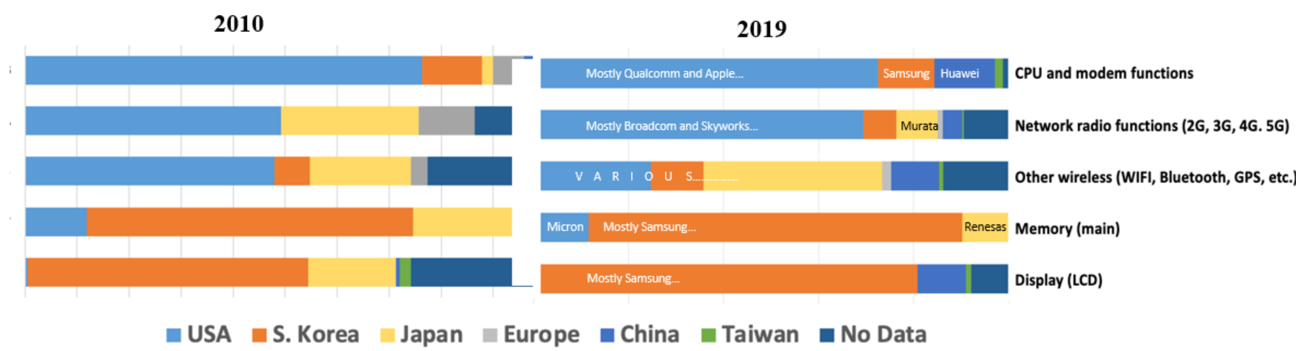
Notes: China includes Hong Kong based on the assumption that most handsets exported from Hong Kong are imported from the Mainland and re-exported, even though they are not reported as such. Export values are calculated are made by summing imports from all trade partners of each reporter.
Source: UN Comtrade, HS 851712 (Telephones for cellular networks or for other wireless networks), from Thun, Taglioni, Sturgeon & Dallas "Massive Modularity: Understanding Industry Organization in a Digital Age," 2022

Layer #2: Major Sub-systems (Modules)

If one were to open the outer casing of the smartphone, there would appear a hodge-podge of very tightly packed hardware components. For instance, the Apple iPhone XS Max (2018) has about 1,745 distinct components depending on how one counts them, but 94% of them cost less than US$0.10. By contrast, Samsung sold Apple the expensive touchscreen display for $110.40. These components are grouped together into major sub-systems or 'modules,' each of which does one major function (like the touchscreen). Figure 3 contains only a few of the most expensive and critical modules, such as the apps processor (main CPU), touchscreen display, memory, the radio frequency front-end module (that connects to the telecommunication system) and various other wireless connectivity.[11]

Figure 3 contains several noteworthy observations. First, most sub-systems are heavily concentrated in a single country, and the level of concentration has increased between 2010 and 2019. For instance, in 2019, 72% of CPUs and 69% of radio frequency module chips come from US-headquartered firms (e.g. Qualcomm and Qorvo, respectively), while 81% of displays and 79% of memory chips come from South Korea firms, such as Samsung and SK Hynix. Since a sub-system is essentially worthless unless it is integrated into a smartphone, these figures reflect a very high level of country specialization and global interdependence – something that every smartphone company (from Layer #1) must deal with. Second, by 2019, China has made a small amount of headway into these major sub-system, with 10% in displays and 13% in CPUs, which in the case of CPUs is almost completely driven by Huawei's fabless IC design subsidiary, HiSilicon. Huawei has followed in the footsteps of Apple and Samsung by bringing CPU design in-house over the past decade. Finally, Japanese and European companies have seen a diminished presence in Layer #2.

Figure 3: Layer #2 – Mobile phone sub-systems value and share by country, 2010 and 2019



Source: IHS Markit based on teardown reports of 456 handsets (average 38 reports per year)
From Thun, Taglioni, Sturgeon & Dallas, "Massive Modularity: Understanding Industry Organization in a Digital Age," 2022.

Layer #3: Operating Systems

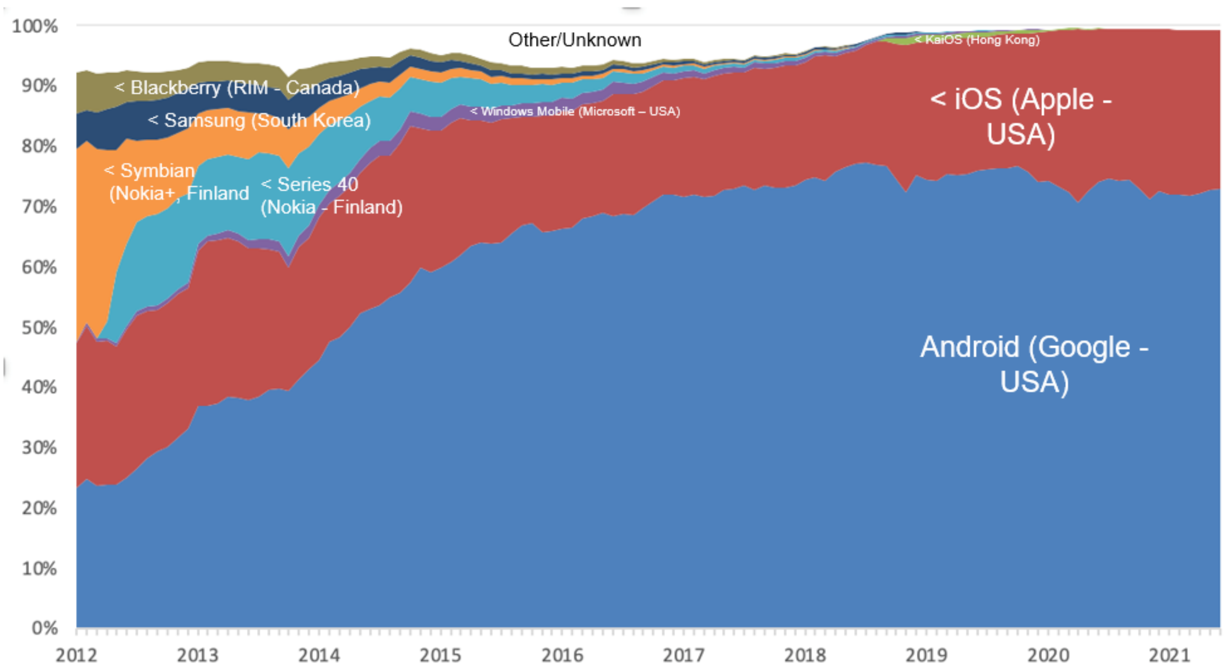
Figure 4 turns to the operating system of smartphones, which is our only insight into software, even though software interpenetrates all layers and components. Operating systems are platforms which contain standardized interfaces (called APIs) which are partially open and through which other companies interconnect with the platform (and with each other) to create and optimize their product. For instance, all of the companies supplying sub-systems in Layer #2 engage with the operating system. And the innumerable app developers all over the world who create the millions of apps that exist on Apple's App Store and Google Play (their respective app stores) must abide by a variety of standards, and go through a rigorous set of testing and verifications through the OS platforms.

Figure 4a shows that the period before 2014 exhibited diversity and competitiveness between mobile operating systems, with Finland's Nokia, Samsung's Tizen and Canada's RIM taking sizeable market shares. However, ultimately Apple and Google created a global duopoly of operating systems, due to the powerful network effects of their platforms. However, Apple iOS and Google's Android differ

[11] Mobile cameras are also very expensive modules which we have not included here, because the IHS Market dataset only gives the firm names of the assembler of the camera module (a layer), which is only a small fraction of the value-added of the camera. By contrast, the image sensors (a component of a lower layer) are some of the core components inside the camera module, and many of these are Japanese headquartered firms, like Sony.

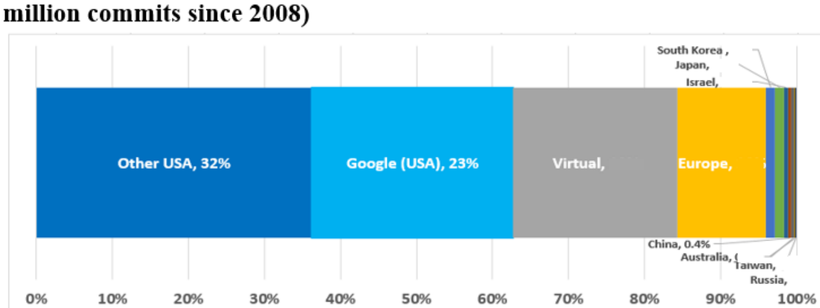
dramatically. While iOS is mostly proprietary, Google has constructed a very complex open-source software platform which allows any company in the world to participate in, contribute to, download and use, and even modify and customize the Android OS – completely for free. To illustrate the very different world of open-source software, Figure 4b reflects the country origin of the companies, non-profits and individual programmers who have contributed to Android's open-source software. While Google predictably contributed the most (23%), US-based software programmer contributed another 33%, with Europeans the only other significant regional contributor. Chinese organizations contributed only 0.4%.

Figure 4a. Layer #3 – Global Mobile handset OS market share, January 2012 – April 2021



Source: Statista based on StatCounter, which calculates OS data based on more than 1.7 billion page views per month worldwide. StatCounter defines a mobile device as a pocket-sized computing device - tablets are not included.
From Thun, Taglioni, Sturgeon & Dallas "Massive Modularity: Understanding Industry Organization in a Digital Age," 2022

Figure 4b: Layer #3 – Contributions (software code "commits") to Google's Android Open-Source Project (about 10 million commits since 2008)



Note: 'Virtual' includes private individuals and individuals who contribute to open-source organizations, but who do not have a formal employment relationship with the organization, such as Linux contributors.
Source: Android Open-Source Project (https://source.android.com/). Courtesy of Jing-Ming Shiu (National Cheng Kung University, Taiwan)

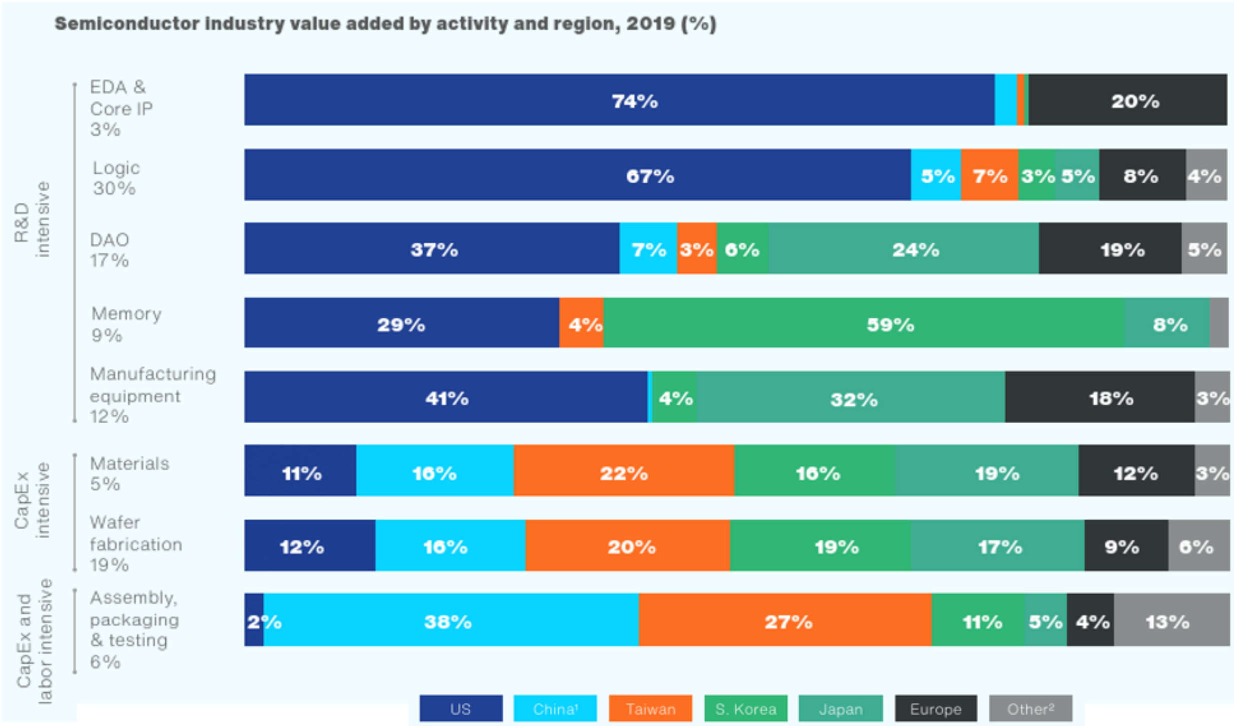
The significance of Android's open-source framework is not widely appreciated. For instance, the operating systems of China's largest smartphone companies (like Oppo, Vivo, Xiaomi and even Huawei) are all customizations (called 'skins') that derive from Android OS. In May 2019, Huawei was put on the US entities list and Google was prohibited from pushing OS updates and patches to Huawei, which over time slowly degraded all existing Huawei phones. In June 2021 and to much fanfare in China, Huawei released its own operating system, HarmonyOS, triumphantly announcing that it was "a milestone," with Huawei's head of software, Wang Chenglu, declaring that it was "neither a copy of Android nor [Apple's] iOS;" even Huawei founder and CEO, Ren Zhengfei declared, "in the software domain, the US will have very little control over our future development, and we have much more autonomy."[12] However, software engineers who explored Harmony OS after its release concluded that "HarmonyOS was identical to what Huawei ships on its Android phones, save for a few changes to the 'about' screen that swapped out the words 'Android' and 'EMUI (Huawei's Android skin) for 'HarmonyOS.'"[13] From a broader perspective, this means that 78% of China's smartphones have a (free, open-source) Google product at their heart, while Apple iOS has a 21% market share in China.[14] While Google's proprietary products exited from China in 2010, its open-source OS is ubiquitous there.

Layer #4: Semiconductors

Semiconductors are ubiquitous in smartphones (and all ICT devices), and they sit at the core of most of the critical components in the sub-systems of Layer #2, including the camera module, and the network and other wireless chips that communicate with the telecommunications system, the internet and other network infrastructures. Figure 5 contains data on all types of semiconductors (not just mobile chips), and it is very roughly organized as a linear supply chain. That is, the chain starts at the top of Figure 5 where the most upstream EDA software and IP cores provide critical inputs for fabless design houses,[15] which then design the myriad varieties of chips (logic, memory, OSD, etc.). Once the designs are set, they are passed off to be physically manufactured, which in Figure 5 encompasses 'semiconductor equipment,' 'materials' and ultimately the 'wafer fabrication' (or foundry). The final stage is 'assembly, packaging and testing.' Figure 5 shows that US firms are dominant in the upstream R&D, design and software-intensive segments, like EDA & IP (74%), logic designs (67%) and semiconductor equipment (41%). By contrast, with a 38% market share, China has entered the industry most significantly in the very last stage, which is capital and labor-intensive. They also have a foothold (16%) in the fabrication segment (e.g. SMIC). However, their leading foundries are two generations behind the leading-edge technology. For instance, in 2020, Taiwan's TSMC dominated 85% of the foundry manufacturing for the most advanced semiconductors (10-5 nm), with Samsung taking the remaining 15%. By contrast, China's leading semiconductor foundry, SMIC, just barely eked out 2 to 3% in the next (less advanced) tranche of semiconductor manufacturing (32-12 nm).[16]

[12] Celia Chen, "Huawei to roll out self-developed Harmony OS for smartphones next month, ending its reliance on Google's Android," South China Morning Post, May 25, 2021. https://www.scmp.com/tech/big-tech/article/3134783/huawei-roll-out-self-developed-harmony-os-smartphones-next-month
[13] Ron Amadeo, "Huawei officially replaces Android with HarmonyOS, which is also Android," Ars Technica, June 2, 2021. https://arstechnica.com/gadgets/2021/06/huaweis-harmonyos-will-rollout-to-100-android-models-over-the-next-year/
[14] Statista, "Market share of mobile operating systems in China from January 2013 to December 2021
[15] Fabless means they lack manufacturing facilities.
[16] Kathrin Hille, "TSMC: how a Taiwanese chipmaker became a linchpin of the global economy," FT, March 24, 2021.

Figure 5: Layer #4 – Semiconductor Supply Chain



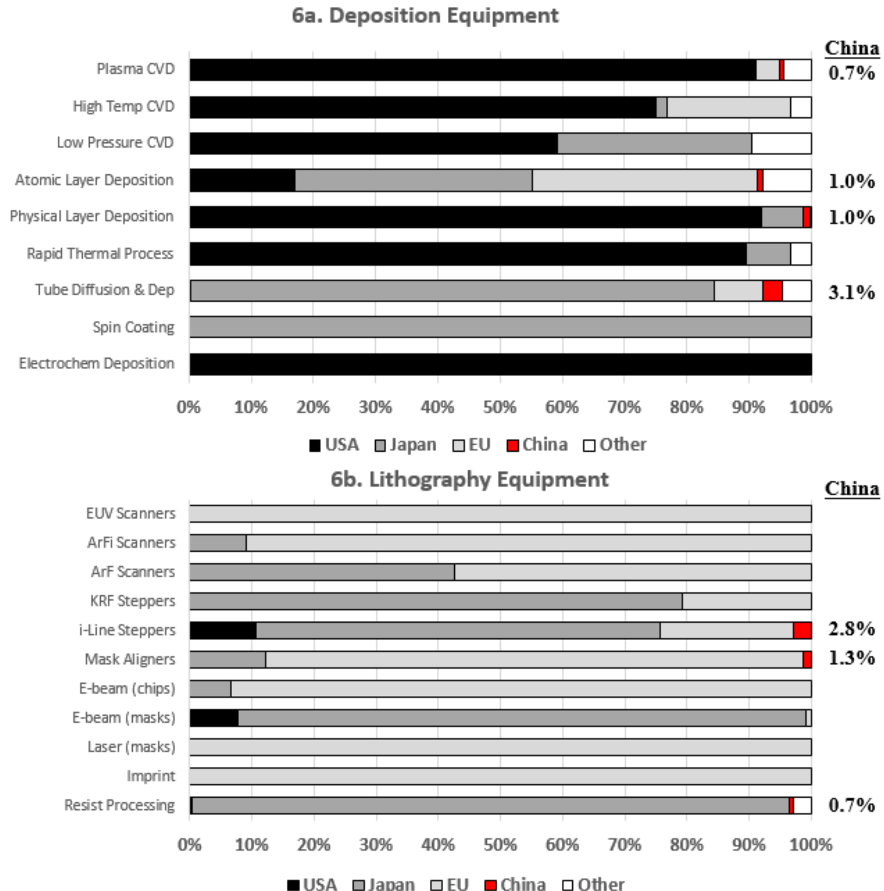
Source: Boston Consulting Group & Semiconductor Industry Association, "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era," 2021.

Layer #5: Semiconductor Equipment

As mentioned, in Figure 5, each 'bar' roughly corresponds to a 'link' in the semiconductor supply chain. Of course, each link can be further disaggregated in various ways. For instance, 'manufacturing equipment' contains a large basket of various machines through which silicon wafers pass through their long journey to become finished chips. Figure 6 offers just a small flavor, using only two categories of semiconductor machinery as examples. Figure 6a shows the country market shares of various 'deposition' machines and Figure 6b shows 'lithography' machines, which are two sequential tasks in the semiconductor manufacturing process. The point of this exercise is not to understand the technology,[17] but to appreciate the complexity and layering of the technology and to understand China's position in these different layers.

[17] Very briefly, however, semiconductor fabrication consists of creating many ultra-thin layers on a silicon wafer to create various miniscule electrical devices (like transistors) and then create a pattern of interconnects between them, forming a circuit. Deposition and lithography machines are some of the most advanced in this process. While there are many steps and types of machines, the rough division of labor is that deposition machines 'deposit' a thin layer of material, while lithography machines draw a pre-designed circuit pattern onto the layer.

Figure 6: Layer #5 – Semiconductor Manufacturing Equipment



Source: Adapted from Khan, Mann & Peterson "The Semiconductor Supply Chain" (2021), p. 30, p.36; Note: CVD: chemical vapor deposition

Figures 6a and 6b (Layer #5) have noteworthy features. US firms (like Applied Materials and Lam Research) are dominant across a range of deposition machines, but Japanese and especially European firms dominate in lithography (like ASML in Netherlands, or Nikon and Canon in Japan). Once again, the degree of country (and firm) concentration is very stark and hence the inter-country and inter-firm interdependencies are profound. Furthermore, China has almost no representation in the market shares, and in fact has less than 5% market share across *nearly all* semiconductor machinery categories, except for some assembly, packaging and test equipment segments.[18] It should be kept in mind that each machine in Figure 6 can be disaggregated further into component and parts (forming Layer #6, etc.). For instance, ASML (Netherlands) has a global monopoly on the most advanced photolithography machines (called EUV or extreme ultraviolet), which are used to fabricate the currently most advanced chips. Those machines alone contain over 100,000 parts, coming from 5,000 suppliers and cost $120 million each.[19] In a word, the layering and supply chains goes deeper and deeper.

Standard-setting: The glue that makes it stick.

As mentioned, standard-setting is the glue that holds many industries together. But, they are particularly important in ICTs because they ensure interoperability (such as allowing the billions of smartphones and

[18] Khan, Mann, & Peterson "The Semiconductor Supply Chain: Assessing National Competitiveness," Center for Security and Emerging Technologies, 2021.
[19] Carrick Flynn, "The chip-making machine at the center of Chinese dual-use concerns," June 20, 2020.

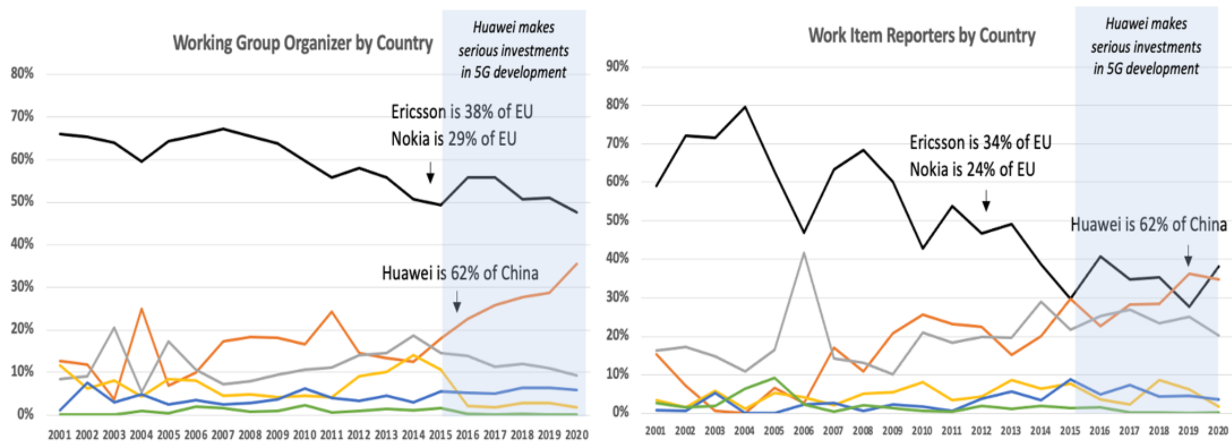
millions of mobile apps to communicate with each other) and they allow for modularity. Each layer of the mobile telecom (and general ICT) stack contains many standards. One careful study estimated there are between 250 and 500 distinct technical standards that go into a typical laptop computer[20] – in some ways, a less sophisticated product than a smartphone. These are created by a variety of organizations. For instance, one online repository contains over 1,100 distinct standard-setting organizations (SSOs) and standards consortia, most of them voluntary, consensus-based, industry-led, and many of them global. However, standards can also be set by dominant firms, like the Android and Apple operating systems, discussed earlier.

Standard-setting is a complex and diverse world unto itself, and so again, there is no one-size-fits all way to describe it. Nevertheless, one common tension in SSOs is that rival firms (e.g. Huawei, Nokia and Ericsson in telecom equipment) must find a way to agree on the most efficient standards. However, once a standard is finalized, some firms may possess an advantage because the standard may be based on technologies developed and most likely patented by a particular firm. In fact, in most SSOs, firms are required to declare when they have a patent which could later be infringed, which is called a standard essential patent (SEP). Given the potential of monopoly rents from SEPs, most SSOs also require that companies commit to offering their SEPs to other companies on "fair, reasonable and non-discriminatory" (FRAND) basis, which has legal weight in all major patent courts worldwide.

In the area of standard-setting in the mobile telecommunications industry, the central SSO is The Third Generational Partnership Project (3GPP). As Figure 7 shows, European firms have traditionally been leaders in mobile telecom standard-setting. But in recent years, Chinese firms (led by Huawei, but also including China Mobile, ZTE and others), have become increasingly important players in standard-setting, especially since around 2015. Chinese firms are now 'lead' sponsors in about one-third of work items (which turn into technical specifications and eventually national standards), and they hold leadership positions in about one-third of the work item committees. While beyond the scope of this testimony, it is important not to overly politicize one's conclusion from Figure 7. The conclusion is *not* that China or Huawei will soon dominate telecommunications standards and hence the industry; rather, the conclusion should be that Chinese firms have become important participants and collaborators in coming to international consensus over standards.[21] That said, there is always a risk that SSOs could become focal points of geopolitical struggle and thus lose their voluntary, consensus-based and industry-led approach. It boils down to *how SSOs are governed*, as discussed in Section 4. However, some government engagement may be helpful to ensure that profit-seeking companies are setting standards in the public interest.

[20] Biddle, Brad, Andrew White, and Sean Woods. "How many standards in a laptop? (And other empirical questions)." In *2010 ITU-T Kaleidoscope: Beyond the Internet?-Innovations for Future Networks and Services*, pp. 1-7. IEEE, 2010.
[21] As just one illustration of this, 3GPP requires a supermajority of participants (71%) to agree to a technical specification before it is finalized. So, Huawei standards cannot be imposed onto 3GPP, they must be effective. Most SSOs have a variety of institutionalized mechanisms to generate broad-based consensus.

Figure 7: Standards – Participation in mobile telecom interconnect standard setting by country (3GPP)



Courtesy of Jing-Ming Shiu (National Cheng Kung University, Taiwan)

<u>Summary</u>

This section offers a simplified but deep-dive into one ICT supply chain and it will be referenced later in this testimony. The key takeaways are:

(i) Supply chains are very intricately balanced, but more importantly, each supply chain is somewhat unique
(ii) There is substantial global specialization at nearly every layer in the ICT stack and this creates extreme interdependencies between companies and countries
(iii) With important exceptions, China's standing in the supply chain varies widely but overall, it is far more dependent on foreign and US capabilities than the reverse. As discussed next, this drives China's deep-seated insecurities regarding technological dependency on foreign countries, and pushes them towards a logic of 'self-reliance.'

These are important insights first because it demonstrates the policy challenges *for all countries*. It raises difficult questions for policy-makers with few concrete answers, such as:

(i) How and where can governments intervene in the supply chain to enhance security or for other worthy goals, without generating unintended consequences that excessively damage domestic constituents either upstream or downstream?
(ii) Will intervening in one link in the chain increase or decrease aggregate vulnerabilities? For instance, it is possible that reshoring in one link will reduce vulnerability in that segment, but then increase *aggregate* vulnerability since that link will have to create new supply chain links in order to remain commercially viable.
(iii) Does government have the necessary expertise to determine the cost-benefit analysis on a supply chain-by-supply chain basis? If not, what expertise and agency organization are needed to get supply chain policy right? Some of these are discussed in Section 4.

China equally is faced with these hard questions. However, despite China's important role in some supply chains, their rhetoric, perceptions and policies do not necessarily match a world organized by supply chains. This will have implications for China and its foreign economic relations.

3. Chinese Perceptions & Policies: Supply Chains, Critical Technologies and Interdependence

This section argues that indeed, there seem to be serious discontinuities between the reality of supply chain interdependence and China's perceptions and policies, such as its declared aspirations for 'self-reliance,' its techno-nationalism, as well as its concrete industrial policies. Furthermore, Chinese rhetoric can diverge from policy. But, before we turn to this, it is important to clarify a few points. First, it is difficult to separate out China's industrial policies and supply chains. Although Chinese policies generally do not explicitly declare a policy to be for 'supply chain security,' many of their stated goals for 'self-reliance,' 'self-strengthening,' or 'indigenous innovation,' all have important supply chain implications, particularly industrial policies with specific targets. Thus, many Chinese policies are *de facto* supply chain policies, without naming them as such.

Second and related, China's political rhetoric and its accompanying industrial policies should not always be interpreted through the lens that China's goal is invariably 'autarky,' or to achieve 'absolute advantage' in competition with foreign countries. For instance, some version of 'self-reliance' has been in the Chinese political lexicon since at least the Mao era (*zili gengsheng*, self-reliance), and continued into the Deng era (post-1978). More recently, it became focused on innovation in the Hu-Wen era (*zizhu changxin*, indigenous innovation), Made in China 2025 (*zizhu baozhang*, indigenous guarantees) and most recently (*zili ziqiang*, self-reliance, self-strengthening). Thus, it has been a common theme through CCP history, despite the epochal changes in China's policies, politics and economy over these eras. Since the Deng reforms in 1978, the same can be said about China's optimistic sloganeering towards 'international cooperation and collaboration,' which may appear in many leadership speeches and policy documents, even when reality may differ on the ground. Thus, much nuance must be applied to differentiate Chinese political rhetoric and sloganeering, and its underlying policy approach which not only continues to evolve but can be self-contradictory.

Together, both of these ideas highlight that it is important to differentiate general and high-level political and policy objectives from the details of Chinese policy and practices. Chinese policies can be incredibly detailed (when they want them to be), for instance targeting very narrowly defined industries or even products and technologies. But, at other times, they can appear very broad and vague, lacking clear, stated purposes. Clearly, the specific and targeted policies are more relevant to supply chains and easier to interpret than broader rhetoric and goals. However, they both matter, and may not always be aligned.

It is impossible to reflect in any summary way the views of the Chinese party-state over time, given bureaucratic and regional differences, and changes over time. The concept 'fragmented authoritarianism' has been perhaps the most enduring metaphor in the study of Chinese politics, and for good reason.[22] As such, any selection of quotes is unsystematic and cannot represent China as a whole, partly because China is not monolithic. Nevertheless, statements by Chinese leadership hold special importance and should be taken seriously, even if local realities diverge from central pronouncements. However, in this section, I report on research with my research collaborators,[23] which use systematic data from Chinese newspapers. Drawing from half a million media articles from over 650 Chinese newspapers between 2005 and 2021, systematic media data offer a birds-eye perspective to complement perceptions of leadership through their speeches or bureaucracies through policy documents.

[22] Lieberthal, Kenneth, and Michel Oksenberg. *Policy Making in China*. Princeton University Press, 1988; Mertha, Andrew. "“Fragmented authoritarianism 2.0”: Political pluralization in the Chinese policy process." *The China Quarterly* 200 (2009): 995-1012; Tan, Yeling. *Disaggregating China, Inc.* Cornell University Press, 2022.
[23] Yeling Tan (University of Oregon), Abraham Newman (Georgetown University) and Henry Farrell (Johns Hopkins University).

There are four high-level conclusions from this section:

(i) Chinese anxiety concerning "technological security" and "economic decoupling" have clearly become more salient in recent years. In addition, there seems to be a lasting step-change, particularly after key events, such as the Snowden revelations in 2013, the various post-2018 denial orders placed on ZTE and Huawei, and finally COVID-19. Almost certainly, the Russian sanctions have reinforced this trend, though we have not collected new data.

(ii) Many of China's foundational economic and technological security concerns pre-date these events and even pre-date Xi Jinping. Thus, we have to be careful not to overemphasis events of the more recent past (5 to 10 years), and thereby forget important continuities concerning China's sense of economic and technological insecurity from prior periods, that predate Xi and even predate the global financial crisis when China's economy and industrial policy took a dramatic turn.

One way to square the circle is that China's insecurities regarding foreign relations and foreign influence have long existed below the surface (hence the perpetual CCP rhetoric of 'self-reliance' since Mao). But more recent events have tapped into China's long-standing insecurities and Xi has given greater voice to them (for instance concerning technological dependency and information security), thereby empowering security-oriented voices in China.

(iii) Despite China long harboring dreams of self-reliance and breaking from foreign dependencies in technology, in recent years, there do seem to be identifiable changes in their industrial policies, starting in 2006 and evolving since then. These changes include: 1) more resources allocations for industrial policies, 2) greater precision in their industrial targeting, and 3) a greater focus on upstream or infrastructural ICT sectors (5G, internet, AI, semiconductors, data) which are perceived to allow China to 'leapfrog' into the technological frontier. The policy precision can also be seen in newer instruments of Chinese economic coercion.

(iv) Chinese industrial policies have disturbing implications, and can distort technological innovation, however, our deep-dive in ICTs suggests even a partially autarkic approach will likely fail. That is, there is a fundamental conflict between China's policy goals and the structure of global supply chains. Unfortunately, China perceives its security as assured through 'self-reliance' and internalizing supply chains through industrial policies. But global innovation is so modularized, decentralized and interdependent, that China's two goals clash. China will likely have to choose between self-reliance and catching up to the global leading edge in most technologies.

3.1 Chinese Perceptions: Mass Media and Leadership

Based on research with my collaborators, we show that China's perceptions (through news media and through leadership and other speeches) have fundamentally shifted in recent years, often in response to unexpected, external events, including the Snowden revelations, the Trump administration's denial orders against ZTE and Huawei, and COVID-19, all of which caught China by surprise. The two figures in this section contain data on over 500,000 news articles from over 650 Chinese newspapers of varying types between 2005 and 2021.[24] The news corpus includes only news articles with at least one of three

[24] Most of the corpus is state-run media (with a small amount of private news), but we differentiate newspapers according to central government, provincial/local government and quasi-governmental (e.g. industry association) newspapers, as well as newspapers that focus on economy and industry, science and technology, security, general readership and specialized topics.

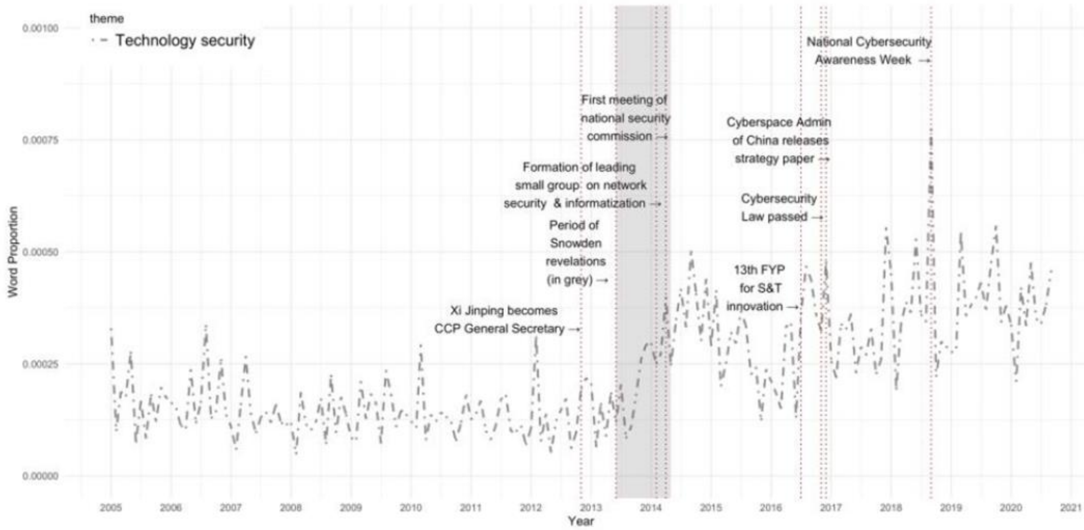
"technology" keywords[25] in the title, which ensures that we only select technology-focused articles. Finally, we focus on the prevalence in the news of two themes: "technology security" and "economic decoupling."[26] The figures are not simply absolute word counts, since there almost certainly has been a great increase in the number of newspapers and news produced over the fifteen year period. Rather, they are word ratios that count the words occurring in each theme *as a percentage of the total number of words* in all articles for the same month, which thereby standardizes the occurrence of keywords over time. Of course, there is always a gap between state-run media and Chinese leadership, so despite the systematic nature of our data collection, this should not be interpreted as reflective of universal agreement on the part of the Chinese central government, the CCP, let alone society at large.

China's "Technology Security": Snowden Revelations and China's Changing Perceptions (2013-)

Figure 8 shows the prevalence of "technology security" issues over time, and benchmarks the changes relative to the Snowden revelations that hit the global media in June 2013, as well as relevant policy and administrative changes in China. Clearly, the Snowden revelations triggered a heightened focus on 'technology security.' However, the heightened attention to technology security is not temporary. It continues to persist for many years afterwards, creating a semi-permanent change in perspective. Notably, this step-change occurs *over half a year after* Xi Jinping became General Secretary of the CCP. Furthermore, it appears that the Snowden revelations set in motion a flurry of policy and institutional changes. Soon after the Snowden revelations, the CCP formed the Leading Small Group on Network Security and Informatization, chaired by General Secretary Xi Jinping himself. The creation of this high-level body is indicative of the importance attributed to technology policy by the Party, and allows the leadership to overcome bureaucratic competition over network security issues and streamlines policy-making.[27] In August 2013, at a national work conference on propaganda thought, Xi portrayed the issue as an inter-civilizational struggle, stating: "Anti-Chinese forces in the West have always endeavored to take down China with the internet. … From America's PRISM and the XKeyscore surveillance plans, it's clear that their internet activity ability and scale have far exceeded people's imagination."[28]

[25] These are 'innovation,' 'science & technology,' and 'technology.'
[26] For "technology security," we count instances in the body of the article for: "information security" (信息安全), "network security" (网络安全), "data sovereignty" (数据主权). For "decoupling," we count for: "chokehold" (卡脖子), "self-reliance" (自力更生), "domestic circulation" (国内大循环) "indigenous research" (自研) and "technology self-sufficiency" (科技自立).
[27] Segal, Adam. "China's New Small Leading Group on Cybersecurity and Internet Management." *Forbes Asia, February* 27, 2014.
[28] Wang chuan Xi Jinping 8•19 jianghua quanwen: Yanlun fangmian yao gan zhua gan guan ganyu liangjian, *China Digital Times*, Nov 4, 2013.

Figure 8: Chinese media reporting on "technology security" and the Snowden effects



Note: These record word ratios, or the share of words associated with "technology security" as a share of total words in the media corpus, by month.
Source: Tan, Dallas, Newman & Farrell, "Driven to Self-Reliance," 2022.

Soon thereafter and in quick succession, the Cybersecurity Administration of China (CAC) was created (2014), the State Council authorized the reestablishment of the State Internet Information Office (2014), the National Security Law was passed (2015), the Cybersecurity Law was passed (2016) and CAC issued a cybersecurity strategy (2016). Foreign supply chains were also singled out. Former PLA colonel Liu Jinghua argued, "what we read from the Snowden files showed that almost all the big companies in China were actually collaborating with the American intelligence agencies…That made China feel really insecure using all these components from American companies."[29]

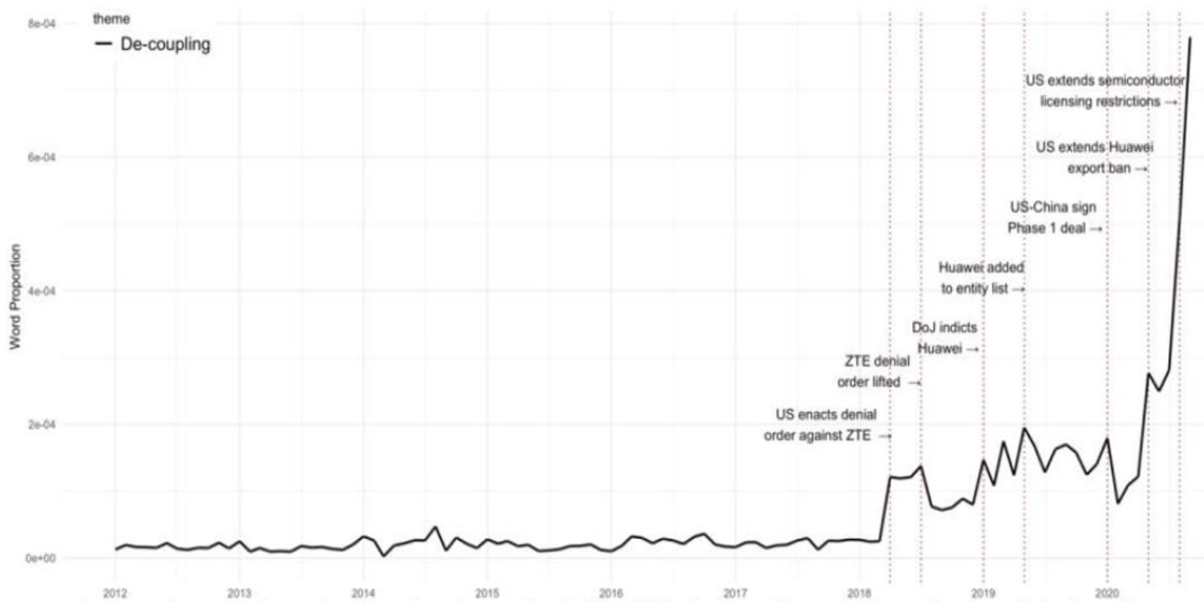
Despite all this, one should not jump to the too easy conclusion that the Snowden revelations "caused" this flurry of activity, in that China would have done none of this, save for Snowden. After all, it may very well be true that in 2013, Xi was at heart a strong advocate of enhancing Chinese security and intended or eventually would have deepened government cybersecurity oversight. Nevertheless, the policy and organizational outcomes arguably could have been different. As former US Ambassador to China, Max Baucus, concluded, "The Snowden leaks dramatically changed Chinese policy towards the internet, its own people, the United States, and the world, with respect to the internet and cybersecurity...It was a watershed development."[30]

"Economic Decoupling": Denial Orders against Huawei and ZTE and Chinese Perceptions (2018-)

A second major set of shocks and one at the heart of supply chain security came in quick succession with a denial order on the sales of US technology to Chinese telecommunications company ZTE (April 2018), the addition of Huawei to the entity list (May 2019) and the application of the direct product rule to Huawei (May 2020). In all cases, Chinese media surrounding "economic decoupling" (including terms like "chokeholds" and "self-reliance") all become elevated and remain elevated.

[29] Eli Binder and Katrina Northrop, 2020, "The Snowden Effect," The Wire China, December 6.
[30] Eli Binder and Katrina Northrop, 2020, "The Snowden Effect," The Wire China, December 6

Figure 9: Chinese media reporting on "economic decoupling" and the ZTE and Huawei Incidents



Note: These record word ratios, or the share of words associated with "economic decoupling" as a share of total words in the media corpus, by month.
Source: Tan, Dallas, Newman & Farrell, "Driven to Self-Reliance," 2022.

A whole slew of articles in April 2018 highlight the conundrum of being "choked" through technology dependence on US firms. One example is an article in *Science and Technology Daily* entitled "We cannot access core technology through begging for alms," which is a phrase previously used by Xi Jinping, in which Xi concludes that "we need self-reliance." China's *People's Daily* pinpoints particular vulnerable links in China's supply chain, stating, "(w)e urgently need to open a new wave of indigenous innovation in a global perspective, so that chips, operating systems, high-end manufacturing equipment and other core areas are no longer subject to the hidden concerns of being 'choked.'"[31] Other articles even from economically liberal leaning perspectives are worth quoting in full, since they question China's own long-held policy of reform, openness and integration into supply chains, arguing now for technological self-reliance:

> "In the past, some views held that with the current state of globalization, the world economy is already a highly integrated industrial chain - and that with the division of labor between countries, a country does not need have mastery over all the key core technologies. In other words, as the saying goes, "it's better to buy than to build, and it's better to rent than to buy." However, harsh reality tells us that with today's rampant trade protectionism and anti-globalization, if a large country does not hold the key technologies of important industries in its own hands, it will often be subject to "targeted attacks" by others, leading the relevant industries and enterprises to face a crisis of survival." … "Lessons from reality have repeatedly shown that technology involving the core competitiveness of a country cannot be bought by money, and the path of exchanging market for technology is also not feasible. We have to abandon such illusory thinking. Only by mastering key core technologies can we truly become an industrial and economic powerhouse."[32]

Of course, the rhetoric of self-reliance skyrockets once COVID-19 hits global supply chains. This is true even though we removed all articles referencing COVID-19 from our dataset in an attempt to neutralize its influence. But, clearly, the Chinese media had already been primed to frame issues as "self-reliance" and "decoupling," and COVID-19 strongly reinforced their prior beliefs. After the start of COVID-19 and during the direct product rule imposed on Huawei, Xi announced a broader strategy centered on the domestic market which incorporates ideas of both a consumption-led economy and self-reliance,

[31] http://opinion.people.com.cn/n1/2018/0425/c1003-29947992.html
[32] *Yi zizhu chuangxin shixian guanjian lingyu zhanlue xing tupo, Jingji cankaobao*, May 21, 2019.

encapsulated in the concept of "dual circulation." This concept was enshrined in Chapter 4 of China's 14th five-year plan in 2021, and can be seen as a continuation of a very long line of policies focused on 'self-reliance,' which will be discussed in the next section. Dual circulation is considered to be a "new development pattern" in which the domestic market is dominant and is supported by the external market.

China's continued lock-downs, most recently in Shanghai and Beijing, the closure of its border and even Xi Jinping's halting of his own in-person international diplomacy all reinforce an inward turn in China and shift towards self-reliance.

3.2 Chinese Industrial Policies and Supply Chains

News media and speeches by Chinese leaders may simply be an intricate dance between the pronouncements of elite leaders, mass propaganda and Chinese nationalism. Policies offer different insights into the intentions and goals of the Chinese party-state, though they too are not fool-proof insights. This final section focuses on Chinese industrial policies. Since that is a very large topic, it will largely focus on issues relevant to supply chains. Of course, the main link between Chinese industrial policy and supply chains is the key theme of this testimony – China's insecurities concerning dependency on foreign technologies drive their goals for self-reliance, which have implications for both technology and supply chains.

A primary conclusion is that although China has long harbored dreams of self-reliance, there has been a distinct shifted in its industrial policies over the past 10 to 15 years, and these changes have supply chain implications. In particular, the section highlights that: Chinese industrial policies have very substantial financial backing, they are more 'precise' in their targeting and they are aimed at 'leapfrogging' into emerging technologies, rather than the more typical and modest industrial policy goal of 'catching up,' which was the Japanese and South Korean strategy in the 20th century.

There are two further implications of this. First, even though Chinese industrial policies have evolved over time, these changes pre-date Xi Jinping (2012) and pre-date the 'Made in China 2025' program (2015), which received a lot of attention in the US and Europe. Second, the enhanced funding, improved targeting and focus on emerging technologies does not mean China will be successful. As Section 2 demonstrates, the geographic and organizational nature of critical supply chains suggest that China will have *to choose* between self-reliance and reaching the technological frontier. While costly, it is possible for China to achieve relative technological security through self-reliance, but they will likely trail the technological cutting-edge. At least in ICTs, the technological ecosystems are just too complex, too layered, too modular, and too dynamic for any country to try to internalize even one 'complete' supply chains, let alone the whole (and expanding) ICT stack.

It is impossible to do justice to Chinese industrial policy in a few paragraphs, but luckily, there is broad agreement about the basic contours.[33] First, industrial policy can have multiple meanings, but a narrow definition is: "measures and programs undertaken by governments to **shape the sectoral structure of the economy through channeling resources** into selected "pillar", "strategic" or "emerging" industries while

[33] The following offer excellent insights into China's most recent industrial policies (and S&T) policies since 2006: Heilmann, Sebastian, and Lea Shih. "The rise of industrial policy in China, 1978–2012." *Harvard-Yenching Institute Working Paper Series* 17, no. 7 (2013): 1-24; Heilmann, Sebastian, and Oliver Melton. "The reinvention of development planning in China, 1993–2012." *Modern China* 39, no. 6 (2013): 580-628; Chen, Ling, and Barry Naughton. "An institutionalized policy-making mechanism: China's return to techno-industrial policy." *Research Policy* 45, no. 10 (2016): 2138-2152; Naughton, Barry. *The Rise of China's Industrial Policy, 1978 to 2020*. Universidad Nacional Autónomica de México, Facultad de Economía, 2021; Sun, Yutao, and Cong Cao. "Planning for science: China's "grand experiment" and global implications." *Humanities and Social Sciences Communications* 8, no. 1 (2021): 1-9.

– ideally or purportedly – preserving market competition and firm-level decision autonomy in the targeted sectors." [34] Of course, within this definition, there can be much variation. Thus, it excludes resources that improve public goods that are shared broadly across industries, such as education, basic and public R&D, most infrastructure, among others.

Even though China's 'reform and opening' policies were the driving forces of the post-1978 Deng era, proponents of industrial policy were still active.[35] As China entered the WTO (2001) and with the transfer of power to the Hu-Wen administration (2002), the green shoots of industrial policy began to appear, which came to fruition with the Medium and Long-term Plan (MLP) in 2006. The centerpiece of the MLP consisted of 16 Mega-projects and 6 Mega-science programs,[36] and it introduced the concept of 'indigenous innovation,' which spurred a whole slew of 'indigenous innovation' policies on government procurement, taxes, accreditation, IPR, cyber, etc. But, it was not until the global financial crisis that China really opened the funding floodgates for the Megaprojects, and thus industrial policy took root.[37] By 2010, China had developed the Strategic Emerging Industries plan (which fed into China's 12th five year plan, 2011) which was better funded than MLP, had many detailed sectoral plans associated with it and attempted to attract private capital. Then, starting in 2015, a series of plans and strategies (timed around the 13th five-year plan, 2016) centered on targeting new emerging technologies. These included the well-known Made in China 2025 (2015), but also Internet Plus (2015), and specialized plans on Artificial Intelligence (2017) and Military-Civil Fusion (2017) and semiconductors (2014). At the heart of these is the 13th five-year plan and the Innovation-Driven Development Strategy (2016).

However, plans are only pieces of paper. What differs since 2006 is the sheer quantity of resources that are being pooled, especially since the global financial crisis. It is not easy to find or properly interpret data on industrial policy funding. A recent effort by CSIS tries to calculate the size of Chinese industrial policy funding and compare it to other countries (South Korea, France, Japan, Germany, US).[38] While it is extremely difficult for anyone to estimate, they carefully classify industrial policy funding into ten distinct channels and find that China's funding far exceeds any other country in the world. In 2019, as a share of GDP, China's industrial policy funding was 1.73% of GDP, while the next highest spender was South Korea at 0.67%, using their methodology. The United States was 0.39%. Looking at just one of these channels (government guidance funds, GGFs), Dr. Barry Naughton finds that they skyrocketed from 2015 to 2018, and that by 2020, 11 trillion RMB (US$1.6 trillion) was committed, however only about half of that was funded, and even less actually invested. Still, the sums are enormous. GGFs carry on the tradition in China of combining state guidance with market incentives. In essence, they try to replicate venture capital funds by investing in start-ups (but more patiently), and in theory are supposed to be profit-seeking with managerial incentives. However, the funds overwhelmingly derive from government or government-directed entities (including state banks and SOEs) and are guided by government objectives, such as industrial policy in strategic industries (but not exclusively them).

[34] Emphasis added, from Heilmann and Shih 2013, p.1. The second half, concerning 'preserving market competition and firm-level decision autonomy' differentiates it from a planned economy. The degree to which firms are autonomous in China and their investment sources is what differentiates China's recent industrial policies from the classic cases of industrial policy in Japan and South Korea.

[35] Heilmann, Sebastian, and Lea Shih. "The rise of industrial policy in China, 1978–2012." *Harvard-Yenching Institute Working Paper Series* 17, no. 7 (2013): 1-24.; Heilmann, Sebastian, and Oliver Melton. "The reinvention of development planning in China, 1993–2012." *Modern China* 39, no. 6 (2013): 580-628.

[36] Sun, Yutao, and Cong Cao. "Planning for science: China's "grand experiment" and global implications." *Humanities and Social Sciences Communications* 8, no. 1 (2021): 1-9..

[37] Naughton, Barry. *The Rise of China's Industrial Policy, 1978 to 2020*. Universidad Nacional Autónomica de México, Facultad de Economía, 2021..

[38] DiPippo, Mazzacco and Kennedy (2022), "Red Ink: Estimating Chinese Industrial Policy Spending in Comparative Perspective," Center for Strategic & International Studies, 2022.

Finally, there seems to be greater precision in Chinese industrial policies. This does not mean more accuracy in government support (i.e. success in outcomes), but rather a shift from more generic concerns about foreign economic and technological dependency to a greater attempt to identify and direct investments across multiple weak links in supply chains, and to identify 'strangleholds' (*qia bozi*) in supply chains. The GGFs are good examples of this. Only about 12% have a narrow industry focus (semiconductors, optoelectronics, etc.), but the venture capital model combined with government guidance is intended to narrow investments to government priorities, but then use more market-oriented assessments to more precisely identify weak points in China's supply chain. Furthermore, some major high-tech markets are also being 'made' by government-directed funding, such as large advanced infrastructure projects like 5G telecom, smart cities, smart grids, state surveillance, and even Industry 4.0 objectives laid out in Made in China 2025. Thus, rather than government itself locating and funding all of the weak points in China's supply chains, China may be combining a demand-side strategy through smart infrastructure, with a supply-side strategy through various industrial policy funding channels, but then hoping to introduce market incentives to pinpoint the actual weak points in China's supply chains in between. I should mention that no government document states this as a strategy, but examining Chinese policy and institutions as a whole, it could be seen as a rough system for rapid technological advancement and self-reliance.

Beyond industrial policies, China has also begun to build a more robust and institutionalized set of economic controls on their relationship with foreign countries and companies, including for purposes of economic coercion. Traditionally, China has used largely informal and imprecise mechanisms to exert selective coercion on targets. These generally centered on informal ways to make access to their domestic market more difficult for their targets, such as withholding domestic licenses, fomenting or encouraging product boycotts, or restricting certain imports based on WTO-permitted reasons, like trumped up phyto-sanitary issues. There was generally no direct legal justification and sometimes the intended target and the product were imprecisely linked, or the action was not comprehensive. This seems to be changing since the 2018 US-China trade and technology conflicts. China has recently expanded its export controls, created an unreliable entities list (which would be a *formalized* mechanism to deprive foreign companies access to the domestic market) as well as the new Measures for Security Review of Foreign Investments. The parallels to the US entity list and CFIUS are obvious. But more importantly, they formalize and add precision, compared to prior methods.

4. Policy Recommendations:

Apart from specific policy recommendations, this final section makes two additional key points:

(i) Supply chains are complex, diverse, malleable and opaque, and thus easily disrupted through unintended consequences. Thus, government agencies must be crystal clear on their precise goals and do proper due diligence to ensure the goals are in the public interest, government believes it has the proper capabilities to achieve them and has done a transparent and public cost-benefit analysis. Otherwise, unintended consequences are very likely.

(ii) There are two key underlying principles in terms of China. First, while easier said than done, the ultimate goal of supply chain policies should always be to achieve security *and* openness *and* prosperity. There is nothing compelling us to make these tradeoffs and we should never assume they cannot be combined. Second, as discussed below, it is deeply counterproductive to brand US policies as more 'hawkish' or more 'dovish' towards China (such as whether to remove Trump era tariffs). This lens is damaging not only because it is overly simplistic, but because they artificially narrow our strategic policy choices, because they imply mutual exclusivity. Rather, we need to acknowledge that the CCP and its leadership will do what is

> in their interests and so we must work hard to shape China's external environment and mold its perceptions to get China to behave in ways that are in our national interests. Both dove-like and hawk-like policies will contribute to this strategy, and they will contribute to our ultimate triple goals of security and openness and prosperity.

I first elaborate on these two points, and then turn to five specific policy recommendations.

Supply chain complexity and matching means to ends

It is worth recalling from the empirical deep-dive that even in the case of the homely smartphone, there are innumerable potential vulnerabilities due to extreme levels of global specialization and concentration, as well as the many interdependencies between layers and links. Furthermore, the supply chain of each product differs, and each can change and evolve over time. Governments who wish to engage with supply chains face a vast and uncertain landscape, filled with potential unintended consequences. What to do?

To begin, it is crucial for government to clarify means and ends for any policy interventions. The Biden administration's Executive Order 14017 (that launched the 100-day supply chain reviews and the full reports) was enormously ambition, filled with many worthy goals.[39] These included not only goals concerning reducing supply chain vulnerability and enhancing security, but job creation, revitalizing American manufacturing, environmental and sustainability goals, social justice, among others. In a word, supply chains were deputized to solve many of America's perceived problems.

On the other hand, there are a variety of means to achieve these goals. A slew of new terminology has been popularized, such as near-shoring, friend-shoring, reshoring, stockpiling, diversifying, trusted partnerships, sustainable domestic production, and ecosystem-building, among others. All of these means and ends can and should be on the table for a worthy reason that is in the public interest and that government believes it can positively contribute in solving (cost-benefit analysis).

However, in between the means and the ends, are the supply chains. Given the complexity and opacity of many supply chains, it is not completely clear how means and ends can or should be matched. For advocates of revitalizing American manufacturing, tax breaks may work in some links of certain supply chain, while fostering automation may work in others. For national supply assurances, government stockpiling and national reserves may work, for instance for primary inputs that will not depreciate in value quickly. By contrast, Moore's law dictates that semiconductors should not be stockpiled and thus other means would be required to ensure supplies, if that is the goal. As mentioned previously, there is no one-size-fits all solution. My fifth recommendation on bolstering supply chain data, knowledge and expertise inside and outside government specifically applies here. But each recommendation aims to a certain goal or end.

Two principles for policy making: No Hawks, No Doves & Shaping China's External Environment

Some of the recommendations below are more generic and can be applied across supply chains, such as enhancing knowledge and expertise. Others are more oriented towards China, geopolitics and technology issues, like a new multilateral export control regime. For these latter issues, however, economics and security are particularly intertwined in complex ways, and thus, there will invariably be struggles between

[39] Executive Order 14017, "Securing America's Supply Chains," Feb 24, 2021. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/02/24/executive-order-on-americas-supply-chains/

objectives that are more security-oriented, more trade-oriented, more employment-oriented, among others.

Nevertheless, I believe there are two general principles that everyone can agree to. First, as a general principle and even in the case of China, the goal should be to achieve security *and* openness *and* prosperity. There is no reason that America should not attempt to have its cake and eat it too. For instance, many of our core agencies that deal with supply chain issues, such as BIS in the Commerce Department and CFIUS, are already designed to keep most economic exchanges open, while *selectively* applying security oversight, even with our rivals. Of course, stating the principle is easy. But, where to draw this line is much harder. The following recommendations do not assist in drawing that line. Rather, they assist in thinking through governance mechanisms by which that line can be drawn, re-drawn and then re-drawn again over time, as supply chains, technologies and our allies and adversaries move and change. Policy-making also needs to be resilient to change.

Second, a China 'hawk' vs China 'dove' mentality is overly simplistic and harmful because it artificially narrows our strategic maneuverability. Maintaining every Trump era tariff on China is not 'more hawkish' or tough on China, if they are harmful to overall American interests; equally, removing the Trump era tariffs is not 'more dovish' or soft on China, if we forego a bargaining chip by unilaterally reducing the tariffs. We can disagree on which is best, but the hawk-dove dichotomy is a self-imposed political constraint on our policy options, and is absolutely harmful. In fact, the best option is to eradicate the political labelling and consider how to creatively *mix ideas* together. For instance, a new Section 301 investigation could lead to the removal of some harmful tariffs, while also imposing new restrictions, given that China has not fulfilled its Phase 1 agreement obligations.

Below, there are recommendations that may appear more hawkish or more dovish towards China. But that is always the wrong lens, because there is a deeper principle at play. On the one hand, we must recognize that China is a continent-sized country with vast resources, a complex and fragmented domestic political system, with an obsession with stability, and that it is facing plenty of domestic and international challenges. Thus, we should not expect to be able to *directly* get China to do what we want, unless the party-state and Chinese leadership find it in their interests. Instead, we should work hard, along with our allies, to shape China's external environment and to mold China's perceptions in ways that naturally and willingly lead them to act towards achieving our ultimate desired goal. And in supply chains that ultimate goal is *security and openness and prosperity*, not choosing one or the other. This is easier said than done, but here are some specific recommendations.

1) <u>Bilateral and Multilateral Free-Trade Agreements….excluding China</u>

Diversification of supply chains is a worthy goal and so is revitalizing American manufacturing. However, companies will make sourcing and production decisions that are in their best interests, not the national interest. As a general rule, and outside of national security concerns, it is best for government to err on the side of not trying to unilaterally pinpoint critical links and directly reshape supply chains, given many unintended consequences and the capacity of supply chains to react flexibly to policy. It is also difficult directly to incentivize companies to diversify specific supply chains, even with light-touch tax incentives or other methods. Again, because supply chains vary widely and change over time, it is very hard to know exactly how or when to dial up or dial down incentives to get specific supply chains to diversify in the ways that government deems in the national interest (itself difficult to define). And this will be a moving target.

While pinpointing specific supply chains for diversification is difficult, one clearer goal is to diversify supply chains that are overly concentrated in China, though the same logic applies to other countries too.

The recently announced Indo-Pacific Economic Framework (IPEF) does exclude China, but there does not appear to be a lowering of tariffs. Thus, it is not likely to incentivize Indo-Pacific countries to negotiate on core concerns of the US, nor likely to shift overly concentrated manufacturing away from China.

By contrast, FTAs can create broad incentives across industries and firms to move operations and thus help diversify supply chains, even if it is hard to pinpoint which ones. Unlike unilateral tariffs, new FTAs would be pro-market, pro-trade, non-discriminatory, would not violate WTO obligations and are not likely to create unintended consequences at the supply chain level, which tariffs often do. By excluding China, some firms in some industries would be incentivized to shift production or outsourcing away from China and to countries within the FTA. Of course, if the incentives of the new FTA were so great, concentrated supply chains in China may simply become concentrated supply chains in Vietnam or India, thus reducing the value of the diversification goal (but perhaps still achieving other goals, like reducing the chances of supply chain weaponization). In fact, diversification of supply chains would prove to be beneficial for many countries. As new countries within the FTA gain a foothold in new supply chains, they will have a chance to learn and upgrade, which over time can create new clusters of specialized capabilities that could then compete even in export markets outside of the FTA. Furthermore, new FTAs would offer opportunities to experiment in a range of other issues areas, like digital trade, labor rights and sustainability.

2) Create a fifth *multilateral* export control regime…and possibly investment regime

As discussed, emerging technologies produced largely for commercial use are transforming our definitions of 'security,' 'critical infrastructure,' 'dual-use,' among others. However, as recently argued by Kevin Wolf and Emily Weinstein,[40] there is an inherent tension in our policy toolbox for export controls when it comes to non-military emerging and foundational technologies. On the one hand, our four existing multilateral export control regimes[41] are narrowly focused on traditional military applications, such as nonproliferation of WMDs, chemical and biological agents, and conventional military and dual-use technologies with clear military usages. Furthermore, the regimes often require consensus to make changes and updates. Thus, new technologies that pose non-military security threats or emergent issues that have non-military but strategic importance cannot be dealt with on a formal multilateral basis.

On the other hand, the US export control regime, especially after its substantial expansion with the introduction of ECRA reforms, provides wide latitude and substantial authorities to the Commerce department to target particular end-users, end-uses and products, and for objectives well-beyond military ones. However, they are strictly unilateral and thus do economic damage to and alienate our closest allies. The patience of our allies will have limits to abiding by the extraterritoriality of US laws, such as the direct product rule. Even if the US were to 'go it alone,' US unilateral export controls are likely only to have a short-term impact before quickly weakening, as ECRA itself admits. Multilateralism achieves longer-term buy-in and durability.

A carefully sculpted multilateral regime, starting with only a small handful of key high-tech allies, could potentially combine the virtues of multilateralism with the effectiveness and precision (end-user, end-uses and product lists) of US controls. It also could be applied to any future strategic objectives, such as threats to supply chain resiliency, unacceptable Chinese industrial policies or misuse of technologies. The seeds of broadly similar approaches to supply chains and emerging technologies are already planted, for

[40] Kevin Wolf and Emily Weinstein, "COCOM's daughter?," WorldECR, 2022.
[41] The Missile Technology Control Regime, the Australia Group, the Nuclear Suppliers Group, and the Wassenaar Arrangement.

instance with the US-EU Trade and Technology Council's Export Control Working Group, the Quad Security Dialogue and the Export Controls and Human Rights Initiative.

Undoubtedly, China would consider this a threat and vehemently and vocally oppose it as yet another example of 'the West' constraining China's rise. Indeed, it would create a unified, clear and multilateral voice. Surprisingly, these facets of a new regime would provide China with many unexpected (and unintended) benefits relative to a US unilateral alternative. For instance, it would create a higher bar to achieve multilateral agreement which would narrow the scope of export controls to truly critical ones. It would also institutionalize the process which indirectly benefits China through greater transparency and stability over time.

For US and member allies it greatly reduces commercial tensions through joint agreement, information sharing, joint enforcement, and could free up trade between member countries even on controlled items. Furthermore, China would be unable to incentivize and peel off our allies on a bilateral basis, such as brow-beating the Netherlands into selling them ASML produced photolithography semiconductor equipment (see Layer #5, above), which China has attempted to do. Finally, with a technological and multilateral sword of Damocles hanging over its own technological and industrial ambitions, China would be incentivized to join additional institutional settings to engage in dialogue over supply chains, cybersecurity and emerging technology issues (Recommendation #3).

Some of these ideas could also migrate to cooperative, multilateral investment security reviews between CFIUS and the growing and strengthening array of CFIUS-like equivalents in Europe (2020), UK (2022) and Australia (2020). Similar to multilateralism in export controls, the goal is to create a united front towards China, generate consensus, information-sharing and joint enforcement among core, technologically-advanced allies, and reduce acrimony among competing and interdependent firms. It would also avoid investment reviews from potentially slipping through the cracks (e.g. the sale of the robotics company Kuka to Midea, a Chinese company), and shed light on undisclosed coordination among Chinese companies, as was the case with Aixtron, a semiconductor company.

3) <u>Weaponized Interdependence and the Road to an International Regime: Baby Steps</u>

The ultimate goal of creating a fifth multilateral export regime or a joint investment review regime is not to isolate China, nor to coerce China. While it would create clear red lines, the real purpose is to shape China's external environment to lead it toward the ends we desire, and in my opinion, a better equilibrium for China too. Ultimately, China will make its own decisions, but we can shape the context within which they make decisions. Thus, if China's external incentives are correctly aligned, such as through a fifth multilateral export regime, it may be possible to coax China into other organizational formats, which may lead to achieving some deeper goals. .

Similar to cybersecurity and finance,[42] supply chains are becoming increasingly weaponized, potentially in devastating ways. While the stakes are much lower compared to nuclear war, we need to work towards building an international regime with a similar set of norms, redlines, formalized lines of communication, procedures and common frameworks of understanding to avoid escalation. This will be a long, drawn out and dynamic process, again because technology and supply chains are not stationary.

An international regime is clearly very complex and beyond this recommendation. However, some initial baby steps in that direction would entail a new forum to foster dialogue on China's and our own security

[42] Farrell, Henry, and Abraham L. Newman. "Weaponized interdependence: How global economic networks shape state coercion." *International Security* 44, no. 1 (2019): 42-79.

concerns. This might exhume a forum akin to the prior US-China Security and Economic Dialogues, and its predecessors under the Bush and Obama administrations. Such a forum should add 'security' back in to the dormant Trump administration's Comprehensive Economic Dialogues. In addition, there should be a third 'technology' track. Or, if there is sufficient demand, a distinct and specialized dialogue on just security and technology with cybersecurity. Clearly, it would be best to sculpt these dialogues so that they can be more substantive than the prior history of US-China dialogues. But, ultimately, the goal is not dialogue itself, but to allow dialogue to lead to the slow, arduous building of a new international regime that handles threats from supply chains, commercial technologies and cybersecurity.

4) Encourage modularity in telecommunications equipment: Open RAN and O-RAN Alliance

One of the layers conspicuously missing from our deep-dive is telecommunications equipment – the layer that Huawei has become so competitive and which sparked much of the technology tensions with China. Indeed, in 2021, Huawei took about 35% of global markets in telecom network infrastructure equipment (the rough equivalent to Level #1 for smartphones but final-use telecom equipment). This was more than Nokia (16%) and Ericsson (11%), combined. While we lack the teardown data to dig deeper,[43] at this Layer #1, these three firms have dominated the industry for a long time and they are frequent collaborators in the standard-setting process (see Section 2). Given their long collaborations, it is likely that they are quite comfortable with the three-way competition and would find any attempt at modularization of their industry to be quite threatening. Traditional telecommunications equipment is more 'integrated' and telcos purchase integrated systems from these major vendors. There is limited interoperability between equipment, which benefits these telecom equipment giants.

While this is a highly technical field, to my knowledge, there are few technical reasons why telecommunications equipment could not be modularized through standard-setting that allows greater interoperability between more specialized modules. This has happened in many ICT products over many decades. For instance, a movement called 'Open RAN,' in principle, would allow telcos to mix vendor equipment and it would allow vendors to increasingly specialize, perhaps evolving into a full-blown massive modular ecosystem. Of course, as we saw in Section 2, modularity can still lead to high market concentrations and even the domination of chokepoints, such as with platforms or if system integration is a critical capability. Nevertheless, modular systems are inherently more flexible than integrated ones, and would introduce competition. Plus, the US innovation ecosystem generally competes quite well in modularized products, partly because of our strengths in software, relative to hardware. Thus far, however, it seems that Japan's NEC and Rakuten and South Korea's Samsung have the most ambitions in this space.

The US Congress appears poised to fund the Public Wireless Supply Chain Innovation Fund through a reconciled USICA and COMPETES Act which is intended to try to jumpstart Open RAN systems in the US. The bill's utility partly depends on its funding level. However, while funding is important, a major concern is how standards will be set. As discussed briefly in Section 2, standard-setting is critical to the development of interoperable systems like telecommunications or the internet. However, the governance of standard-setting organizations (SSOs) substantially influences the standards that are finalized. SSOs are generally voluntary, consensus-based and industry-led, but their governance can vary widely along different dimensions, including: transparency, openness and distribution of membership, patent obligations, degree of egalitarianism such as in voting rights, leadership positions, and the role of large and small firms, among other things. 3GPP, the central SSO for mobile telecom, is generally on the more

[43] Unfortunately, we do not have access to equivalent 'teardown' of each component contained within Huawei radio access network (RAN) base stations or other telecom equipment, to conduct the same multi-level analysis of Section 2. This is why it was neglected in Section 2.

open and egalitarian end of the spectrum. The O-RAN Alliance is less so, with privileges granted to its founding members, as well as a high share of Chinese firms due to its historical development. However, just like any international organization, public or private, Chinese participation should be welcomed. However, it must be within governance mechanisms that are fair, open, voluntary and robust, and which limit the power of any set of firms or countries. The ultimate goal of SSOs is to agree upon the most efficient overall standards. Properly structured governance of SSOs can achieve that, even when the participants are direct commercial rivals or even geopolitical competitors, as is the case in the well-run 3GPP. But vigilance is essential and so is participation. As such, the US government should try to encourage participation in SSOs, especially among small and medium enterprises who may not be able to afford the time or personnel to attend meetings and vote.

5) <u>Bolstering information, data and expertise on supply chains in and outside government</u>

While increasing information, knowledge and expertise may sound simple and straightforward, achieving the proper organization, incentives and flow of new knowledge through government is easier said than done. Furthermore, as discussed below, creating supply chain knowledge should not simply mimic the existing exercises of creating long lists of products (such as in dual-use arms control). This is because supply chain knowledge is fundamentally different.

Given the complexity, diversity and malleability of supply chains, there is a very good rationale to tap into *different types* of information sources and expertise, especially through public-private interactions. The Biden administration's proposal for a Supply Chain Resilience Program housed within the Commerce Department is broadly in this spirit, although it is not clear why supply chain expertise should be concentrated in a single agency.[44]

There is substantial expertise outside of government that already is utilized, and could be utilized more by diverse methods. For instance, the technical advisory committees (TACs) that rotate on a regular basis in Commerce department is one format, but specialized ones focused on supply chains would be needed, and they could be established across different agencies. However, it is important that they are filled with *diverse stakeholders* and not dominated by industry representatives. Currently, TACs are nearly costless to government, as TAC participants are unpaid and they are not even reimbursed for travel expenses. This unnecessarily limits the pool of willing candidates mostly to industry representatives.

Another possible model is even less formalized. Similar to the process of peer-review in academic publishing, government agencies could maintain long lists of experts who were willing on an *ad hoc* basis to offer expert reports on particular, pressing issues.

Since supply chains evolve and change, forecasting capabilities are also worthy additions in some areas of government, such as those dealing with emerging technologies and in the intelligence community. This was mentioned in the 100-Day Reports too, though implementation is unclear. The future is murky, but companies constantly try to forecast to survive. Attracting that talent into government may be difficult and expensive, but likely worth the cost in certain critical areas. Furthermore, with the internet, social media, increasing commercial surveillance and more powerful computing, there is enormous and growing potential to use open-source intelligence (OSINT), something which academics on shoe-string research budgets have learned to leverage well, including some of the data in this very testimony.

[44] White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing and Fostering Broad-based Grown: 100-Day Reviews under Executive Order 14017," June 2021.

It is also encouraging that legislation is likely to enhance funding to the NSF and establish a technology directorate. However, research on supply chains is highly interdisciplinary, and thus it falls between the cracks of established academic disciplines. It would be encouraging if funding for research and data readily crossed disciplinary boundaries. For instance, small slices of funding under the broad NSF rubric of 'technology' could be hived off to researchers not directly contributing to the advancement of technology itself.

In terms of expertise within government, knowledgeable personnel should be spread across relevant government agencies where particular supply chains goals are sought. Again, the Biden administration's Executive Order targeted particular industries (ICTs, Pharma, etc.) and matched them to particular Departments (Commerce, HHS, etc.). So, why a supply chain taskforce should be housed only within Commerce is not clear. There are already deep expertise in each agency, which can be supplemented with experts that bring a supply chain perspective in certain critical areas. For critical supply chains, they may work to produce regular supply chain audits or identify supply chain vulnerabilities, using cutting-edge data. It seems some of these ideas are in the works, but how the information flows are organized and where data and information comes from and flows to, also matters.

As mentioned, creating 'lists' of technologies or products does not constitute generating supply chain knowledge. As Section 2's deep-dive demonstrated, supply chain research is principally about the technological, business, political and other *interdependencies* between products and production processes. Furthermore, this information collection and knowledge creation needs to be dynamic and evolving, because supply chains evolve. Apart from analysis of supply chains, this include potentially profound re-thinking of core concepts surrounding critical infrastructure, dual-use, strategic technologies, and other security issues, as the deep-dive hopefully illustrated.

PANEL I QUESTION AND ANSWER

COMMISSIONER GOODWIN: Thank you all very much. We will be going in alphabetical order by Commissioners' last name. But I will take the prerogative of the chair and pose the first question.

I want to ask a question of you, Dr. Bulman, with regard to rare earths. You talk about how China came to really dominate that sector without strong central support or central planning. And in fact, you testified that they came to dominate the sector perhaps despite central planning.

Instead, their rise has been more attributable to geography, local incentives, local competition, and lax environmental enforcement. So I have a couple questions. First, isn't that lax environmental enforcement policy itself, which is the inability of the central government or unwillingness of the central government to enforce stated rules and objectives and guidance, didn't that provide China with a competitive advantage in that sector, number one.

Number two, we will hear from a witness later today who takes a contrary position on China's rise in the rare earth sector. And they said that its market position was not simply accident of geography or the availability of reserves. It was attributable specifically to policy, thorough investment and research, especially in the refinement process, development of talent and expertise, and fostering public-private cooperation. So I invite your thoughts on both those questions.

DR. BULMAN: Thank you very much, Senator. On the first question on lax environmental standards, I think, yes, for sure, lax environmental standards in other fields lacks labor standards can definitely be seen as a policy that supported China and gave it an unfair advantage. I was asked for my discussion today, for my testimony to really focus on central industrial policy, intentional industrial policy versus more of a bottom-up local government approach to what's going on and where control is.

I think, yes, lax environmental standards played a key role. Lax environmental standards also exist in many other developing countries around the world. I don't think China is particularly special in lax environmental standards at its level of per capita income, especially in the '80s and '90s when China came to dominate the sector.

I think a lot of making that China doesn't actually have 98 percent of reserves as it once had 98 percent of actual production. It does have 40 percent of global rare earth reserves. That's a large number. And when China was coming in, in the '80s and '90s, this is exactly when France, Japan, the U.S. were shutting down mines for pollution.

So definitely lax environmental standards played a role. I don't see this as an intentional central policy which is why I think it changed over time. In the 2000s in particular, China put a lot of effort into shutting down illegal overproduction which was about 50 percent it seems for many different estimates of overall production in China.

And this was due to a better imposition of environmental regulations, better implementation. And I think that actually helps to reduce much of China's production. Now in terms of the intentional policy, it's definitely true that quotas have been more binding since 2010 that led to the spike in prices. But that also led to a lot more global production in response which is why China's global share has basically been cut in half.

The public-private partnership, the creation of the six SOE groups, the creation of one new extra-large SOE in December of last year, these are all efforts to try to gain control of the sector and have more control. And obviously, it is something that should be followed to see what China does with that control. But I don't think this is a cause of China's overproduction early on.

COMMISSIONER GOODWIN: And what about the investment in research on the refinement side? How much of a competitive advantage has that given them? Even the Mountain Pass Mine that we have here, everything that they mind is going to China for refinement. So on the front end, the investment on that side of the process from the central government, a central policy directive to invest on that side of it, how much of that contributed to the rise in the sector?

DR. BULMAN: To be perfectly honest, Senator, I do not know on all 17 different subsectors of ours how much of this central investment took place. I know with my own field work about a decade ago in Anhui Province and some places in some small counties, there was no central control in this rare earth mining. And this was a very corrupt set of small counties that were doing what they could to produce it.

There was a lot of discussion about how they were going to keep producing despite central regulation. So that was more what I focused on. I don't see that this was a very high-tech endeavor, but an expert in mining would be able to shed a lot more light. Thank you.

COMMISSIONER GOODWIN: Thank you. Commissioner Borochoff?

COMMISSIONER BOROCHOFF: Thank you very much. I wish I had more time. I'd have questions for every one of you. Dr. Dallas, my experience usually dictates everything that I think. And I like what you said about the idea of changing the environment to get the opponent to make a move that you want them to make.

So, I have a couple of questions on that subject, and I have to say that I reminds me of numerous business battles that I have experienced in my career. And dumbing it down, an example would be people who were opening retail restaurants without parking lots which gave them a huge financial advantage over the restaurants that were forced to have parking lots for whatever reason. And in many cities in America, that was fixed through zoning.

And the folks who had the existing businesses with no parking lots either went out of business due to competition changing or they were forced to buy parking lots and all of a sudden there was a level playing field. So that's a simplistic way of my reacting to what you said. So, my question is -- I understood your argument about asymmetric interdependence versus the other kind.

How do you -- you said it would be hard to identify asymmetric interdependence. Do you have in mind an example of an asymmetric situation? And how would you change the environment to affect that? Give me an example of that if you can.

DR. DALLAS: Sure, absolutely. So in terms of shaping the environment, I like to think of things as sort of at a more macro level and at a detailed level. So, if you look at a specific supply chain or a specific link in a supply chain, that's getting very down in the dirt into the details, right?

And so, in terms of shaping the strategic environment, I'm thinking more at a high level actually for that aspect. So let me start with that. And so, you can look at my more detailed policy recommendations. And in there, maybe I should've been more clear about it.

But I tried to show that the U.S. engages in preferential trade agreements that exclude China, right? You're going to see some of the concentration and especially let's say in assembly and manufacturing start to shift away. Okay? So then suddenly that's a goal that the U.S. seems to want is diversification.

It's very straightforward. That's a very soft, pro-market, pro-trade way of doing that. And it will start to shape China's strategic environment because they will be excluded. Okay. Of course, it has to include countries that could potentially replicate what China does well. It's not easy.

And then the second one was the fifth export multi-lateral, export control regime. And that's much more clearly aimed at China. They would know that. But it would basically offer an opportunity in which the United States and their allies would basically have quite clear red lines as to which types of technologies China will not get access to. And that will prevent them from -- the Chinese from peeling off allies or something like that to get what they want, the machinery or whatever they're pursuing technologically.

So, having that, again, shapes their environment. Well, hopefully, these types of things -- I'm not saying that those were complete -- will guide them to something we do want in which we can engage them once they realize that there are pathways that have been cut off. It can lead them to certain other types of engagement.

Now my third recommendation of just sort of more dialogue, okay, that might be a relatively weak one. But the goals is to get to something else. So that's at the high level.

Now you also asked about a specific example, let's say. I mean, I think rare earths is a good example where at least in the past there was asymmetric interdependence. And that's because China felt confident that it had an extreme concentration. And I don't know the specifics of rare earth. But I imagine that the economic impact may not have been huge as opposed to, for instance, the cell phones in our pockets.

That employs hundreds and hundreds of thousands of Chinese. So even though that may be concentrated -- that link may be concentrated in China also, there's a lot of costs there to them for trying to prevent trade in final assembly that goes to American consumers. And so I think even though they're both links in a supply chain, one link only, I think there's a difference there and we have to think through that process.

COMMISSIONER BOROCHOFF: That was a good answer. Thank you very much.

DR. DALLAS: Sure.

COMMISSIONER GOODWIN: Commissioner Cleveland?

COMMISSIONER CLEVELAND: Thank you. I have a question for Dr. Bulman and a question for Dr. Dallas. Dr. Bulman, you noted -- I think you are suggesting that the concerns that we have expressed in the past and that others have expressed about central industrial policies may be less of a concern relative to natural competitive advantages.

And as you just discussed with Senator Goodwin, you point out that there's a five-tier system of administration in China with 85 percent of fiscal expenditures coming at the subnational level. Your experience of bank and loan, we know we try to lend at the subnational level. And one of the critical issues you also just identified in your own research in Anhui was the level of corruption or inefficiencies depending on how one looks at this.

I'd like you, if you could, to elaborate on why it's important to differentiate between central industrial policies and local autonomy and decision making because industrial policies are industrial polies are industrial policies at the end of the day when it comes to open markets and competition. And if you could talk a little bit about why it's important to say that 85 percent of fiscal expenditures are designated or directed at the local -- the subnational level, what the sources of revenues are -- what the source of revenues may be. And as I said, differentiate between the significance of local industrial policies or subnational and national.

And for Dr. Dallas -- I think if I don't ask both questions, we won't get within the time period -- you discuss and I really appreciate your assessment of standard setting organizations. And your testimony says that we should -- that these are generally voluntary, consensus-based, and industry led, but governance can vary widely. And you note -- and I think these are important considerations -- that transparency, openness, and distribution of membership, patent obligations, degree of egalitarianism such as voting rights, leadership, and the role of large and small firms are among the factors to take into consideration.

I think using your own checklist, I'd like you to assess whether or not you see evidence that China is committed to transparency, openness, distribution of membership and these principles as they have moved to take on a larger role in these organizations and then what the significance of that may be. So Bulman, if you would go first. Thank you.

DR. BULMAN: Thank you so much for that question. It lies directly with research interests. And I'll try to keep this as short as possible given the timing. So, I think it's very important to know --

COMMISSIONER CLEVELAND: Feel free to add for the record. We invite questions afterwards. So, if you run out of time --

DR. BULMAN: Sure.

COMMISSIONER CLEVELAND: -- that's an option.

DR. BULMAN: I would be more than happy to. I think there's a common misperception that China has a very centralized state is I think why it's important to note this, right? China is actually extremely decentralized. Very few countries in the world have 85 percent of fiscal expenditure at the subnational level.

China is simply too large to be run from the center. And one of the key strengths of its reform era has been this decentralization process. And the way that worked and the reason it was successful and not bringing a ton a local corruption, although there was plenty of local corruption, was an upwardly accountable system in which cadres were sent down from outside areas to take over localities and be in charge for technically five-year terms but really in practice two- to three-year terms before moving on.

This led to strong incentives to do something very quick, to have rapid growth, something you can identify, and not to have a large problem like a firm closing and a lot of people unemployed on the street being upset, right? So you had a lot of incentives for maintaining stability and really rapid growth. And these incentives haven't shifted over time.

And this is why I think it's really important to understand central versus local industrial policy. Central industrial policy is drafted by experts in the field with bureaucratic input, scientific input. This process, as many people have now identified it, has become much more rigorous and scientific.

And yet when you have these broad policies that includes hundreds of billions of dollars, when they get down to the local level, the incentives aren't to try to produce long-term growth that's going to be productive in five, ten years with startup firms. It's to have something that works right now, and not to let any firms that are already there close. So that's why I think it's extremely important to look at.

I could talk at length about the different revenue streams. I mean, I think one of the most important ones has been land sales, and, honestly, debt more recently, or land sales collateralizing debt. But I think the key really is just the incentives of local officials really differ. So local industrial policy is really important, and we need to understand it. But it doesn't necessarily reflect the central policies that we're all looking at, the Made in China 2025, that gets so much attention here.

COMMISSIONER CLEVELAND: But does it have an impact on our concern for today which is supply chains? Do you see that differentiation of central versus local as having an impact on how we should think about supply chains?

DR. BULMAN: I think it does based on -- so when I try to break down by sector, I think a lot of Chinese industrial policy has tried to focus on these high tech sectors where the local incentives are not aligned and you don't have very good results. Sometimes like semiconductors, I think local industrial policy has really failed. It's led to a lot of fraud, a lot of wasted investment. And we haven't seen very much increase in Chinese capacity.

I think the key is using central money for demand side subsidies and new industries where there's no one there and no firm needs to close in response like producing EVs and giving all these new subsidies and government procurement policies. It's much more likely to be effective. So, I think that is important to understand local industrial policy insofar as it matches local incentives for short-term growth. And that's when policy works. Thank you.

DR. DALLAS: Okay. Thank you, Commissioner. I'm glad you're -- I got caught on standard setting organization. It's not something that a lot of people really find exciting. I do, and they're very important. And of course, China has Policy Standards 2035 where they want to have a much greater role in global standard setting. This is for interoperability standards, particularly in ICTs and high tech.

So, the point I was trying to make in the piece is that those attributes are really about the governance of the standard setting organization itself. And if the governance mechanisms internal to the standard setting organization are strong, China just comes to it and has to basically play by those rules. And yes, so my example and the one that I know well is 3GPP which is the mobile telecom, a standard setting organization.

And in general, those are very strong rules, very egalitarian and whatnot. China has done very well in them, especially Huawei but also other companies, China Mobile, ZTE, and others, because they've been able to set more standards over time. Now there are ways they can gain the system, for instance.

I read a PowerPoint where 3GPP had to ban the use of cell phones in the voting booths essentially because Chinese companies were showing and proving how they were voting. So it can be gained. But there are change in the institutional environment to prevent those sorts of things.

And so, in terms of China's approach to it, the Standards 2035, I mean, it's hard to know I would say. Obviously, 2035 is a long way away. But it appears as if they're shifting a little bit more to industry-led standard setting rather than government-led standard setting.

Now the bureaucracy may be pushing back on that. It's going to be a dynamic process. But they're trying to get industry more involved in that process.

They're aiming to use the standards as a form of upgrading which is kind of a little bit unusual compared to most countries where they're using the standards to create benchmarks. It actually may shoot them in the foot because it's often hard for firms to reach that high benchmark. The other thing that I'd be a little bit more worried about is, are they going to integrate the Standards 2035 policy into sort of Belt and Road Initiative type countries where they're trying to set, let's say, smart city standards or smart infrastructure standards across other countries?

I'm not an expert in this area. But that's something that in my mind is infrastructural. It's long lasting and takes a long time to reverse. I think the things that the U.S. government could do potentially is keep an eye on these standard setting organizations, see what is happening. But also support more American firms in participating in them.

In fact, in 3GPP, American firms surprisingly don't participate as much. It's really

European and Chinese firms that do much more. And there's for reasons for that which I won't get into.

COMMISSIONER CLEVELAND: I just want to give credit to Senator Goodwin who had interest in SSOs two years ago.

COMMISSIONER GOODWIN: Thank you, Commissioner Cleveland. Commissioner Fiedler?

COMMISSIONER FIEDLER: So, I want to look at a worst possible case. Let's assume that this time next year Xi Jinping decides to take Taiwan by force and the U.S. government decides to defend it. What would you expect to happen to the U.S. economy and supply chains in that scenario?

DR. DALLAS: I'm sorry. Was that to me, or --

COMMISSIONER FIEDLER: All of you. Any of you. Anybody thought about it?

DR. DALLAS: Well, yes, of course. I mean, I'll say a few words, I suppose. Yeah, I mean, that would be catastrophic, of course, for that to happen. And we have to be extremely vigilant to it, of course.

And of course, it's also not just Taiwan. I mean, that kind of war or conflict would be a regional -- have regional consequences for supply chains. Of course everyone knows that Taiwan has got the high-end semiconductors, and that always seems to be the conversation when it comes to conflict with Taiwan as well.

So it undoubtedly would be disastrous. I think the issue is really how do you -- do you develop policy -- supply chain policy around that possibility. Should we be making major changes in supply chains and whatnot?

And if so, if the answer to that is a collective yes, then what exactly would one do? And it's worth studying. It depends on the sector. Is it for U.S. military purposes? Well, then it's more important to make sure that we have much more secure supply chains.

But I don't think we should be reshaping all of East Asian supply or attempting to. I probably wouldn't work. Just on the possibility that a war would take place and that the U.S. would get involved in it.

COMMISSIONER FIEDLER: Anyone else?

DR. SHIH: Yes, let me suggest I think the disruption to the supply chain is it would be much more significant than many people appreciate at this time. It's not just semiconductors. It's many other products as well, materials. And so it would be a very wide scope disruption.

I do not think we are prepared for that, and I think we should really try to strengthen our position rapidly before we enter into any kind of conflict like that, right? So it goes to what Dr. Dallas was saying earlier which is it wouldn't hurt to have a more conciliatory position and not kind of poke the tiger in the eye repeatedly, unless we are at a position where we think we can suffer the consequences. I do not think we're in that kind of position.

COMMISSIONER FIEDLER: You're saying that -- excuse me. Did you have a response, Doctor?

DR. BULMAN: Please go ahead. I can add on.

COMMISSIONER FIEDLER: I mean, when you talk about catastrophic, let's just get specific. The shelf-life of drugs is finite. A war with Taiwan, if lengthy, what impact would that have, for instance, on American's availability of drugs?

DR. SHIH: Let me say that I believe 79 or 80 percent of all fine chemicals come from China. A lot of the essential pharmaceuticals, we saw this during the pandemic, that come from India rely on China for drug APIs. We have a much broader dependence on China than I think most people realize.

As my colleagues here have also pointed out, China also has a heavy dependence on us, right? We should not underestimate how much that interdependency is. So, I for one would be very careful in how we lay out our strategy and be -- I used to pass out copies of Sun Tzu's Art of War to people who work for me. That was when I was in industry, right? I mean, we really ought to think about these things and not rush towards a conclusion that we think is inevitable.

COMMISSIONER FIEDLER: But you each do believe that it would be a catastrophic effect?

DR. SHIH: Yes, much worse. I think our interdependencies are much worse than people realize. When people ask me about dependencies, I say, okay, you told me about that dependency we have on China. For every one that you give me, I can give you four more that people aren't really thinking about.

COMMISSIONER FIEDLER: Thank you very much.

COMMISSIONER GOODWIN: Commissioner Friedberg?

COMMISSIONER FRIEDBERG: Thank you very much. I thank the witnesses for their very interesting testimony. I have questions for Dr. Bulman and Dr. Dallas, and I'll ask them both and hope that we get a chance to hear your responses.

Dr. Bulman, it seems to me that your argument is that China achieved the position it currently holds largely in spite of industrial policies -- deliberate industrial polices. But it seems to me, although that's an interesting point, it's also not really relevant to the question of whether the current situation is threatening in various ways. Isn't it the case also now that the Chinese leadership has declared its intention deliberately to undertake policies that will maintain the dependence of the United States and other western countries on China as a manufacturing platform and as a source of inputs while taking steps to reduce their dependency on us?

That seems to be the essence of what they're trying to do now. And some of that involves activity in sectors where by your description industrial policy has, in fact, worked in the past. So I guess my question is, do you assume that their policies will fail and what would happen if that assumptions proves to be correct?

Dr. Dallas, you note that -- you describe much of what China has been doing in this domain as reactive or defensive. And that may be true. But even reactive and defensive policies can create risks and dangers for others.

And you suggest that we need to do things that will reduce their sense of insecurity. So, my question for you is, how? What exactly does that mean? It certainly seems like this sense of insecurity is hardwired. It's deeply rooted.

As you note, China's industrial policies began to shift in the mid-2000s. And that was well before we began to worry about any of this to take steps that might make them feel we were exploiting their dependence on us. So, Dr. Bulman?

DR. BULMAN: Sure. Thank you very much for that question. So, I think that we should think about China's industrial policies as possibly -- and supply chain countering or addressing three issues. One, is as you note possibly increasing foreign dependence as a goal.

Two is becoming a leader in new industries because that's where China thinks it can actually boost its economy because it has an in, something like on EVs. And third is reducing vulnerabilities. And I think from what we've seen, China has relatively good success in becoming a leader in new industries where they aren't incumbent and you can just plow in a lot of money.

I don't think the goal of that is to increase foreign dependency. I think it's a goal to not be stuck in low value-added production. I think that was the initial cause of industrial -- initial sort of justification for industrial policy prior to the global financial crisis in particular when the MLP came out that Professor Dallas discussed.

I think the second issue that's most important to them is reducing vulnerability. And this again came out really strongly in Professor Dallas' testimony. But China, especially after ZTE and Huawei in the last four years, realizes how dependent the economy is on the U.S. And I think this dependence is still asymmetrical and China is still more dependent on the U.S.

And in particular, I think China has had relatively low success at reducing this vulnerability, right? This is where we're not seeing success. China's ability to plow money into semiconductors, to ploy money to high tech spheres where it could actually reduce dependence on the U.S., has largely failed. China is still extremely dependent on the U.S.

The other example where this has failed is the financial sector. China's efforts to have an internationalized renminbi, to have a central bank digital currency, to not be reliant on SWIFT, have gone nowhere. And you can see with the response China has had to Ukraine, it's been to call in everyone. Call in the bankers and figure out what's going on with the financial system and how vulnerable it is. And it is still very vulnerable.

I think the third issue of increasing foreign dependence on China has really not been as important. Now there may very well be sectors. But I think if you look at -- again, rare earth, not to get back to this too much.

But if you look at rare earth as a sector where China wants to increase dependence, it is after all the sector that's often cited as in 2010 the conflict with Japan, China increased quotas and cut off -- put on basically a soft embargo on exports to Japan. And that totally backfired for China, I believe. So I think China had very little success of actually increasing foreign dependence intentionally. That's how I would answer that.

COMMISSIONER FRIEDBERG: Dr. Dallas?

DR. DALLAS: Yes, so in terms of reducing insecurities, I agree that it's not easy to reduce insecurities for China. I think one is to not overuse weaponization of supply chains in terms of the purely supply chain perspective. And of course, actually, the conflict with Russia is a major change I would say in which China has been put on alert in terms of what is possible.

And I think the U.S. government is also learning about its new tools and capabilities when it comes to sort of a larger conflict like that. And so to a certain extent it may be that the cat's out of the bag in the sense that I'm sure China is going to be looking, studying this very, very closely in terms of the conflict with Russia and a lot of the policies around that. So, it may be much harder to do it.

But on our side, we can at least not overuse or ill use supply chain weaponization. I think also rhetoric is important because China has a domestic audience also. If our rhetoric is overly bellicose, then they're going to respond, and it's just going to recreate the sort of major nationalism, techno-national and other types of nationalism in China.

I think dialogue is very important also. And I know that's somewhat simple. But I mean, Secretary Blinken's Invest, Align, Compete, I would just say dot, dot, dot, Engage. I think that is still important, and that sort of level of conversation could also potentially reduce insecurities. I'm not saying we're going to -- that's why I said we have to shape their environment, not try to reshape their direct behavior. And so it is a tough line to cross.

COMMISSIONER FRIEDBERG: Thank you very much.

COMMISSIONER GOODWIN: Vice Chair Glas?

VICE CHAIR GLAS: Many thanks to all of you for testifying today. This is a timely hearing, and this is a really hot topic, supply chains. I've been working on supply chains most of my career, but I'm so glad that we're talking about this on a national level almost on a daily basis.

Over the years, our lexicon, talking about supply chains has changed. It sounds good, global value chains. That means the value is being somewhere done else than the United States and done in countries like China at a great cost to manufacturers.

I know, Dr. Bulman, you talked about competitive advantage. And you're trying to educate us about some of the localized investment tools that China uses and maybe some of their industrial policies don't get down to the local level. But I sort of reject that notion to be quite frank with you, and I just want to be honest about my assessment.

When you're looking at the Made in 2025 plans, when you're looking at their energy policy, when you're getting 1/16th of your global greenhouse gas emissions based on overcapacity in the aluminum sector alone in China, when you have policies associated with Xinjiang and forced labor, that is coming from higher than just the local level. So I want to give you the opportunity to respond to that. And also, Dr. Shih and Dr. Dallas, Dr. Dallas, in your testimony, you talked about smartphones.

And we have a lot of conversation in Washington these days about what are strategic industries. Which ones should we be protecting? Is this a strategic industry? Is this a strategic industry? Is this a strategic industry?

The plastic that goes into this water bottle is used to make PPE or vials for medicine or for component parts for machinery equipment. So I would really like a discussion about what is a strategic industry. But I'll start with you, Dr. Bulman, and then I'll turn it over to Dr. Shih and Dr. Dallas.

DR. BULMAN: Sure. I entirely take your point. I don't think that -- I think especially if we're bringing Xinjiang into the discussion that the center, of course, knows what's going on and is responsible, right? And I think that's not necessarily directly a supply chain of this sort we're talking about today but needs a U.S. response, no question there.

I think on the environment, it's a little more complicated, central versus local, and also China's level of culpability. I think a lot of things have been outsourced to China because environment standards are lower. But I think environmental standards are lower throughout the developing world. So I think that's less of a central top-down policy. But I entirely take your point that there are areas where the center has been heavily involved that need a U.S. response.

DR. SHIH: Let me make a couple points. First of all, I agree with Dr. Bulman that an awful lot of China's policy and actually one of the things that I think makes it very successful is they will have these top-down goals which then you see a competition at the provincial and the regional level. Okay? And it's actually a competition of ideas, and it's a competition to implement by their own means. Okay?

We see a lot of examples of that. So, I think that's been very effective. One of the things that I think China has focused on especially in the early 2000s if you walk through a factory then, they were bemoaning the fact that their capture of the value add -- at the time they were flip phones, before smartphones -- was only a couple dollars for the labor, right? And all the other parts were imported, right?

So, one of the things we've seen is them trying to move up the value chain to try to capture more of those things. Now let's distinguish between things like Made in China 2025 or the semiconductor initiative where they put 150 billion U.S. equivalent into that. Most of that is wasted. Okay?

I've been in a lot of those factories and some of those fabs. And you can see kind of the capabilities. That's not necessarily an efficient way to develop the capabilities.

There will be instances, especially, for example, they've poured huge amounts of money into Yangtze Memory, who is becoming successful in 3D NAND memory but at huge costs. You pour that much money into the bucket and an awful lot sloshes out. So, it's kind of a unique combination that we're seeing. Some of the -- in general, I'm not a fan of that type of top-down planning because it is really hard to get right.

DR. DALLAS: Thank you, Commissioner. I think one important thing here, when you say, what is a strategic industry, I think it depends on what the goal is and in terms of our relationship to China as well as our own goals in the United States. So, the answer to that question actually is going to vary widely, I would say, by industry and by what our objectives are.

Now as an example, if it's about fear of China's weaponizing a supply chain, let's say plastic in the bottle you mentioned or something like that, that's a different realm, let's say, than other types of more -- a supply chain disruption that could occur because of weather or other issues like that. So it's hard to give a single definition of it. And it really depends on what our objectives are and also what's the possibility of damage that could occur.

I also think that we mentioned before also that to a certain extent, levels of -- I think that's the way we're measuring it these days is sort of the market share and things like that. And that's a useful exercise to see potentially where are the vulnerabilities. But what I was trying to do with the testimony also is to show that as you break down products over and over again, you have to look not just different layers of it to see where the vulnerabilities may exist.

And finally, that's the idea of asymmetric interdependence is we have to really think hard about if we're in the world in which we're worried about weaponization of a supply chain, we have to really think about what are the costs to China if they were to try to weaponize as well. If we're in the more generic world of, let's say, just supply chain disruptions, then the answer may be quite different. But I'm going to say that I don't have an answer for you, but I think that's the type of hard work that needs to be done in government agencies to think through that.

COMMISSIONER GOODWIN: Thank you. Commissioner Mann?

COMMISSIONER MANN: Can you hear me?

COMMISSIONER GOODWIN: Yes.

COMMISSIONER MANN: I had a couple of questions for David Bulman that I want you to explain a little further, things that are in your testimony seemed to underlie much of your testimony, the broader statements. You said that China's use of trade as a political tool is general ineffective. I wanted you to say where you get that idea and to respond to a separate rendition of that which I would say that China's threatened use of trade as a political tool is quite effective in inhibiting other governments.

DR. BULMAN: Thank you, Commissioner Mann. So I agree that the potential use of trade is a lot more effective than the actual use of trade as a political tool. And I think that unfortunately it's very tough to test potential use as an indicator, as a variable.

In the cases where China has actually used trade tools and we know all sorts of them. We know the Japan case. We know salmon from Norway. We know after Dalai Lama visits, obviously what's going on with Australia now.

It's very rare that China actually sees policy change from the target country is part of what I mean. Obviously, there are many cases where we don't see anything. The dog is not barking, right? And I think you're correct that China's asymmetric -- other countries' asymmetric dependence on China.

China is the country that has the most -- the largest trade with the most countries in the world, having superseded the U.S. in that. It's clearly important, and I think there's evidence that other countries align, for instance, U.N. voting with China. There's an interesting paper on that when they are more dependent on trade with China.

So, I think there's no question that China uses trade as a political tool and that this is important for China's rise. I guess my point is China has not been willing to use trade as a political tool very much when the cost for China would be high. And that's really the key issue for the U.S. given the opposite of the asymmetric dependence here.

COMMISSIONER MANN: So, the second question arising from your testimony, you say that we should incentivize China's adherence to international trade norms. Isn't that what the policy was? That sounds an awful lot like the old responsible stakeholder policy. And where do you see evidence in the last 10 or 20 years that that is going to be an effective policy, because it seems to me it hasn't.

DR. BULMAN: Well, I would say that our use of a WTO while obviously China used the WTO in its own way as well and was able to slow roll many decisions. I mean, we won the rare earth case against China. That was important for changing Chinese behavior on our rare earth quotas. So, I think that international trade rules have worked to our advantage at times.

I also think that we ourselves have been moving away from trade integration rather than towards. So, it's tough to test in the last ten years. If you look at something like China's the one that's integrating now.

China is integrating through RCEP and many other forms of preferred trade agreements. It's also applied to joint CPTPP which we, of course, have not. So it is tough to tell where we could incentivize China, where we would've seen that in the last ten years.

I don't want to sit here and relitigate the entire PNTR and WTO accession and what that did for China's policies. But I think China did adhere to international trade norms more after WTO than before. So, I don't know what the counterfactual is there exactly.

COMMISSIONER MANN: Do either of the other witnesses have any thoughts on these issues?

DR. SHIH: One thing that I would add, if you look at what Dr. Bulman was saying where trade has had an influence, it's on the demand side. And China exercises a lot of influence when they can cut off demand, whether it's Korea or whether it's Australia. And I'd just remind us that one of the reasons we've seen such supply chain congestion is because we've been on an import binge from China over the last two years on the trans-Pacific trade lane.

DR. DALLAS: I agree with my colleagues. I won't add anymore.

COMMISSIONER MANN: If I have time, Dr. Bulman, one more question. Are you familiar as an economist with the studies by David Autor and others at MIT on the millions of job losses following WTO? And I wonder what is your answer on that. It's kind of tough. It takes the American economy a long time to adjust. Or what is your view on those?

DR. BULMAN: Yes, I'm very aware, and I think it's excellent literature. I think there's clearly been a China shock. I think China has the largest labor force in the world and entered the global economy. And that had a huge impact.

I think what we should be clear about, though, is what the actually takeaways of the Autor, Dorn, and Hanson literature is. And the takeaway is not that China's unfair policies took over and hollowed out manufacturing. The takeaway is that U.S. policy did not respond and allow for trade adjustment in the U.S., right?

So, I think clearly we need different trade policy. I'm not here to discuss U.S. trade policy. But I don't believe that the takeaways of Autor, Dorn, and Hanson are that China unfairly used the system. Thank you.

COMMISSIONER MANN: Okay. Thank you.

COMMISSIONER GOODWIN: Thank you. Commissioner Scissors?

COMMISSIONER SCISSORS: As we've been sitting here, I have grown wanting to attack all the witnesses' verbal testimony. And I realize as this process went on that I didn't really want to attack their testimony on supply chains. So, I'm not going to do that mostly.

I will say, Dr. Dallas, that your discussion of Chinese insecurity touches on a point I make all the time, and I'm just using you as another target. China under Xi Jinping is not the same country as it was before. And people who disagree with that are just wrong, but some people forget it.

And in particular, you cannot address China's insecurities anymore. You can only address Xi Jinping's insecurities. That won't work because he is paranoid about keeping his position and it's reprehensible.

So, saying we should've dealt with China a certain way in 2005, I might agree with. That's not the case anymore. And as a side note, he wants to be General Secretary until he's dead.

But on a supply chain side, I have a question for Professor Shih. You and I have discussed this before, separately and together. I think we were on a panel recently about this.

I usually find your characterization of the supply chain situation to be fairly close to mine. I also agree with your long-term solutions to a large extent. Do you see any short-term actions that we can take?

And you may say no, or you may say, look, we can do this on the short term. We're going to blow a lot of money, but it'll have some positive impact because, say, tax reform which I support, we'd have to get tax reform passed next year to have an impact in the next four or five years. That's a big ask. Is there anything that you can see that we can do in the short term?

DR. SHIH: I do see short term actions. Mostly as mentioned in my testimony, to the extent that we see these technology transitions coming up in several industries, I will call out in particular pharmaceuticals and drug API which is, of course, a critical one. There's new technology coming.

I think we can invest in it. We can send demand signals to startups in that area by buying for strategic stockpiles so that they have the cash flow to perfect what they're trying to do. So, I do think we can identify technologies like that. We can use our own needs and stockpile needs.

I'm very keen on new processes for making titanium which we are dependent on Russia, Kazakhstan, and China for a majority. We don't have any domestic sources of titanium sponge. There's new process technology that I talked to one company about that's trying to mine it in Tennessee and process it domestically. What we can do is we can send demand signals and provide stable demand to some of these startups as a way of bringing some of those things back and starting to rebuild.

I also -- and my thoughts are -- I mentioned this a little in my written testimony and my thoughts are still incomplete on this because I'm continuing to do research on it. On tax reform, what we need to ask ourselves is why are some of these industries that we deem strategic not investable or not the preferred investment destination of many investors who would rather invest in other things. Okay. Now what I've been looking at are things like if we give them help, does it occur in the form of R&D tax credits?

Does it occur above the EBITDA line, or does it occur below the EBITDA line?

Everybody looks at EBITDA, right? And so, are there things that we can structurally do that will favor some of these industries?

I would argue tax law in this country tends to favor things that don't have a lot of capital intensity, don't have some of that long horizon risk like I want to dig a new rare earth mine or a lithium mine in the United States. And I may not see positive cash flow for ten years, right? Our tax law does not favor stuff like that.

Historically, we have done things like that. If you look at the oil industry a century ago, we help those with tax laws. So, I think there are opportunities, but we have to be very strategic about it.

Going back to the earlier question in terms of what are those strategic industries. Okay. There are some of those, right? If you look at one of the reasons the Chinese were able to ramp up PPE manufacturing and we were not is because we have lost the tooling sector. Okay? And so, there's a strategic industry. And what we can do is we can give demand signals to some of these industries to help them grow back.

COMMISSIONER SCISSORS: I just want to close, you're making a really important point. It opens an enormous hornets' nest. But if we're going to call industry strategic and we're going to have a massive fight over what that means, then why are we taxing strategic industries, right?

If we really decide something is important for the United States, it's not just a particular interest that certain people benefit from, there's a very strong case once we decided that for serious tax relief for those areas. And it would be great if Congress would take that up in 2023. It is going to be very difficult as we have already discussed today to determine what a strategic industry is.

But if we ever decide, pharma, parts of pharma, parts of semiconductor industry are strategic, that's where we could have a more focused tax program. And I'm not looking for a response. I'm making an editorial comment thinking about next year.

DR. SHIH: Could I just quickly comment. Countries besides China do that.

COMMISSIONER GOODWIN: Thank you. Commissioner Wessel?

COMMISSIONER WESSEL: I'm going to start where Derek started. I'm not sure I'm going to end up in the same place. But thank you all for being here. But I have to tell you. I hope I don't leave but I expect to leave this panel deeply frustrated with the economics profession.

The economics profession has told us that in the long term, trade balances will be eliminated because the currency values will adjust. We're told that -- and Dr. Bulman, I think you were talking about rare earths. You negated or neglected to talk about Magnequench and the purchase of U.S. separation and processing equipment by China with state support.

I'd say their policies -- their industrial policies in a number of areas have been exceptionally successful, not in an efficient way which is how U.S. economists gauge things. China is a non-market economy. They don't gauge things and measure things the same way.

Willy, you just talked about EBITDA, and EBITDA certainly is a valuation of an investment approach by companies. But it's first led by IRR, NPVs, and ROICs. EBITDA is a calculation. But the reality of EBITDA on the balance sheet doesn't occur till a number of years later.

So, when you look at what China is doing to incent U.S. and other companies to go to China, the classic market-based calculations are all in China's favor. We are not investing. Even the 52 billion in the chips package is a drop in the bucket according to most people for what needs to be done.

Help me with how I should square and policymakers should square your classical economy approach with the reality of Chinese industrial policies and what they're doing to acquire the industries of the future. And in my view, EVs and all the other things have done a pretty damn good job of today's industries as well. Doctor, do you want to start?

DR. BULMAN: Sure. Well, I think this -- and thank you for the question. I mean, I think you get back to many of the things we've discussed. I think there are sectoral differences.

I think we have to have some standards for judging success. And I do think that China uses a lot of the same standards of efficiency and output that we use and value added. And again, there are definitely --

COMMISSIONER WESSEL: But let me -- and I'm going to go in and out here. They measure success as Derek was just talking about, about the power of their leadership. You talked earlier -- again, unless I'm misquoting you -- that we should not be concerned about Chinese policies and alternative renewable energy because that's providing subsidized products here to us in the U.S., even though it's displaced massive employment, et cetera.

So, they judge success based on different metrics, not just efficiency, not just consumer gain which is how classical economists do it. They do it based on power. And as we advise Congress, Congress is interested in what's going to happen to their constituents. Will they have jobs? Will they be able to put food on the table?

DR. BULMAN: Sure. And again, I completely agree. I think there's still differences among sectors, right? I cited new energy vehicles as an area where China had been successful or these policies had worked. And I think Chinese policy would think that despite all of the waste, right?

The written testimony demonstrates how much waste there has been. And I still think that would be deemed a successful sector, these new sectors where China has come through. But semiconductors is a case where I don't think Chinese policymakers by any metric of power or economic efficiency would say they've been at all successful.

And yet this is a sector they have plowed the most money into. You can find at least one trillion renminbi have been plowed into this sector with very little to show for it and a lot of fraud. So, I think, yes, obviously Xi Jinping and the CCP, their key concern is their own power. But that power comes from the same economic indicators in strength that we're using globally. And I think that's what they want to achieve.

COMMISSIONER WESSEL: Willy?

DR. SHIH: One thing highlighted in the example which I think might help with what Dr. Bulman said, okay, I was once looking at setting up a new facility. If you wanted to set up a chemical manufacturing facility in Shanghai, they had an industrial park where all industrial power, all the sewers, everything you needed was there. You could set up. You could be up and running relatively quickly.

I have seen factories in China that are bare dirt in the month of May that are staffed and operating in August. That is because the government set priorities. And local regions said, well, here's one of the ways we can facilitate a rapid growth in those sectors.

So, it's a combination of things. I'll be interested to see how long it takes Intel to get their new fab in Ohio permitted. It's probably going to be four, six times longer than it would in China.

DR. DALLAS: Commissioner, I actually agree completely with your characterization. And I think that even in cases like solar or other areas that Chinese industrial policy can actually work innovation. So, we may not have actually taken the best technological route given the fact that they had first mover advantage.

They scaled very quickly. And they have produced a global technology that is suboptimal given that it's obviously very important. But also, there's a lot of experimentation going on in Europe and the United States. So, I think that's another thing.

It's not just jobs in other words. It's also about the long, long track innovation trajectories. So, I think you're -- I'm actually in agreement.

And actually, Commissioner Scissors, I'm actually in agreement with you. I don't think I said that nothing changed with Xi came into power. And so, I agree with you.

I'm just simply saying that there are continuities from the past that we have to be aware of. And that is these continuities came pre-Xi with industrial policy. And obviously, Dr. Bulman has been talking a lot about the failure of industrial policy too.

That's a continuity from the past as well. And so, it's merely to point out those continuities. I think in my testimony, I did talk about sort of the new types of leapfrogging that they're trying to do, technological leapfrogging.

I would say that is new, and I think it very well does come from the top as well. So, in terms of strictly industrial policy, I think you're right. But in terms of your characterization of Xi, I actually don't have a problem with what you said.

COMMISSIONER GOODWIN: Thank you. Chairman Wong?

CHAIRMAN WONG: Thank you. Mr. Bulman, I just want to follow up a little bit on what Commissioner Mann had focused on in your recommendation number two. And I'm just trying to get a better understanding because I know in a limited set of words, it's hard to get out all the detail.

But your recommendation is, in part, to use trade carrots to shape Chinese policy, at least in the medium term. But if I understand your testimony correctly, you take the position that at least in the main -- the industrial policies, the policies of China to insulate or build up supply chain leverage either have been ineffective or not contributory because it's been natural or comparative advantages that have given rise to this leverage. And to the extent that they do have an effect, they can affect the global public good, at least in the terms of subsidies, lowering costs in certain sectors.

So, my question is in your recommendation, what Chinese policies are you talking about that we're trying to affect? That's question number one. And to affect them, what carrots would you suggest that we offer? That's number two. And number three, you mentioned the same recommendation, CPTPP and the emergent IPEF. And given that at least at present those frameworks don't include China, how does that directly connect to changing or shaping the Chinese policies?

DR. BULMAN: Sure. Thank you very much. So, I want to be clear that although Chinese overcapacity in certain sectors can lower costs and this can have positive effects globally, there are also a lot of, of course, negative effects for manipulating determinants of trade. And I'm sorry if that was not clear in the testimony. It clearly wasn't given comments.

I think that we need to -- when I gave the recommendation on trade, I think there's two parts to it. One was that the U.S. needs to integrate more, especially in the East Asian region, leaving China to the side, right? I think that right now China has integrated much more with East Asia and gotten much more tightly involved in regional supply chains and the U.S. has been left out. And I think RCEP will continue that. And there are a lot of estimates about the gains to China and to the region from RCEP that the U.S. will not be part of.

CPTTP is something that lowers tariffs. It, of course, would help on that front in terms of U.S. integration. But it also had obviously WTO-plus type arrangements as well included. And these were much more likely to be able to affect things like public subsidies within China and to actually know the cost of production and market access in China, right? So, I think that whether or not the U.S. joining would have served as the carrot to get China to join and change its policies, this is sort of trade integration that works for the U.S.

But public subsidization is market distorting, and we need more transparency on what China is actually doing and we don't have that. And obviously this was one reason that we had a bit of a breakdown at the WTO as well. So, I think these sorts of policies are essential to continue both for incentivizing China, but also just for getting U.S. integration and incentivizing its budgets to move out of China.

CHAIRMAN WONG: So just so I understand correctly, your position is Chinese policies have been essentially ineffectual in -- or not the main driver of building up their supply chain leverage. So, if we sought to change them, it would have little effect on the supply chain situation. But there's still negative affects you would like to get at. What are those negative effects?

DR. BULMAN: I mean, I think that overcapacity in certain -- so if you look at various subsidy policies that have gone down in, like, robotics, right? We're about to have a huge overcapacity in robots. And China has been incentivized at a local level and is a new industry where you have a top-down policy, local government to implement with that to create this demand, and you get overcapacity.

And that does harm industry abroad, right? So, I think that there are -- and especially in the testimony I can give here in a short amount of time. It's tough to dig down --

CHAIRMAN WONG: Let me just on the robotics examples. But the harm to industry abroad is it is -- and correct me if I'm wrong. Because the profit motive is required for investment for R&D, if overcapacity diminishes that profit motive, especially from a subsidized industry, we will not have that industry in the United States or elsewhere or in allies and partners, right?

DR. BULMAN: Right.

CHAIRMAN WONG: And is that a supply chain issue?

DR. BULMAN: I think in certain sectors, it can be a supply chain issue, yes.

CHAIRMAN WONG: So, Chines policies do in certain -- whether they mean to or not, these subsidies do create leverage for them, artificially separate from their natural or what you would term natural comparative advantages?

DR. BULMAN: Sure. I'm not sure I would call it leverage, but I think there is a form of leverage there. But I also think -- I mean, as I tried to lay out, I think especially with these new emerging industries, yes, these policies have led to success in China if that is success, right?

CHAIRMAN WONG: Okay. I'll read your testimony closely on the second run. But I appreciate your contributions. Thank you.

COMMISSIONER GOODWIN: For a second round, Commissioner Scissors.

DR. DALLAS: I want -- Dr. Dallas, I want to talk to you about industrial policy -- this history of industrial policy. I actually wrote for private sector clients in 2002 that there was a new industrial policy coming associated with the transition. And I say that because I want to note that was a transition to worse police from China.

And we have very little prospect of transition to better policy from China because we have a General Secretary who never wants to leave. That industrial policy, however, was mostly macro. It was a surge of fixed investment that distorted demand in a number of ways and then led to a Chinese supply surge, boosted trade deficits, et cetera, unbalanced Chinese economy.

The reason it was mostly macro is China wasn't really a competitor of the U.S. In most of the industries, it was trying to help. It was trying to displace other -- and it did, displace other suppliers to the United States, among other things.

And the reason I bring that up is because industrial policy now, 20 years later, is very different than industrial policy then because as we all know China has moved up in terms of its technological capability. So, you now get the Germans caring about Chinese policy whereas 10 years ago, they were, like, China's great, what are you talking about, because it wasn't aimed at them. So, there's an obvious way in which industrial policy should not be used in 2022 the way it was in 2002, 2007, and so on.

That's implicit criticism of the way people use continuity industrial policy. But I want to be -- I do have a constructive question which is -- and you mentioned something I totally agree. China warps the technological chain that we're on.

It predates non-Chinese firms that could've been more innovative, substitutes its own less innovative firms. It is globally discouraging of innovation. Corporate R&D spending is dropping, all of that.

So that's an example. But what I want from you is, like, where would you say -- because it's relevant to everything we've been talking about -- Chinese industrial policy now is most different than where it was in the past? And you can pick the time frame.

You can say 10 years. You can say 20 years. But pick out the areas where you think, hey, now this is where industrial policy is really different than it was before. And that can be because of technological change of the policies themselves are whatever.

DR. DALLAS: Sure. No, I think one is an obvious one and it's sort of well-known in how much money is going into it. The sheer quantity of funding is much different. So, in terms of the medium and long-term plan back in 2006 was not substantially funded, although there was funding for it.

The global financial crisis then really -- China started to kick in a lot more funding, mostly to boost demand. I think that is another difference that you might highlight. The strategic emerging industries program, they were -- because of the financial crisis, they were more trying to boost demand.

Now I think it's more about investing and supply. So, I think that's another distinction in terms of the current industrial policy, so just sheer quantity of resources. Now whether that's going to work or not I think is another issue.

And again, I think Dr. Bowman did a good job in his testimony to show that it may not. And I'm particularly also thinking about the government guided funds and whether or not that's really going to be a decent mechanism by which distribute these funds. And I'm also very skeptical of that.

Now the other thing I highlighted in the testimony is it seems to be a shift to leapfrogging technology. And I think that is a more concerning thing that needs to be -- an eye needs to be kept on that because these are emerging technologies. We don't have the standards yet.

There isn't sort of -- there is a potential for first mover advantage in these. I'm not as expert in those industries. There's plenty of experts on them around Washington.

And so, I think that that's another area where there seems to be a step change in terms what their goals are. And to your point about, let's say, the Germans being concerned about Chinese industrial policy, especially Made in China 2025 I would say, I think that they should be. And they need to keep a close eye on it.

I think it's partly driven also by broader factors, not necessarily international competitiveness but also on sort of their demographic decline where they're going to need to use these Industry 4.0 means in order to get a lot more productivity from each worker. So again, I agree with you in terms the world changes over time and Chinese industrial policy has changed over time. And these are things that we do have to keep an eye on.

COMMISSIONER SCISSORS: So I want to make another closing comment which fits with what one of the witnesses said at least which is if we look back on Chinese industrial policy distorting supply chains which it did and it harmed the United States. And I think it harmed the United States more than you guys may think it harmed the United States. That's going to mess up our policies.

What we're facing now is a Chinese attempt use less labor, jump in technology. It's a new set of industrial policies what we're looking for, the next five or ten years, is not that same. And as a subset of that, the supply chains we have to focus on are not the same as the ones in my view the Chinese very badly harmed. But the ones are going to harm are a different set of chains than the one they've already harmed. Sorry. Another editorial comment at the end.

COMMISSIONER GOODWIN: All right. Vice Chair Glas?

VICE CHAIR GLAS: I just had a follow-up question to Dr. Shih. In your testimony, you talked about the metal casting industry as a critical part of U.S. manufacturing economy. You talked about high capacity batteries.

And in your previous comment around how to show the demand signal to industry here in the United States, that we have to sort of take the long-term view and look at tax policy and regulatory policy and maybe even the strategic national stockpile. Do you think we're removing fast enough to indicate to industries that you're going to have a demand signal that your U.S. government is responding quickly? And if you don't think we're moving fast enough, what policies do you think we should try to move within the next year around some of these issues?

And the other question I had as a follow-up, some of these industries are heavily dominated in China. And we're trying to de-risk, right, out of China. And we obviously want to bring some of these industries onshore.

So how much should we be sourcing from China for either raw materials or finished products and, quote, strategic industries? And I know that we don't have a defined strategic industry now. We have an ongoing debate on what strategic industries are.

DR. SHIH: Okay. Let me start with the metal casting example because I think it's informative. What happened is when we moved a lot of our casting capacity offshore, what that did then is -- especially in China but also India. If you talk to SME casters, I've talked to a lot of these metal casting companies, they said, yeah, those guys got all the new equipment. We're left with the old equipment.

What happens is the offshore -- the OEMs who consume a lot of these castings send all the high volume, higher profit stuff offshore. And then they keep the low volume quick turn stuff nearby, right? When in fact what those local manufacturers, the domestic manufactures need is they need the revenue stream in order to get the cash flow to invest in the future, right?

So I think there are things that we can help them with by directing government purchases. For example, if you look at -- and you'll hear about it this afternoon I'm sure in terms of defense critical parts that, can we use that demand as a way of driving the upgrading and modernization of some American industry? I think that's a short-term recommendation.

I'm on a Department of Commerce committee, and those are the types of recommendations we are putting in. And then the question is, how much do you want to source? I think a lot of that goes back to the where are those strategic platforms upon which other things are built.

And other things that are build, I need to make sure that I have some healthy domestic capabilities. Now one of the things we can also do is we can rethink how we -- government buying policies, domestic mask manufacturer who stepped up during the pandemic, invested over ten million of his own money to make N95 masks. I patronize them because I want them to be in business.

He just shut down a couple weeks ago, right, because he said, the U.S. government comes in and they say, I'm going to give you ten days to bid. We're going to want to buy 100 million plus masks over the next 90 days. And then they're not going to buy any again for ten years. Nobody is going to build a factory around that. It's, like, we have buying practices that do not favor -- or I should say we have buying practices that we could with a little more thought use them as a tool as well.

COMMISSIONER GOODWIN: We're going to have to leave it there. I want to thank the witnesses for their great testimony this morning. We're going to take a quick break and try to start back up here at 10:50. Thank you all.

(Whereupon, the above-entitled matter went off the record at 10:44 a.m. and resumed at 10:52 a.m.)

PANEL II INTRODUCTION BY COMMISSIONER BOB BOROCHOFF

COMMISSIONER BOROCHOFF: I'd like to welcome everybody back to our second panel which will evaluate the challenges the United States faces in securing select supply chains and review strategic frameworks and policy options for supply chain realignment. We're going to start the day with the panel with Mr. John VerWey, East Asia National Security Advisor at the Pacific Northwest National Laboratory. Next, we will hear from Mr. Jan-Peter Kleinhans, Project Director for Technology and Geopolitics at the German think tank and I'm just going to say SNV. I'll let you pronounce it, and I want to say thank you for coming all the way from Germany.

Then we'll hear from Kristin Vekasi, Associate Professor at the Department of Political Science and School of Policy and International Affairs at the University of Maine. Finally, we will hear from Mr. Harry Moser, President of the Reshoring Initiative. Thank you all very much for your testimony.

The Commission is looking forward to your remarks. I ask all of our witnesses to please keep their remarks to seven minutes. Mr. VerWey, we've begin with you.

OPENING STATEMENT OF JOHN VERWEY, EAST ASIA NATIONAL SECURITY ADVISER, PACIFIC NORTHWEST NATIONAL LABORATORY

MR. VERWEY: Good morning. Thank you for the opportunity to testify before the Commission today. I'm a longtime admirer of this Commission and its work, and I've relied extensively on the Commission's annual reports and staff level research during my time inside and outside government for the last ten years.

My remarks today focus on presenting key supply chain concepts and definitions, China's role in critical technology supply chains, and summarizing U.S. government critical technology supply chain resilience efforts. Different U.S. government agencies maintain different definitions of supply chain and various lists of critical technologies. For the purposes of my testimony, when I refer to a supply chain, I'm talking about a network of people, processes, technology, information, and resources that delivers a product or service.

When referring to critical technologies, I'm generally referring to a range of technologies most recently identified by the White House Office of Science and Technology Policy in February 2022. Supply chain risk management is the management of risk to the integrity, trustworthiness, and authenticity of products and services within a supply chain. Historically, the primary focus on supply chain risk management has revolved around maintaining cost, schedule, and performance.

Private sector efforts prioritize delivery of products and services on time, at cost, and to specifications or to spec. However, for national security systems, supply chain risk management also focuses on security. At a very basic level, U.S. government supply chain risk management efforts attempt to answer the question, can we trust who we are buying from to deliver products and services on time, at cost, to spec securely.

Regardless of whether this question is answered affirmatively or negatively, the goal is to increase the overall resilience of a supply chain to prepare for unexpected events, respond to disruptions, and recover from them. Answering this question for specific critical technologies requires access to high fidelity data, detailed supply chain mapping, technical expertise, ongoing monitoring and evaluation, and modeling. The fact that critical technology supply chains are entirely commercial and outside government control and limited data is available at the multiple tiers of vendors located in adversary countries makes this effort more complex and difficult.

Chinese firms maintain monopolies or near monopolies in many critical technology supply chain segments, particularly in raw materials, mining, refining, and processing where in some cases U.S. reliance is 100 percent. In my written testimony, I've provided a quantitative open source replicable methodology that uses international trade statistics to characterize U.S. import dependence on China for critical technologies. Building on these findings, I then describe a more qualitative example of the challenges imposed by China's dominance, the mitigation options for policymakers, and tradeoffs they face.

My analysis shows that China is responsible for over one-third of U.S. imports of critical technology goods. Note that this does not include software or things that are intangible trade. My written testimony also includes a case study that expands on this methodology to show how international trade data combined with detailed supply chain mapping can reveal lower tier vulnerabilities.

The U.S. is attempting to mitigate some of these vulnerabilities. But mitigation efforts frequently come with tradeoffs. For example, the U.S. has abundant raw material resources. But increasing domestic mining and refining capacity has long lead times, is costly, and comes with tradeoffs.

The U.S. government has taken a wide variety of initiatives to review and manage critical technology supply chains. The most recent and visible example of these efforts to review supply chain security are the February 2022 reports prepared by executive branch agencies in response to Executive Order 14017 on America's supply chains. There are also ongoing industrial-based studies conducted by the Departments of Commerce and Defense, GAO reports, NIST and DHS working groups, and U.S. geological survey reports that review U.S. supply chain resilience for various technologies and segments.

U.S. government efforts to manage supply chain vulnerabilities are less extensive than the aforementioned efforts to review supply chains. And the maturity of these efforts varies by agency due to statutory authorities and scope of work. The reason for this divergence is simple. Some agencies have sprawling supply chains and authorities while others do not.

In general, the U.S. government manages supply chain vulnerabilities through four avenues. First, identification and mapping of critical technology supply chains, from raw materials to end of life recycling. Second, sharing supply chain risk management best practices.

Examples of this include practices developed by NIST, CISA and the Department, and ODNI. Applying supply chain risk management standards to public sector operations is the third line of effort. These include DoD instructions related to supply chains and intelligence community directives.

Finally, there's also strategic allocation of funds to increase supply chain resilience through innovation, stockpiling, or financial aid to distressed by critical firms. This takes the form of DPA funds, DOE loan program office funds, and SBIR grants, for example. The goal of U.S. critical technology supply chain security policies should be to ensure that for each segment of a critical technology supply change, there are at least three manufacturers, domestically or in friendly countries that combined are able to meet 50 percent of current and forecast demand.

In support of this goal, U.S. government efforts to review and manage critical technology supply chains should take the following into account. There's a need to harmonize definitions, directives, mapping, and best practices developed across the government and have that adopted by all other government agencies as it relates to supply chains and supply chain risk management. There's also a need to increase interagency participation in supply chain work.

For example, the U.S. International Trade Commission, the Environmental Protection Agency, and the U.S. Geological Survey all have important roles to play in mapping critical technology supply chains, characterizing choke points and import dependence, and also determining the viability or lack of viability of a proposed mitigation. There's also a need to think strategically about how we can leverage critical technology supply chain co-dependencies.

Many of the findings developed in the most recent reports could be integrated to identify instances where critical technology supply chains and supply chain segments share co-dependencies or competing application demand.

And funds can be directed to create win-win investments for supply chain resilience in that regard. Large castings were discussed by the previous panel, and they're important for both nuclear energy generation and ship building, for example, equity shared by the Department of Energy and Department of Defense, respectively. Finally, there's a need to coordinate information collection and dissemination.

Sustained critical technology, supply chain information, collection integration, monitoring and analysis is necessary as technology supply chains evolve, vendors enter or exit, and U.S. government systems increase or reduce their reliance on a technology. A process for procuring information and sharing vendor risk assessments would also be helpful. Thank you for the opportunity. I look forward to your questions.

PREPARED STATEMENT OF JOHN VERWEY, EAST ASIA NATIONAL SECURITY ADVISER, PACIFIC NORTHWEST NATIONAL LABORATORY

Pacific Northwest
NATIONAL LABORATORY

PNNL-SA-173570

U.S.-China Competition in Global Supply Chains

Testimony before the U.S.-China Economic and Security Review Commission

June 2022

John VerWey - East Asia National Security Advisor

1. Key Concepts and Definitions

Different U.S. government agencies maintain different definitions of "supply chain" and various lists of "critical technologies."[1] I will discuss both of these concepts in detail later, but for the purposes of my testimony, when I refer to a supply chain I am talking about "a network of people, processes, technology, information, and resources that delivers a product or service."[2] When referring to critical technologies, I am generally referring to a range of technologies identified by the White House Office of Science and Technology Policy in February 2022.[3]

Supply chain risk management (SCRM) is the management of risk to the integrity, trustworthiness, and authenticity of products and services within a supply chain.[4] Historically the primary focus of SCRM has revolved around maintaining *cost*, *schedule*, and *performance*.[5] Private sector SCRM efforts prioritize delivery of products and services on time, at reasonable cost, and to specifications ("to spec"). However, for national security systems, SCRM also focuses on *security*. The term "security" encompasses concepts like trust, traceability, integrity, and resilience, among others. SCRM draws on many disciplines and requires participation from subject matter experts in acquisition, information assurance, logistics, analysis, and risk.[6]

At a very basic level, U.S. government SCRM efforts attempt to answer the question "can we trust who we're buying from to deliver products and services on time, at cost, to spec, securely?" Regardless of whether this question is answered affirmatively or negatively, the goal is to increase the overall resilience of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them.[7] Answering this question for specific critical technologies can require access to high fidelity data, detailed supply chain mapping, technical expertise, ongoing monitoring and evaluation, and modeling. The fact that critical technology supply chains are often entirely commercial and outside government control and limited data is available at the multiple tiers of vendors located in adversary countries, makes this effort more complex and difficult.

"Tiers" refer to different levels in a supply chain. Supply chain tiers are easily understood by thinking about aircraft manufacturing. A plane is provided by an original equipment manufacturer (OEM). This OEM relies on Tier 1 vendors to provide various components like wings, engines, avionics, and tires. Tier 1 vendors rely on Tier 2 vendors to supply subcomponents. For example, avionic suppliers rely on electronic assemblies. These Tier 2 suppliers rely on Tier 3 suppliers for items that go into electronic assemblies like printed circuit boards (PCBs) and integrated circuits (ICs). And these Tier 3 suppliers rely on Tier 4 suppliers for equipment used to fabricate PCBs and ICs. Finally Tier 4 suppliers rely on Tier 5 suppliers for raw materials like silicon. Mapping supply chains gets progressively more difficult the

[1] See Appendix A and F for representative examples.
[2] https://www.dni.gov/files/NCSC/documents/supplychain/20200925-NCSC-Supply-Chain-Risk-Management-tri-fold.pdf
[3] https://www.whitehouse.gov/wp-content/uploads/2022/02/02-2022-Critical-and-Emerging-Technologies-List-Update.pdf
[4] https://www.dni.gov/files/NCSC/documents/supplychain/20190327-ICD731-Supply-Chain-Risk-Manage20131207.pdf
[5] https://www.dni.gov/files/NCSC/documents/supplychain/20190327-Deliver-uncompromised.pdf
[6] https://www.dni.gov/files/NCSC/documents/supplychain/20190327-ICD731-Supply-Chain-Risk-Manage20131207.pdf
[7] https://www.emerald.com/insight/content/doi/10.1108/09574090910954873/full/html.

"deeper" one looks into the tiers. Frequently, OEMs do not have good visibility in to their Tier 4 and Tier 5 suppliers.

Chinese firms are dominant in a wide variety of critical technology supply chains at various tiers. This dominance may range from obvious to opaque and requires careful analysis of upstream and downstream supply chains to correctly identify and map the tier in which their dominance is present. As will be discussed later, Chinese dominance is particularly acute in raw materials mining, refining, and processing, where the U.S. is 100% reliant on Chinese firms for supply of certain minerals.[8]

In the supply chain world, the concept of being 100% reliant on a particular firm for supply of a product or service makes that vendor a "sole-source supplier" or a "single-source supplier." A sole-source supplier is the only *known* vendor of a particular product or service. A single-source supplier is the only *qualified* vendor of a particular product or service. For many U.S. national security systems, there are single or sole-source suppliers present in various tiers of the supply chain. Single- and sole- source suppliers are among the most obvious and acute supply chain risks.

There are a wide variety of supply chain risks. Single- and sole- source suppliers are examples of market concentration risks, in which a small number of suppliers control the vast majority of supply of a product. Supply chain risks take many other forms, including geographic concentration, geopolitical, price and market volatility, environmental health and safety (EHS), intellectual property (IP), standards, substitution, integrity (counterfeits), and cybersecurity. Different technologies face different supply chain risks: information communications technology supply chains focus on cybersecurity risk. Conversely, raw materials supply chains focus much less on cybersecurity risk and far more on EHS risks associated with mining.

Characterizing critical technology supply chain risks is a sequential effort.[9] First, a technology's criticality must be assessed. Second, the supply chain of critical technologies must be mapped. These maps generally share similar segments regardless of the technology: raw materials are mined, refined, and processed into subcomponents, which are then incorporated into components that are then combined to form a finished system. Once these finished systems reach end of life (EOL), recycling and recovery is undertaken to generate raw materials for re-use.[10] Third, current vendors and alternate vendors are identified for each of these segments. Fourth, threats, vulnerabilities, and risks presented by the vendors are analyzed. Fifth, a determination to accept, reject, transfer, share, or mitigate these risks is made. Finally, an ongoing monitoring and assessment function re-evaluates each of these sequential steps over time.

2. China's Role in Critical Technology Supply Chains

Chinese firms maintain monopolies or near monopolies in many critical technology supply chain segments. Recent reports published by the U.S. government describe this dominance in detail both qualitatively and quantitatively.[11] In this section I present a quantitative open-source replicable methodology that uses international trade statistics to characterize U.S. import dependence on China

[8] https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals

[9] This section is derived from NIST SP 800-161 Rev. 1

[10] There are also important vendors adjacent to these segments, such as suppliers of specialty equipment or cybersecurity services.

[11] https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf

for critical technologies. Building on these findings, I describe a more qualitative example of the challenges imposed by China's dominance, the mitigation options for policymakers, and trade-offs.

2.1. Quantifying U.S. Critical Technology Industry Import Reliance on China

In 2018, the Congress passed the Foreign Investment Risk Review and Modernization Act, which resulted in the expansion of the Committee on Foreign Investment in the United States' mandate to review transactions of certain critical technology industries.[12] In response to this law, the Department of the Treasury identified 27 industries involved in critical technologies and their corresponding North American Industrial Classification System (NAICS) codes.[13] These industries included aircraft manufacturing, semiconductor manufacturing, batteries, and power distribution/transformers, among others. The NAICS codes are correlated with international trade statistics, making determination of aggregate imports and exports associated with a specific industry relatively straight-forward.[14]

Using the NAICS codes of technology industries defined as "critical" under the Department of the Treasury's pilot program, it is possible to determine U.S. imports from China for each of these industries and U.S. imports from the world for each of these industries. Analysis of U.S. imports from China as a percent of U.S. imports from the world for the time period between 2017-2021, showed U.S. reliance on imports from China of goods affiliated with these critical technology industries declined from 40% in 2017 to 36% in 2021. Not surprisingly, U.S. import dependence is particularly acute for information communication technologies and comparatively minor for aircraft and petrochemicals where the U.S. has a strong domestic supplier base. Additional details are presented in Appendix B.

The NAICS code analysis shows that ***China is responsible for over 1/3rd of U.S. imports of critical technology goods.*** However, U.S. import dependence on China for critical technology goods is even more pronounced when looking at specific critical technology industries and interpreting trade statistics more carefully. According to this NAICS code analysis, 40% of U.S. imports of storage batteries in 2021 were from China alone. Correlating this NAICS code with Harmonized Tariff System codes, which allow for more granular interpretation of trade data, shows that U.S. import reliance on China is more pronounced. For example, U.S. imports of lithium-ion batteries (HTS 8507.60) from China grew from $1 billion in 2017 (43% of total U.S. imports) to $4.2 billion in 2021 (56% of total U.S. imports).[15] Additional details are presented in Appendix C.

2.2. Qualitative Assessment of U.S. Battery Supply Chain on Imports from China

Lithium-ion batteries have been recognized in U.S. Department of Energy (DOE) and U.S. Department of Defense (DOD) supply chain reports as an important technology for economic and national security, making the import reliance on China described in the previous section a vulnerability.[16] However, the quantitative analysis presented in the previous section understates U.S. reliance on China for battery

[12] https://www.congress.gov/bill/115th-congress/house-bill/5841/text
[13] https://home.treasury.gov/system/files/291/Pilot-Program-FAQs.pdf
[14] All statistics derived from U.S. International Trade Commission (USITC) DataWeb: https://dataweb.usitc.gov/. There are several caveats to this analysis: (1) there are many critical technology industries that do not have a NAICS code (all software industries, for example); (2) several NAICS codes identified by Treasury do not have any trade affiliated with them (221113, 332117, 336414, 541713, 541714).
[15] All statistics derived from USITC DataWeb: https://dataweb.usitc.gov/.
[16] https://media.defense.gov/2022/Feb/24/2002944158/-1/-1/1/DOD-EO-14017-REPORT-SECURING-DEFENSE-CRITICAL-SUPPLY-CHAINS.PDF; https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf

technology. When the battery supply chain is broken down into segments, the acute dependence of the U.S. on China becomes apparent.

Raw Materials → Processed Materials → Subcomponents → Manufacturing → Recycling

The U.S. Geological Survey recently found that China was the leading producer of 16 out of 32 critical minerals identified in its 2022 report.[17] This leading position is particularly true for lithium-ion battery based materials. Lithium-ion batteries rely on cobalt, iron, nickel (C1), manganese, lithium, and graphite. China leads the world in raw material mining of graphite, accounting for 82% of the global production. The DOE recently found "China has near absolute dominance of today's refining capacity for metals necessary for lithium-ion batteries,"[18] which includes cobalt sulfate (62%), high-purity manganese sulfate (95%), and lithium hydroxide carbonate (61%). Similarly, for subcomponents, China's has dominance in the worldwide production of cathodes (63%), anode materials (84%), separators (66%), and electrolytes (69%). Finally, China leads in actual battery cell manufacturing (80%) and is expected to lead the market for recycling of these batteries (50%) as well. Importantly, forecasts show that China's share in each of these supply chain segments is expected to increase as under-development capacity comes online.[19]

The U.S. is attempting to mitigate some of these vulnerabilities, but mitigation efforts frequently come with trade-offs. The U.S. has abundant raw material resources, but increasing domestic mining and refining capacity has long lead times and well understood environmental trade-offs. One recent DOE report found that establishing mining and refining can cost up to $1 billion depending on mine depth, ore type, planned base material production, and location. Location factors include labor costs, taxes, land rents, and availability of infrastructure (water, energy, and transportation), making barriers to entry high.[20] These factors also implicate USG agencies with regulatory equities outside of the traditional supply chain world including the Environmental Protection Agency, the Department of the Interior, and the Army Corp of Engineers.

U.S. firms attempting to enter the subcomponent and product markets for lithium-ion batteries must also contend with high barriers to entry, unknown paths to commercialization, large established competitors, and price volatility. The DOD report noted that defense-specific custom design standards, acquisition policy, and a paucity of good industry data all compound the aforementioned vulnerabilities.[21] In response to these challenges, the DOD recently leveraged Defense Production Act Title III authorities to support development of critical materials for large-capacity batteries.[22] Other DOE-led ongoing initiatives in this domain include the Critical Minerals Institute, the Minerals Sustainability

[17] https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals
[18] https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf (page nos.: 17-21)
[19] https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf (page nos.: 17-21)
[20] https://www.energy.gov/sites/default/files/2022-02/PGM%20catalyst%20supply%20chain%20report%20-%20final%20draft%202.25.22.pdf (page no.: 13).
[21] https://media.defense.gov/2022/Feb/24/2002944158/-1/-1/1/DOD-EO-14017-REPORT-SECURING-DEFENSE-CRITICAL-SUPPLY-CHAINS.PDF (page no.: 20)
[22] https://www.defense.gov/News/Releases/Release/Article/2989973/defense-production-act-title-iii-presidential-determination-for-critical-materi/

program, and Federal Consortium for Advanced Batteries.[23] Later in my testimony I will describe how these efforts could be coordinated to facilitate win-win investments across multiple critical technology supply chain segments.

3. U.S. Government Efforts to Review Supply Chains

In response to these challenges and others, the U.S. government (USG) has undertaken a wide variety of initiatives to review and manage critical technology supply chains.

The most recent and visible example of USG efforts to review supply chain security are the February 2022 reports prepared by the Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, and Homeland Security in response to Executive Order 14017 on America's Supply Chains.[24] These reports, which included both 100-day and 1-year deliverables, reviewed a wide variety of critical technology supply chains in industries important to U.S. economic and national security.[25]

The U.S. government has engaged in several supply chain review efforts in the past five years. These efforts include Executive Order 13817 and Executive Order 13953, both of which focused on increasing critical mineral supply chain security.[26] Relatedly, Executive Order 13806 tasked the DOD with analysis of its defense industrial base and supply chain resilience.[27] The Department of Commerce's Bureau of Industry and Security also maintains an industrial base assessments division which has published several reports on specific critical technologies and their supply chains in the past five years.[28] Moreover, the Government Accountability Office (GAO) regularly reviews government efforts to assess and manage supply chain risks, especially as they relate to critical technology. Recent GAO reports in 2020 and 2021 focused on government information technology supply chain risks and DOD efforts to protect critical technologies respectively.[29]

Several agencies maintain ongoing efforts to review supply chain vulnerabilities across sectors. The U.S. Geological Survey releases an annual "List of Critical Minerals" deemed important to "national security, [the] economy, renewable energy development and infrastructure."[30] The National Institute of Standards and Technology (NIST) at the Department of Commerce has produced SCRM guidelines for cybersecurity management designed to increase public and private sector supply chain resilience.[31] NIST is also currently studying the feasibility, advisability, and costs of establishing a national supply chain

[23] https://www.energy.gov/policy/articles/americas-strategy-secure-supply-chain-robust-clean-energy-transition (page no.: 23)

[24] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/02/24/executive-order-on-americas-supply-chains/

[25] https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/24/the-biden-harris-plan-to-revitalize-american-manufacturing-and-secure-critical-supply-chains-in-2022/

[26] https://www.federalregister.gov/documents/2017/12/26/2017-27899/a-federal-strategy-to-ensure-secure-and-reliable-supplies-of-critical-minerals; https://www.federalregister.gov/documents/2020/10/05/2020-22064/addressing-the-threat-to-the-domestic-supply-chain-from-reliance-on-critical-minerals-from-foreign

[27] https://www.federalregister.gov/documents/2017/07/26/2017-15860/assessing-and-strengthening-the-manufacturing-and-defense-industrial-base-and-supply-chain.

[28] https://www.bis.doc.gov/index.php/other-areas/office-of-technology-evaluation-ote/industrial-base-assessments

[29] https://www.gao.gov/products/gao-21-171; https://www.gao.gov/assets/gao-21-158.pdf

[30] https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals

[31] https://www.nist.gov/news-events/news/2022/05/nist-updates-cybersecurity-guidance-supply-chain-risk-management

database.[32] The Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA) has had a standing Information and Communications Technology (ICT) Supply Chain Management Task Force since December 2018.[33] The Department of Commerce is also leading the U.S. government's engagement with the European Union under the aegis of the U.S.-EU Trade and Technology Council to review critical technology supply chains and identify areas of collaboration to increase resilience.[34] Finally, the DOD produces an annual Industrial Capabilities report which presents the Department's priority industrial base risks and vulnerabilities within its supply chains.[35]

4. USG Efforts to Manage Supply Chains

The U.S. government's efforts to manage supply chain vulnerabilities are less expansive than the aforementioned efforts to review supply chains, and the maturity of these efforts varies by agency due to statutory authorities and scope of work. The reason for this divergence is simple: some agencies have sprawling supply chains and authorities, while others do not. For example, the F-35 Joint Strike Fighter relies on a supply chain of at least 1,900 companies and that system is just one of dozens of aircrafts that support DOD missions.[36] As a result of this vast industrial base, the DOD has entire sub-agencies dedicated to supply chain management and logistics (e.g., the Defense Logistics Agency)[37] as well as unique statutory authorities such as Title III of the Defense Production Act which provides for the use government funds to sustain critical production, commercialize research and development investments, and scale emerging technologies.[38] Conversely, the Department of Education has a much smaller supply chain and its statutory authorities related to supply chains are commensurately limited.

In general, the U.S. government manages supply chain vulnerabilities through four avenues: (1) identification and mapping of critical technology supply chains; (2) SCRM best practices; (3) applying SCRM standards to public sector operations; and (4) strategic allocation of funds to increase supply chain resilience through innovation, stockpiling, or financial aid to distressed but critical firms.

4.1. Mapping Critical Technology Supply Chains

The aforementioned government reports map critical technology supply chains with various levels of granularity and fidelity. These mapping efforts focus on determining specific supply chain segments and, in some cases, specific vendors and their market shares in these segments. Some of these mapping efforts are limited by a lack of access to data (which may be paywalled or simply not exist) or an inability to define the supply chain for a particular technology, which may be too nascent or emerging to have well-defined supply chain segments. In general, the supply chain vulnerabilities these reports identify are not systematically monitored or updated as supply chains change, but rather present a "snapshot in time" view. Harmonizing the varied methodologies used to map supply chains, data sources consulted, and the ad hoc nature of the risks identified and mitigation recommended would improve U.S. government efforts to review and manage supply chains across different agencies.

[32] https://www.nist.gov/document/chart
[33] https://www.cisa.gov/ict-scrm-task-force
[34] https://www.commerce.gov/news/press-releases/2022/05/us-eu-joint-statement-trade-and-technology-council
[35] https://www.defense.gov/News/Releases/Release/Article/2472854/dod-releases-industrial-capabilities-report/
[36] https://www.lockheedmartin.com/en-us/products/f-35/f-35-global-partnership.html#:~:text=Six%20Foreign%20Military%20Sales%20customers,nation%20acquiring%20the%20F%2D35
[37] https://www.dla.mil/AboutDLA/
[38] https://www.businessdefense.gov/ai/dpat3/overview.html.

4.2. Supply Chain Risk Management Best Practices

Various U.S. government agencies create "best practices" or standards documents designed to be shared with the public and private sector to harmonize SCRM efforts. NIST published Supply Chain Risk Management Practices for Federal Information Systems and Organizations in 2015 (updated as of May 2022) to provide guidance on identifying, assessing, and responding to cybersecurity risks throughout the supply chain at all levels of an organization."[39] CISA's ICT SCRM Task Force hosts an annual supply chain integrity month, has generated an SCRM toolkit, and maintains an ICT Supply Chain Resource Library.[40] In addition, the National Counterintelligence and Security Center (NCSC) hosts an annual "Supply Chain Integrity" month that includes a calendar of training events as well as a website with a repository of SCRM best practices documents generated by the public sector.[41] This summary of efforts is indicative, not exhaustive, and many of the subject matter specific resources contain best practices that are relevant across critical technology sectors.

4.3. Applying SCRM Standards to Public Sector Operations

The DOD and the intelligence community maintain a series of instructions and directives designed to promote SCRM best practices throughout their organizations. Department of Defense Instruction (DoDI) 4140.01 states the Department's supply chain material management policy while DoDI 5200.44 and 8500.01 focus on methods to establish trust and resilience in mission critical systems and cybersecurity.[42] Intelligence Community Directive (ICD) 731 was established in 2013 to protect the supply chain for mission critical products, materials, and services used across the intelligence community's organizations.[43] Subsequent directives have focused on supply chain criticality assessments, threat assessments, information sharing, vulnerability assessments, and risk assessments.[44] The Committee on National Security Systems has also issued a directive on SCRM.[45]

4.4. Strategic Allocation of Public Sector Funds

The U.S. government manages supply chains and mitigates known supply chain vulnerabilities through the use of funds to increase innovation, supports stockpiling, and provides financial support to particularly important suppliers. The DOE's Loan Programs Office (LPO) and Advanced Research Projects Agency–Energy (ARPA-E) distribute funds that can target sectors or technologies to increase innovation and resolve particular supply chain chokepoints.[46] Similarly, the Defense Advanced Research Projects Agency (DARPA) has funded initiatives focused on increasing semiconductor supply chain resilience as well as software development to provide real-time supply chain system awareness.[47] The Small Business Administration oversees the Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) program which provides federal funds to small innovative businesses to demonstrate

[39] https://www.nist.gov/news-events/news/2022/05/nist-updates-cybersecurity-guidance-supply-chain-risk-management

[40] https://www.cisa.gov/ict-scrm-task-force

[41] https://www.dni.gov/index.php/ncsc-what-we-do/ncsc-supply-chain-threats.

[42] https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/414001p.pdf; https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/520044p.pdf; https://www.esd.whs.mil/portals/54/documents/dd/issuances/dodi/850001_2014.pdf

[43] https://www.dni.gov/files/NCSC/documents/supplychain/20190327-ICD731-Supply-Chain-Risk-Manage20131207.pdf

[44] https://www.dni.gov/index.php/ncsc-what-we-do/ncsc-supply-chain-threats

[45] https://www.dni.gov/files/NCSC/documents/supplychain/CNSSD_505_Final2-891B85C3-.pdf

[46] https://www.energy.gov/lpo/loan-programs-office; https://arpa-e.energy.gov/

[47] https://www.darpa.mil/news-events/2020-05-27; https://www.darpa.mil/program/logx

project feasibility, develop prototypes, and commercialize promising technologies. The Defense Logistics Agency maintains the National Defense Stockpile, which stores 42 commodities ranging from zinc, cobalt, and chromium to platinum, palladium, and iridium, cumulatively valued at $1.1 billion.[48] The DOE's National Nuclear Security Administration also maintains a stockpile to support of the nuclear weapons enterprise.[49] Finally, the DOD's Industrial Base Policy office maintains the ability to conduct assessments of supply chains and distribute funds to firms engaged in the production of technologies that support national security under Title III of the Defense Production Act and the Cornerstone Other Transaction Authority (OTA), among others.[50]

5. USG Critical Technology Supply Chain Security: Harmonizing Definitions, Mapping, Risks, and Mitigation

The ultimate goal of U.S. critical technology supply chain security policies should be to ensure that for each segment of a critical technology supply chain there are at least three manufacturers located domestically or in allied countries that in combination have the capabilities to meet 50% of current and forecast domestic demands.[51] Where this goal is not attainable, the U.S. should have a process for determining if this supply chain risk should be accepted, rejected, transferred, shared, or mitigated.

Achieving this goal would restructure critical technology supply chains to increase their resilience and trust-ability. The goal of a comprehensive U.S. government supply chain security strategy should be establishment of a sustained capability aligned across executive branch agencies to:

- Develop a process to identify (and de-identify) a technology as "critical".
- Map, monitor, and assess technology supply chains deemed "critical".
- Create a qualitative and quantitative technology-agnostic supply chain risk assessment metric.
- Determine risk mitigation options and their trade-offs.
- Identify win-win investments that increase resilience across multiple supply chains shared by executive branch agencies.

There is a unique opportunity to increase harmonization of the aforementioned efforts to review and manage critical technology supply chains across agencies. U.S. government efforts to review and manage critical technology supply chains could be improved by: (1) harmonizing definitions of "supply chain" and "critical technology," (2) creating a template for interagency use when mapping critical technology supply chains, (3) developing a technology-agnostic supply chain risk assessment metric to determine vulnerabilities; (4) developing a taxonomy of supply chain risks; and (5) developing a register of mitigation options that corresponds with supply chain risks.

5.1. Shared Definitions of Supply Chain and Critical Technology

There are a wide variety of U.S. government definitions of "supply chain" and "supply chain risk management."[52] For example, the DOD, the Office of the Director of National Intelligence, and the National Institute of Standards and Technology at the Department of Commerce have all published

[48] https://www.dla.mil/Strategic-Materials/About/Our-Offices/
[49] https://www.energy.gov/nnsa/articles/stockpile-stewardship-and-management-plan-ssmp
[50] https://www.businessdefense.gov/ai/index.html
[51] These notional statistics are borrowed from: https://www.energy.gov/sites/default/files/2022-02/Electric%20Grid%20Supply%20Chain%20Report%20-%20Final.pdf (page no.: 44).
[52] See Appendix A for an indicative list drawn from NIST, DOD, and ODNI publications.

definitions of "supply chain" and "supply chain risk management." Harmonizing these definitions would support efforts to map supply chains by defining the key elements and actors. Harmonizing each of these agency's definitions of SCRM would likewise ensure that SCRM efforts are more aligned across the executive branch.

The U.S. government also has several different lists of "critical" and/or "emerging" technologies. The process of identifying critical technologies and developing a shared nomenclature to describe them is ongoing. Lists have been generated by the Department of Commerce's Bureau of Industry and Security (2018),[53] the White House (2020, 2022),[54] the Office of the Director of National Intelligence (2021),[55] the Department of Defense (2022),[56] and through the interagency coordinated effort in response to EO 14017.[57] These lists all make reference to advanced computing, artificial intelligence/machine learning, biotechnology, semiconductor technology, and quantum information science. Several lists are more expansive and also include technologies important to the financial industry (ex. distributed ledger technologies) and the energy sector industrial base (e.g., nuclear energy, fuel cells, batteries). A full comparison is provided in Appendix F.

Developing a harmonized list of critical technologies would help prioritize which supply chains to map, which threats and risks are short-term vs. long-term, and what mitigation options are available. Several U.S. government supply chain reports have presented examples of how to identify critical technologies and map their supply chains. For example, the DOE's supply chain reports used 10 criteria when considering whether a technology might be considered "critical":[58]

- **National security**: Is the technology critical to national security?
- **Exposure to supply chain risks**: Is the technology subject to supply chain risks stemming from limited domestic production and/or limited availability of raw materials, or malicious risks from foreign adversaries?
- **Importance to other critical infrastructure**: Are other critical infrastructure and energy systems reliant on the technology in a way that would compound supply chain vulnerabilities?
- **High-quality jobs**: Is there a significant opportunity to create sustained new high-quality jobs?
- **Decarbonization**: Is the technology a big contributor (e.g., new capacity additions) to U.S. decarbonization pathways? Can it reduce emissions by a certain target through Federal deployment?
- **Leverage of U.S. capabilities**: Could the manufacturing process leverage existing processes/capabilities where U.S. has technical leadership or a cost advantage, or where U.S. has ongoing research investments?

[53] https://www.federalregister.gov/documents/2018/11/19/2018-25221/review-of-controls-for-certain-emerging-technologies
[54] https://nps.edu/web/slamr/-/2020-national-strategy-for-critical-emerging-technologies; https://www.whitehouse.gov/wp-content/uploads/2022/02/02-2022-Critical-and-Emerging-Technologies-List-Update.pdf
[55] https://www.dni.gov/index.php/ncsc-newsroom/item/2254-ncsc-fact-sheet-protecting-critical-and-emerging-u-s-technologies-from-foreign-threats
[56] https://www.cto.mil/usdre-strat-vision-critical-tech-areas/
[57] https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/24/the-biden-harris-plan-to-revitalize-american-manufacturing-and-secure-critical-supply-chains-in-2022/.
[58] https://www.energy.gov/policy/articles/americas-strategy-secure-supply-chain-robust-clean-energy-transition
(page no: 57)

- **Stage of commercialization**: Is domestic manufacturing near cost-competitive today or projected to be within five years given sufficient R&D or U.S. industrial policy?
- **Market size**: Is the projected global market for the technology big enough to support supply contributions from multiple economies? Is domestic demand alone sufficient to support a significant level of domestic manufacturing?
- **Global trade potential**: Is the supply chain for the technology subject to high shipping costs or other barriers that support domestic production (e.g., wind blades)?
- **Value add**: Does increased domestic production provide a significant increase in value added to the U.S. economy in comparison to existing manufacturing footprint?

5.2. Harmonizing Supply Chain Mapping Elements

Efforts undertaken by executive branch agencies in response to EO 14017 generated original and authoritative supply chain maps for many critical technologies. These efforts should serve as a template that subsequent USG supply chain mapping efforts can emulate. Importantly, these efforts produced model supply chain analyses of both high-technology readiness level (TRL)[59] (mature, existing) technologies as well as low-TRL (emerging) technologies. An example of this mapping is presented in Appendix E. Building on this mapping system for determining vendors for each raw material, subcomponent, component, and device will also feed in to the risk assessment described in the next section.

The supply chains of high-TRL existing and mature technologies all resemble the same general steps described above: raw materials are mined and refined, these refined materials are processed, the materials are then incorporated into subcomponents and components/systems, applied to their end use, and (ideally) recycled at EOL. In general, for mature supply chains, there are multiple suppliers in multiple countries capable of meeting the demand in each segment. Mapping should identify vendors for each segment of a critical technology supply chain as well as their market share and capacity.

The supply chains of emerging technologies with a low-TRL are necessarily harder to characterize and define. In emerging technology supply chains there may be cases wherein all segments are executed in-house by a vertically integrated firm or a well-defined vendor base for certain supply chain segments simply may not exist. Careful analysis of academic publications, patent filings, and technical standards as well as collaborations with industry and industry associations can help the government generate an indicative bill of materials (BOM) to define the steps in a particular emerging technology supply chain.

5.3. Technology-Agnostic Supply Chain Risk Assessment

Many of the supply chain analyses produced in response to EO 14017 demonstrated qualitative and quantitative supply chain risk assessments that could, and should, serve as a model for technology-agnostic risk assessments going forward.[60] A technology-agnostic supply chain risk assessment would consist of a set of criteria that could be used to assess existing and future threats, risks, and vulnerabilities regardless of the critical technology supply chain in question. Qualitative supply chain risk assessments are necessary when data on a particular industry is unreliable or unavailable. Quantitative supply chain risk assessments are ideal, but can only be accomplished when a variety of high fidelity data on the industry in question is available. For each critical technology supply chain segment, a

[59] https://api.army.mil/e2/c/downloads/404585.pdf.
[60] https://www.energy.gov/sites/default/files/2022-02/Nuclear%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf (page no.: 51)

qualitative or quantitative assessment could be undertaken to characterize threats, vulnerabilities, and risks. For a particular critical technology sector, a model supply chain risk assessment[61] would determine:

- **Domestic supply and demand**: quantifying the number of domestic suppliers, their current capacity, and their ability to meet current domestic demand. Depending on data availability, supplemental research on domestic capacity under development and its ability to meet forecast demand would also be optimal.
- **Global supply and demand**: quantifying the number of international suppliers, the number that are located in friendly vs. adversary countries, and their respective abilities to meet current and projected global demand.
- **Net import reliance**: the dependence of a country on imports to meet domestic consumption, measured by the share of total apparent consumption that is provided by imports.
- **Market concentration:** the extent to which an industry or supply chain is controlled by a small number of firms or countries. Highly concentrated industries are those where a single or few factor(s) affect market outcomes, such as by restricting supply to raise prices, or by oversupplying the market to lower prices below a profitable level for competitors. The Herfindahl-Hirschman Index (HHI) is commonly used to quantify market concentration.[62]
- **Geopolitical sensitivity:** the strength of a producing nations' relationships with the U.S., covering issues including political stability, strength of institutions, labor rights issues, political rivalry, acrimonious relationship, and stability of supply coming from a given country.
- **Price and market volatility:** fluctuations in the price and supply/demand balance of a commodity. High volatility increases the cost and riskiness of doing business, as low prices may disincentivize new investments or make production unprofitable for producers, while high prices may make producers operating on the margin unprofitable. Price volatility is a particular issue in some raw materials markets.
- **Substitutability:** the ability of firms/supply chains to alter their material, product, manufacturing, or consumption patterns in response to price changes or other market shocks.
- **Environmental compliance and workplace safety conditions**: potential environmental damage and occupational safety and health practices that could result in unsteady supply. Producers that have a poor record of adherence to environmental policies have a greater likelihood of being shut down or penalized with fees (increasing costs), and those with poor safety records may face labor shortages or boycotts.
- **Barriers to entry:** large IP moats, standards ecosystems that result in control by one or more firms, and high startup costs all may impede the ability of a supply chain to innovate around chokepoints.
- **Competing application demand:** multiple industries may compete for the same product or upstream raw material, meaning supply of a particular product could become constrained due to a demand shock in an adjacent industry.
- **Lead time and qualification time:** the amount of time it takes to identify new suppliers, take delivery after an order has been purchased, and qualify the new product or service after delivery all impacts the resilience of a supply chain.

[61] https://www.energy.gov/sites/default/files/2022-02/PGM%20catalyst%20supply%20chain%20report%20-%20final%20draft%202.25.22.pdf (Page no.: 25) and https://www.energy.gov/sites/default/files/2022-02/Electric%20Grid%20Supply%20Chain%20Report%20-%20Final.pdf (Page no.: 43)
[62] https://www.justice.gov/atr/herfindahl-hirschman-index.

- **Technology readiness level:** an assessment to determine the TRL of the critical technology in question will assist in mapping the supply chain.
- **Stockpiling:** understanding what if any reserves are held in stockpiles and their sufficiency to meet current or forecast demand in the event of a supply shock.
- **End of life/recycling:** to what extent are recycled products an important feedstock to meet demand in a particular technology supply chain and under what circumstances might this supply change over time.

5.4. Taxonomy of Supply Chain Risks

There are a wide variety of supply chain risks. Depending on the critical technology supply chain, these risks include vendor concentration (single- or sole- source suppliers), geographic concentration (in a particular region), critical infrastructure failures, natural disasters, financial solvency of key vendors, IP theft, product tampering, cybersecurity, regulatory barriers, counterfeiting, workforce, substitutability (or lack thereof), geopolitics, and expropriation. Characterizing these risks in a systematic way is an important part of determining both the severity of the risk and identifying the mitigation options available.

Developing a shared taxonomy of risks that is applicable across supply chains would help the U.S. government better characterize the types of shared risks critical technology supply chains face, and identify the mitigation options available, and determine if any trade-offs exist. Some of the most comprehensive work by the U.S. government on this subject was done by U.S. Department of Homeland Security/CISA's ICT SCRM Threat Evaluation Working Group.[63] This group generated a list of supplier threats, categorized these threats, developed scenarios for threats, and reviewed and documented these scenarios specifically with reference to ICT supply chains.[64] These categories of risk included counterfeit parts, cybersecurity, internal controls, insider threat, economic, extended supply chain, legal, and end-to-end/external supply chain risks. This group also assigned "impact" and "likelihood" scores to each risk, the result of which generated a "risk score." Finally, this group also developed mitigation strategies which took in to account the estimated costs/trade-offs of implementing these mitigating strategies, how they would change likelihood/impact, and estimated residual risk. While specific to ICT supply chains, these efforts could serve as a model that other critical technology SCRM efforts may emulate.

5.5. Mitigation and Trade-offs

Once supply chain risks have been identified, impact and likelihood can be assigned to calculate an overall risk score. For the highest scoring risks, mitigation should be pursued. These risks can either be accepted, rejected, transferred, shared, or mitigated.[65] Each of these choices come with trade-offs, and understanding these trade-offs should be systematized so that policymakers clearly understand their options. A sample of the mitigation options identified by the DOE[66] is provided below:

- Increase domestic raw material availability.
- Expand domestic manufacturing capabilities.

[63] https://www.cisa.gov/ict-scrm-task-force.
[64] https://www.cisa.gov/ict-supply-chain-library
[65] https://csrc.nist.gov/publications/detail/sp/800-161/rev-1/final
[66] https://www.energy.gov/policy/articles/americas-strategy-secure-supply-chain-robust-clean-energy-transition

- Invest and support the formation of diverse and reliable foreign supply chains to meet global climate ambitions.
- Increase the adoption and deployment of clean energy.
- Improve EOL waste management.
- Attract and support a skilled U.S. workforce for the clean energy transition.
- Augment supply chain knowledge and decision-making.

However, more granular work could be done to define these mitigation options, their trade-offs, and next steps. For example, efforts to increase domestic raw material availability would require expansion of domestic mining. However, domestic mining can present environmental, health, and safety concerns which need to be weighed in to balance with the desire for greater supply chain security. In addition, mining regulations are overseen by agencies like the Department of the Interior and Environmental Protection Agency, that are not normally thought of as having major supply chain equities. Other supply chain risks have more difficult trade-offs.

Increasing domestic production of neodymium-iron-boron magnets (hereafter referred to as "rare-earth magnets") illustrates the complex mitigation and tradeoff options policymakers face. Rare-earth magnets are intensively used in generators, wind turbines, as well as national security systems,[67] making an increase in domestic production beneficial for multiple critical technology supply chains. The production of rare-earth magnets in the U.S. production has traditionally been limited across all segments of this supply chain, with China accounting for 58% of mining, 89% of separation, 90% of metal refining, and 92% of metal alloy manufacturing.[68]

Significant expansion of domestic U.S. offshore wind energy would create a commercial demand signal that may increase domestic production of these magnets.[69] However, increasing offshore wind energy production requires that the physical components used in wind turbines be delivered to their final destination and the size of these components is "approaching or over road and rail size limits, meaning the number of routes components can be transported from ports or factories to deployment is decreasing over time."[70] Even where overland transportation is an option, regulatory coordination with county, local, and state regulators is necessary. One alternative is delivering these components by sea, but doing so requires Jones Act-compliant maritime vessels.[71] And the "business case for [Jones Act-compliant maritime vessels] is challenged by lack of certainty in near-term offshore wind demand." As, this example shows, SCRM mitigation comes with complicated trade offs, some of which require regulatory harmonization and USG intervention beyond the discrete risk identified.

[67] https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf (page no.: viii); https://www.federalregister.gov/documents/2021/09/27/2021-20903/notice-of-request-for-public-comments-on-section-232-national-security-investigation-of-imports-of.
[68] https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf (page no.: 26)
[69] https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf (page no.: viii); https://www.federalregister.gov/documents/2021/09/27/2021-20903/notice-of-request-for-public-comments-on-section-232-national-security-investigation-of-imports-of
[70] https://www.energy.gov/policy/articles/americas-strategy-secure-supply-chain-robust-clean-energy-transition (page no.: 17).
[71] https://www.energy.gov/policy/articles/americas-strategy-secure-supply-chain-robust-clean-energy-transition (page no.: 18)

5.6. Identifying Win-Win Supply Chain Investments to Support Critical Technologies

This section synthesizes the findings and recommendations in each of the preceding sections and presents an example of a critical technology supply chain strategy policymakers could consider. It recommends that policymakers look for investments that leverage shared market demand across critical technology supply chains. Specifically, it proposes that an increase in U.S. refining of copper would increase resilience in the semiconductor, battery, and pharmaceutical supply chains.[72]

Based on the findings presented earlier in this report, the lithium-ion battery supply chain is deemed critical by both the DOE and DOD for economic and national security reasons. However, mapping of this supply chain that was undertaken in response to EO 14017 found that most segments are located in China. More specifically, this mapping determined that U.S. domestic supply is insufficient to meet current and forecast demand, global demand is expected to increase substantially, market concentration is high, U.S. net import reliance is high, substitutability is low, there are substantial barriers to entry, several raw materials face competing application demand, and that EOL/recycling is a growth area but the U.S. is not currently positioned to take full advantage of this growth.

Policymakers should pay particular attention to critical technology supply chains where competing application demand is identified as a risk. This risk can be mitigated and turned in to an opportunity that actually increases critical technology supply chain resilience. For example, in the case of battery supply chains, copper was identified as low risk raw material in recent U.S. government reports given that "The United States mines, smelts, refines, and recycles copper, and it has significant copper reserves..."[73]

In spite of this seemingly stable supply chain, increased domestic copper refining capacity would have favorable subsequent effects for the semiconductor and pharmaceutical industries as well the battery industry. Even though the U.S. mines and refines some copper, refined copper accounted for 85% of all unmanufactured copper imports in 2021.[74] Refined copper is particularly important for several technology industries in addition to batteries. The semiconductor industry primarily relies on refined copper for "back-end" assembly, test, and packaging. Specifically, copper is one of many materials used to connect a manufactured chip to a PCBs. In response to a recent Commerce Department Request for Information, one industry representative stated "the domestic electronics industrial base is lacking additive process capability to produce ultra-fine copper circuits."[75] A recent report from the DOE on the semiconductor supply chain identified direct bond copper (DBC) insulator substrates as a particular chokepoint.[76] The pharmaceutical industry also increasingly relies on copper catalyst, a byproduct of copper refining, as a substitute for harder-to-source materials used in drug synthesis.[77] Both industries are expected to intensively consume these copper refining byproducts in the future. Finally, several U.S. companies make equipment that uses copper, among many other materials, to serve the semiconductor and battery markets.[78] Increasing copper refining capacity in the U.S. would increase the resilience of these supply chains as well.

[72] For this example I am grateful to my PNNL colleague Dr. Mark Willey.
[73] https://www.energy.gov/sites/default/files/2022-02/Fuel%20Cells%20%26%20Electrolyzers%20Supply%20Chain%20Report%20-%20Final.pdf (page no.: 31)
[74] https://pubs.er.usgs.gov/publication/mcs2022
[75] https://www.regulations.gov/comment/BIS-2021-0011-0090
[76] https://www.energy.gov/sites/default/files/2022-02/Semiconductor%20Supply%20Chain%20Report%20-%20Final.pdf (page no.:5)
[77] https://onlinelibrary.wiley.com/doi/abs/10.1002/anie.201609837
[78] https://arpa-e.energy.gov/technologies/projects/new-electrode-manufacturing-process-equipment

6. Conclusion

U.S. efforts to review and manage critical technology supply chains are ongoing and require greater interagency coordination to realize their potential. Additional supply chain efforts should incorporate existing best practices across the government. These best practices[79] include:

- Mapping critical technology supply chains by segment, by vendor (including their market share and capacity)
- Identifying existing and future threats, risks, and vulnerabilities.
- Identifying opportunities and major barriers; including financial and commercial, scientific, technical, regulatory, and market barriers.
- Identifying areas where government and private sector can collaborate to expand the industrial base for multiple USG agencies
- Identifying specific actions needed to incentivize companies in critical technology sectors to re-shore or near-shore manufacturing investments
- Identifying specific actions to address threats, risks, and vulnerabilities and help build resilient supply chains.

The goal of U.S. critical technology supply chain security policies should be to ensure that for each segment of a critical technology supply chain there are at least three manufacturers domestically or in friendly countries that combined are able to meet 50% of current and forecast domestic demand.

To summarize several of the points made earlier in my testimony, there are several considerations that should be taken in to account if the U.S. government wants to increase critical technology supply chain resilience:

- **Interagency coordination and harmonization of supply chain initiatives**:
  - Harmonize definitions, directives, mapping, and best practices: The Intelligence Community, the Department of Defense, and the National Institute of Standards and Technology have developed a series of directives, instructions, and best practices related to supply chains and supply chain risk management. This work should be increasingly coordinated by these, and other, executive branch agencies. Examples of productive collaborations could include developing:
    - Shared definitions of "supply chain" and "SCRM"
    - Shared best practices for mapping supply chains
    - Shared best practices reflected in DOD instructions and Intelligence Community Directives on supply chains and SCRM
  - Increase interagency participation in supply chain work: In addition to agencies with obvious supply chain equities such as the Departments of Defense and Energy, The U.S. Geological Survey, the U.S. International Trade Commission, and the Environmental Protection Agency all have important roles to play in mapping supply chains, characterizing chokepoints/U.S. import dependence, and determining the viability of

[79] https://www.energy.gov/policy/articles/americas-strategy-secure-supply-chain-robust-clean-energy-transition (page no.: 3).

mitigation (ex. identifying regulatory hurdles to domestic mining production expansion) respectively. Increasing their participation in ongoing SCRM efforts would be valuable.

    - For example, using it's access to high fidelity trade data, the U.S. International Trade Commission could undertake a Section 332 Fact Finding Investigation to determine U.S. Net Import Dependence on Critical Technologies, using the methodology introduced in Section 2 of my written testimony.

- **Leverage critical technology supply chain co-dependencies**: Building upon the efforts undertaken in response to EO 14017, executive branch agencies could integrate their findings to identify critical technology supply chains and supply chain segments that share co-dependencies and/or competing application demand
    - For example, reports by the Department of Energy and Department of Defense noted that large castings and forgings are important for some renewable energy generation, nuclear energy, and shipbuilding and there is a dearth of U.S. availability.
    - Using existing statutory authorities under the DPA and DOE LPO, among others, these agencies could coordinate increased and prioritized funding for critical technology supply chains and supply chain segments that result in win-win resiliency outcomes for raw materials, sub-component, and component manufacturing in the U.S. and allied countries.
- **Coordinate information collection and dissemination**: Sustained critical technology supply chain information collection, integration, monitoring, and analysis is also necessary as technology supply chains evolve, vendors enter or exit a market, and USG systems increase or reduce their reliance on a technology.
    - This information sharing could take the form of a new supply chain office or standing interagency committee that leverages access to relevant USG data sources and private sector information providers to conduct ongoing SCRM assessments and identifies win-win mitigation opportunities.

Appendix A. U.S. Government Definitions of Supply Chain and Supply Chain Risk Management

Agency	Supply Chain	Supply Chain Risk Management (SCRM)
DOD[80]	"The linked activities associated with providing material to end users for consumption. Those activities include supply activities (such as organic and commercial ICPs and retail supply activities), maintenance activities (such as organic and commercial depot level maintenance facilities and intermediate repair activities), and distribution activities (such as distribution depots and other storage locations, container consolidation points, ports of embarkation and debarkation, and ground, air, and ocean transporters)."	"The process for managing risk by identifying, assessing, and mitigating threats, vulnerabilities, and disruptions to the DOD supply chain from beginning to end to ensure mission effectiveness.”
NIST[81]	"[A] linked set of resources and processes between and among multiple levels of organizations, each of which is an acquirer, that begins with the sourcing of products and services and extends through their life cycle."	"A systematic process for managing exposure to...risks throughout the supply chain and developing appropriate response strategies, policies, processes, and procedures."
ODNI[82]	"A supply chain is a network of people, processes, technology, information, and resources that delivers a product or service. Key supply chains are essential to protecting critical infrastructure; countering economic exploitation; and defending against cyber and technical operations."	"The management of risk to the integrity, trustworthiness, and authenticity of products and services within the supply chain."

80 https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/414001p.pdf
81 https://doi.org/10.6028/NIST.SP.800-161r1
82 Office of the Director of National Intelligence (ODNI); https://www.dni.gov/files/NCSC/documents/supplychain/20200925-NCSC-Supply-Chain-Risk-Management-tri-fold.pdf; https://www.dni.gov/files/documents/ICD/ICD%20731%20-%20Supply%20Chain%20Risk%20Management.pdf

Appendix B. China as a Percent of U.S. Imports for Select Critical Technologies, 2017-21[83]

NAICS Code	Description	2017	2018	2019	2020	2021
325110	Petrochemicals	1%	1%	0%	0%	0%
325180	All other basic inorganic chemicals	11%	12%	8%	7%	7%
331313	Alumina refined and primary aluminum	0%	0%	1%	0%	0%
331314	Secondary smelting & alloying of aluminum	13%	9%	7%	0%	0%
332991	Ball & roller bearings	21%	21%	20%	20%	20%
333242	Semiconductor machinery	34%	32%	15%	18%	15%
333314	Optical instruments &lenses	25%	24%	22%	24%	24%
333611	Turbines & turbine generator sets	19%	14%	11%	12%	4%
334111	Electronic computers	66%	61%	55%	58%	61%
334112	Computer storage devices	22%	13%	4%	3%	1%
334210	Telephone apparatus	75%	73%	65%	48%	57%
334220	Radio/TV broadcast & wireless communication equip	63%	63%	61%	56%	55%
334413	Semiconductors & related devices	11%	11%	6%	5%	5%
334511	Search, detection & navigation instruments	10%	9%	5%	5%	6%
335311	Power/distribution/specialty transformers	10%	10%	7%	7%	5%
335911	Storage batteries	30%	33%	33%	32%	40%
335912	Primary batteries	39%	36%	33%	36%	32%
336411	Aircraft	0%	0%	0%	0%	0%
336412	Aircraft engines & engine parts	2%	2%	2%	2%	2%
336415	Missile/space vehicle propulsion units & parts	0%	0%	0%	0%	0%
336419	Missile/space vehicle parts & auxiliary equip.	1%	2%	2%	3%	3%
336992	Military armored vehicle, tank & tank components	0%	0%	0%	0%	0%
	Total	40%	39%	35%	36%	36%

[83] https://dataweb.usitc.gov/; There are several caveats to this analysis: (1) there are many critical technology industries that do not have a NAICS code (all software industries, for example); (2) several NAICS codes identified by Treasury do not have any trade affiliated with them in USITC data (221113, 332117, 336414, 541713, 541714).

Appendix C. China as a Percent of U.S. Imports of Storage Batteries[84]

NAICS Code	HTS Code	HTS Code Description	2017	2018	2019	2020	2021
335911: Storage Battery Manufacturing	8507.10.00	Lead-acid storage batteries of a kind used for starting piston engines	6%	6%	5%	6%	3%
	8507.20.40	Lead-acid storage batteries of a kind used as the primary source of electrical power for electrically powered vehicles of 8703.90	13%	60%	39%	37%	60%
	8507.20.80	Lead-acid storage batteries other than of a kind used for starting piston engines or as the primary source of power for electric vehicles	36%	35%	21%	16%	15%
	8507.30.40	Nickel-cadmium storage batteries, of a kind used as the primary source of electrical power for electrically powered vehicles of 8703.90	37%	48%	4%	4%	4%
	8507.30.80	Nickel-cadmium storage batteries, other than of a kind used as the primary source of power for electric vehicles	30%	22%	23%	20%	23%
	8507.40.40	Nickel-iron storage batteries, of a kind used as the primary source of electrical power for electrically powered vehicles of 8703.90	10%	15%	44%	64%	0%
	8507.40.80	Nickel-iron storage batteries, other than of a kind used as the primary source of power for electric vehicles	40%	19%	16%	13%	12%
	8507.50.00	Nickel-metal hydride batteries	35%	38%	34%	26%	14%
	8507.60.00	Lithium-ion batteries	43%	47%	51%	47%	56%
	8507.80.40	Other storage batteries, of a kind used as the primary source of electrical power for electrically powered vehicles of 8703.90	26%	16%	3%	4%	1%
	8507.80.81	Other storage batteries, other than of a kind used as the primary source of power for electric vehicles	56%	65%	24%	26%	35%
	8507.90.40	Parts of lead-acid storage batteries, including separators therefor	14%	10%	22%	39%	35%
	8507.90.80	Parts of storage batteries, including separators therefor, other than parts of lead-acid storage batteries	11%	9%	18%	17%	30%

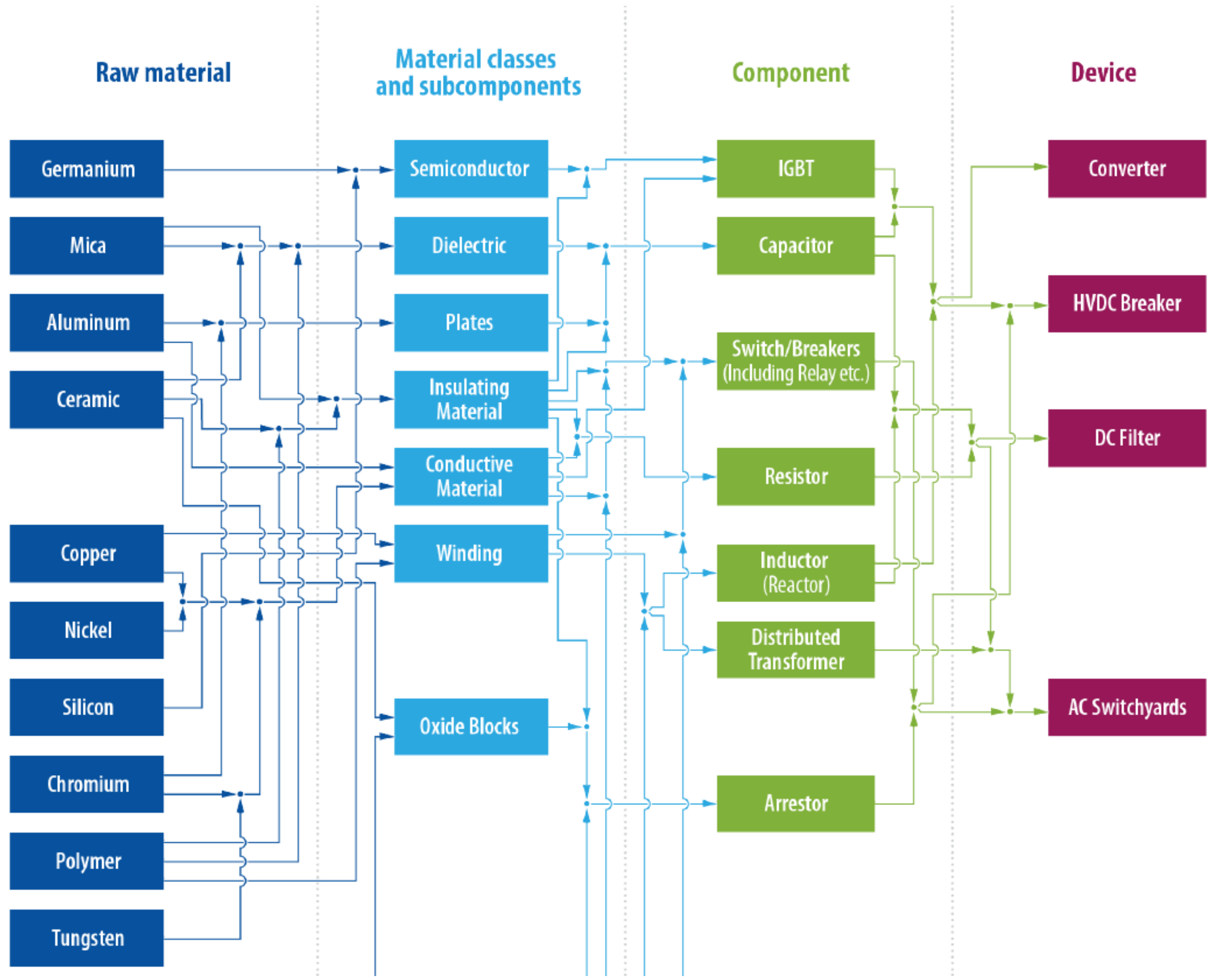
[84] https://dataweb.usitc.gov/; Data is presented in percentages, which may overstate the criticality of the import dependency as overall import values may be small.

Appendix D. Example Supply Chain Risk Factors[85]

Risk	Definition
Barriers to Entry	Is there a regulatory/IP moat that new entrant firms must overcome?
Complexity	Is technical know-how essential for realizing value?
Components	Are there components on which a product relies? <100? >100?
Concentration of Suppliers	Are any supply chain segments supplied by fewer than 3 vendors or does one vendor account for 50% of capacity?
Consolidation of Suppliers (Geographic)	Is more than 50% of worldwide capacity concentrated in one country?
Consumption	Is consistent, ongoing supply of the good, necessary (not a one off purchase)?
Durability	Is maintenance/servicing required for ongoing use?
Excellence	Is there a distinction between the capabilities of SOTA and non-SOTA?
Intensity of Consumption	Is the item a once per month, once per year, or once per decade purchase?
Inter-Industry Demand	Do other industries compete for the same product? (Could supply disappear for reasons exogenous to this industry?)
Inter-Industry Supply	Does the industry using it generate it? (Is supply of good tied to the industry that consumes it or exogenous?)
Intrinsic Value	Is the thing by itself worth anything to anyone else or is it industry-specific?
Lead Time	How long would it take to purchase and take delivery of a replacement under normal circumstances?
Location of Suppliers	Is a replacement available domestically?
Mobility	Are transport costs high?
National Security	Does the stand-alone product pose an obvious national security threat?
Political/Social Interest	Has the good or service been subject to recent export controls, environmental objections etc.?
Qualification Time	Does a user need to ensure a replacement inter-operates with existing process? If so, under what timeframe?
R&D Intensity	Is it complicated to produce (is R&D required for any replacement)?
Stockpiling	Is stockpiling an option? Would stockpiling result in obsolescence, half-life concerns etc.?
Substitutability	Are there ways to innovate around an observed supply chain segment chokepoint?
Technology Readiness Level	What is the TRL?
Value Added	How much value does it add to final product?
Zero Sum (Fixed Supply?)	If your competitor buys more of the product, does that mean there is less available for you?

[85] This list is derived in part from: https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf (page no.: 23)

Appendix E. Example of Supply Chain Mapping[86]



[86] https://www.energy.gov/sites/default/files/2022-02/Electric%20Grid%20Supply%20Chain%20Report%20-%20Final.pdf

Appendix F. U.S. Government Critical Technology Lists[87]

Critical Technology Category	Commerce/BIS Emerging Technology List (2018)	WH Critical and Emerging Technologies List (2020)	ODNI (2021)	DOD Critical Technology Areas (2022)	WH Critical and Emerging Technologies List (2022)	EO 14017 Critical Supply Chain Reports: Sectors Covered (2022)
Advanced/Integrated Sensing, Signature Management, & Systems		X		X	X	
Advanced Computing	X	X		X	X	
Advanced Conventional Weapons Technologies		X				X
Advanced Engine Technologies		X			X	X
Advanced Materials + Advanced/Additive Manufacturing	X	X		X	X	X
Advanced Surveillance Technologies	X					
Agricultural Technologies		X				X
Artificial Intelligence/Machine Learning	X	X	X	X	X	
Autonomous Systems		X	X	X	X	
Biotechnologies	X	X	X	X	X	X
Chemical, Biological, Radiological, & Nuclear (CBRN) Mitigation Technologies		X				
Communication & Networking Technologies		X		X	X	X
Data Analytics Technology	X	X				
Directed Energy				X	X	
Renewable Energy Technologies		X		X	X	X
Financial/Distributed Ledger Technologies		X			X	
Human-Machine Interfaces	X	X			X	
Hypersonics	X		X	X	X	
Logistics Technology	X					X
Medical & Public Health Technologies		X				X
Nuclear Energy Technologies					X	X
Position, Navigation, & Timing (PNT) Technologies	X					
Quantum Information Science	X	X	X	X	X	
Robotics	X					
Semiconductors & Microelectronics	X	X	X	X	X	X
Space Technologies & Systems		X		X	X	

[87] Note that some technology names have been paraphrased to harmonize the nomenclature across lists. Sources include:
Commerce (2018): https://www.federalregister.gov/documents/2018/11/19/2018-25221/review-of-controls-for-certain-emerging-technologies;
WH (2020): https://trumpwhitehouse.archives.gov/briefings-statements/statement-press-secretary-regarding-national-strategy-critical-emerging-technologies/;
ODNI (2021): https://www.dni.gov/index.php/ncsc-newsroom/item/2254-ncsc-fact-sheet-protecting-critical-and-emerging-u-s-technologies-from-foreign-threats;
DOD (2022): https://www.cto.mil/wp-content/uploads/2022/02/usdre_strategic_vision_critical_tech_areas.pdf;
WH (2022): https://www.whitehouse.gov/ostp/news-updates/2022/02/07/technologies-for-american-innovation-and-national-security/;
EO 14017 Reports (2022): https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/24/the-biden-harris-plan-to-revitalize-american-manufacturing-and-secure-critical-supply-chains-in-2022/.

OPENING STATEMENT OF JAN-PETER KLEINHANS, PROJECT DIRECTOR, "TECHNOLOGY AND GEOPOLITICS," STIFTUNG NEUE VERANTWORTUNG

COMMISSIONER BOROCHOFF: Thank you, Mr. VerWey. Mr. Kleinhans?

MR. KLEINHANS: Thank you also from my side for the opportunity to testify today, specifically to the chairs, Mr. Goodwin and Mr. Borochoff. I'm very happy to be here today. I would like in my opening statement to focus on three points.

First, if we are -- and I will often say, we, because Europe faces very similar questions currently, specifically looking at semiconductors. So if we are willing and ambitious enough to reshape and restructure global supply chains, I think we have to be very clear about the objective. Is it national security is technological competitive or is it global supply chain resilience and local or domestic security of supply?

Second point, very similar to what John VerWey just said, we need to invest in the government's capabilities to understand, assess, and identify interdependencies and chokepoints and global supply chains. Third, none of this will work without end-customer industries. Two individual points, I think clarity about the ultimate objective is crucial and we need to differentiate between different objectives if the objective is national security.

So not being at risk of compromise of a chip -- and my remarks are all focused on the global chip supply chain. Not being at risk that China can compromise a chip, the famous hardware backdoor or kill switch similar to discussions on 5G and Huawei. Then we actually need to do very different things than if we are worried about technological competitiveness and ensuring that in 10, 15, 20 years' time, we still have the capabilities to design highly competitive chips, for example, for artificial intelligence.

If we are worried about national security, we actually need to look at not chip design or front-end manufacturing because especially back-end manufacturing, printed circuit boards, and substrates because back-end manufacturing, often also called assembly test and packaging, it is significantly easier to compromise a chip than during front-end manufacturing. If we are worried about technological competitiveness, we are one step into industrial policy. We need to think about how to incentivize research, how to strengthen, for example, the U.S. chip design ecosystem.

The U.S. is by far leading in different chip design areas. How to incentivize that in the future and how to ensure that 10, 15 years down the road U.S. companies still have a competitive edge at designing the next generation of chips. If we are worried about global supply chain resilience, in the panel before, the chip shortages have been mentioned.

We actually need to do again very different things because to the largest extent, the chip shortages were not a result of our dependence on China or East Asia. But it was often due to poor purchasing decisions and poor supply chain management from end-customer industry, so from the automotive sector, from medical equipment manufacturers and others. If you want to ensure security of supply in the future, you need to include end-customer industries into the equation and think about their supply chain management, talking about strategic overstocks and so on.

My second point, invest in your own capabilities to understand supply chains. We talk about -- and that has been mentioned before at the panel. We talk about just looking at semiconductors, a highly complex, interdependent value chain that depends on global division of labor, that is in different production steps defined by high market entry barriers, by long production cycle times.

And that is very hard to shift in the mid-term. And even in the long term, we can already see that certain dependencies will not go away. To understand the interdependencies, to understand how they're linked to technological competitiveness, before on the panel, the question has been asked, what are strategic sectors?

To decide and identify what are of the different production steps for semiconductor manufacturing do we consider of strategic importance to our national security or to our technological competitiveness? Again, these are two very different questions that will ask for very different policy incentives. In order to do that, one-off reports can only be the first step.

I think the 100-day supply chain review was the right step, but it's only a first step. Not a single report currently, be that in the U.S. or in Europe, that is a one-off ad hoc assessment of the value chain is sufficient to address any of the issues that lay ahead. It needs substantial investment in government internal resources in terms of dedicated units within the government that do nothing else than map interdependencies and chokepoints in supply chain if we are serious about reshaping those global supply chains.

Last point, governments do not play a role in the global semiconductor value chain. And I saw that for a good reason, a little bit snarkily because government sales of global semiconductors accounted for one percent, including the military. So there is almost no purchasing power for governments in semiconductors.

The volume business for semiconductors are consumer electronics, mobile, hyperscalers, cloud infrastructure, and others. Nonetheless, governments play a huge role in export restrictions, in investment screening, and other areas. But if we want to move value chains, if you're worried about or interested in reshoring manufacturing, you have to include the end-customer industries.

And I see that also cross the Atlantic. In Europe, currently the conversations about restructuring value chains is very much driven by a push from government and the push from the semiconductor industry to do something. But it should be a pull from end-customer industries, from the automotive industry, from the smartphone industries to be willing to pay more, to be willing to in the future procure chips from allied nations. And my impression is that there's currently very little discussion about that. Thank you very much for your attention.

PREPARED STATEMENT OF JAN-PETER KELINHANS, PROJECT DIRECTOR, "TECHNOLOGY AND GEOPOLITICS," STIFTUNG NEUE VERANTWORTUNG

Testimony before the

U.S.–China Economic and Security Review Commission

Hearing on

"U.S.–China Competition in Global Supply Chains"

June 9, 2022

Jan-Peter Kleinhans

Director of Technology and Geopolitics
Stiftung Neue Verantwortung e.V.
Berlin, Germany

Contents

Provide a brief overview of the key components of the semiconductor supply chain and their geographic distribution.

To better understand the global semiconductor value chain, one should understand the different ***production steps (including the supplier markets)***, the ***business models,*** and the different ***types of semiconductors***.

PROCESS STEPS AND SUPPLIER MARKETS

The ***first production step*** in semiconductor manufacturing is ***chip design***. It is the step with the highest value add (50%)[1] and mainly depends on ***electronic design automation (EDA) tool vendors*** and ***third-party IP vendors*** as critical ***supplier markets***. Chip design is not done in isolation but is always based on a particular manufacturing process; it is highly skill and R&D intensive. EDA tools play a crucial role in developing, verifying, and simulating a new chip design on a specific manufacturing technology. Third-party IP is used heavily for standardized functionality such as USB or Bluetooth connectivity that can simply be implemented in a new design, saving development time. Increasingly, companies today develop (but do not necessarily manufacture) their own chips—from automotive OEMs to cloud providers and smartphone manufacturers. U.S. companies are not only leading substantially in chip design for many types of semiconductors, but also the largest (by revenue) EDA tool vendors and IP vendors are ***based in the US***.[2] ***China***'s chip design ecosystem and capabilities are also quickly increasing, mainly due to China's strength in smartphones and consumer electronics.[3]

The ***second production step***, after chip design, is ***wafer fabrication*** (also called "front-end" manufacturing) done in fabrication plants or "fabs." Today, wafer fabrication depends on around 300 chemicals and more than 50 different types of specialized manufacturing equipment and takes more than 1,000 process steps and more than 12 weeks.[4] Thus, front-end manufacturing is highly capital intensive, with new 3nm fabs costing upward of $20 billion. More than 70% of that is due to high manufacturing equipment costs.[5] That also means that fab owners try to utilize their equipment as efficiently as possible: In March 2019, global fab utilization rates were higher than 80% and have been higher than 95% since December 2020.[6] This cost-driven lack of spare manufacturing capacity explains why the value chain struggles to cope with sudden and strong demand fluctuations. Another important aspect is that front-end manufacturing diversified significantly over the past few decades. Public discourse often distinguishes between "cutting-edge" fabs and "everything else." In fact, front-end manufacturing is highly diversified with different types of chips relying on different process technologies and materials. For example, logic semiconductors, such as processors in laptops and smartphones, rely on ever-smaller manufacturing technology (often called "More Moore Scaling"). In contrast, most analog semiconductors, such as chips to charge the battery of an electric vehicle, to transfer data over 28 GHz radio waves, or to control an electric engine, depend on very different materials (silicon-carbide and gallium-nitride) and manufacturing processes. The important regions for front-end manufacturing are ***Taiwan***, ***South Korea***, ***China,*** and ***Japan***.

The third and ***last production step*** is ***assembly, test, and packaging*** (also called "back-end" manufacturing). During this step, all the individual integrated circuits (etched onto the wafer during front-end processes) are diced from the wafer, tested, and then packaged to protect them from the environment and to be able to solder them into the final product, such as a smartphone. Historically, back-end manufacturing has been much more labor-intensive than front-end manufacturing, with lower profit margins and significantly lower added value. This explains why U.S. and European semiconductor companies quickly out-sourced and off-shored back-end fabs to Asia, mainly ***China***, ***Taiwan,*** and ***Malaysia***. [7] However, the economics of back-end manufacturing are changing due to the rise of "advanced packaging" approaches, such as heterogeneous integration. To further push the performance and energy efficiency of future chips, advanced packaging plays a crucial role, blurring the line between front-end and back-end manufacturing but also potentially increasing the added value and R&D intensity of the last production step.[8]

The three important ***supplier markets*** for semiconductor manufacturing (apart from the EDA tool vendors and third-party IP vendors) are ***equipment, chemical***, and ***wafer suppliers***.

Semiconductor manufacturing equipment (SME) is needed for front-end and back-end manufacturing. Front-end manufacturing relies on more than 50 types of SME, such as etch, deposition, and lithography equipment. "More Moore Scaling" (being able to squeeze evermore transistors onto a square millimeter of wafer) forces equipment manufacturers to constantly innovate to increase precision, control contamination and defects, and closely collaborate with chemical suppliers. Furthermore, SME companies typically specialize in specific types of equipment. For example, ASML (NL), Nikon (JP), and Canon (JP) mainly focus on lithography equipment. Thus, fabs rely on a variety of SME vendors, mainly from the ***US***, ***Japan,*** and ***Europe,*** to equip their fabs.[9] China is investing in domestic SME vendors, such as AMEC, Naura, and SMEE, but they are several generations behind their foreign competitors,[10] especially in lithography and etching equipment.[11]

Specialty and bulk ***chemicals***, as well as (noble) gases, are the second important supplier market for semiconductor manufacturing. Modern process technology relies on the highest purity chemicals that often can be supplied only by a small set of vendors. The chemicals market has also seen considerable consolidation in many areas over the past decade, because only large suppliers can justify the necessary investments in new purification and enrichment plants. Fabs today rely heavily on ***Japanese***, ***U.S.,*** and ***European*** chemical suppliers.[12]

Finally, ***wafers*** are the third important supplier market for semiconductor manufacturing. Most semiconductor manufacturing is based on wafers made of silicon. The silicon wafer market is essentially controlled by five vendors: Shin-Etsu Handotai (JP), SUMCO Corporation (JP), GlobalWafers (TW), Siltronic (DE), and SK Siltron (KR). Together, they control around 90% of the global silicon wafer market ($12.6 billion).[13] The two ***leading Japanese vendors*** control more than half of the market. Other types of wafers for specialty and niche technologies, such as silicon-on-insulator (SOI), silicon-carbide (SiC), and gallium-nitride (GaN), are produced by other vendors and supply chains.

For a comprehensive overview of China's competitiveness in each production step and supplier market, please see endnote 11.

BUSINESS MODELS

Historically, all three productions steps—(1) chip design, (2) wafer fabrication, and (3) assembly, test, and packaging—were carried out within a single company, called an ***integrated device manufacturer (IDM)***. The IDM business model, for different reasons, is still predominant in certain semiconductor areas, such as memory chip vendors (Samsung, Micron, and SK Hynix) and analog semiconductor suppliers (Texas Instruments, Analog Devices, Infineon, etc.).

However, since at least the 1990s, an increasing number of companies have focused on one of the three production steps. ***Fabless*** companies focus on chip design and rely on ***foundries*** for contract chip manufacturing. Fabless and ***system companies*** design only chips and outsource manufacturing. However, system companies, such as Apple, Tesla, and Amazon, do not sell their chips but implement them in their own products and systems. The US has, by far, the largest share of fabless companies, such as AMD, Nvidia, and Qualcomm.

Fabs for contract manufacturing are operated by either ***pure-play foundries***, such as TSMC (TW), UMC (TW), Globalfoundries (US), and SMIC (CN), or IDMs that also offer foundry services in some of their fabs, such as Samsung (KR) and Intel (US) in the future. In 2021, TSMC controlled 53% of the global foundry market by revenue.[14]

IDMs and pure-play foundries might perform only front-end manufacturing and outsource back-end manufacturing to ***outsourced semiconductor assembly and test (OSAT)*** suppliers. The biggest OSAT companies are ASE (TW), Amkor (US) and JCET (CN) and the regions with the most back-end capacity (operated by IDMs, pure-play foundries, or OSATs) are ***Taiwan***, ***China,*** and ***Malaysia***.

Finally, IDMs are increasingly outsourcing front-end manufacturing to pure-play foundries. Most analog semiconductor IDMs, such as Infineon (DE), STMicroelectronics (FR), and NXP (NL), rely on pure-play foundries for front-end manufacturing of some of their logic chips, such as microcontrollers. Another example is Intel, which has relied on TSMC for certain types of chips for more than a decade.[15]

TYPES OF SEMICONDUCTORS

The level of market concentration and dynamics also differ for the various types of chips. The following examples illustrate different levels of concentration.

Three ***memory chip*** suppliers—Samsung (KR), SK Hynix (KR), and Micron (US)—control more than 94% of the global DRAM market, which totaled $96 billion in volume in 2021. DRAM is a standardized product that is traded like a commodity, and the three IDMs rely on economies of scale in a highly volatile market with growth rates ranging from +77% to –37% within two years.[16] As most DRAM manufacturing of Samsung and SK Hynix is in ***South Korea***, the country plays a crucial role in the global supply of memory chips.

European, ***U.S.,*** and ***Japanese*** companies are key suppliers of ***analog semiconductors***. Processors and memory chips are purely digital devices, but analog semiconductors interact with the real world (from sensors to motor controllers or radio frequency chips) and are mostly produced by IDMs. The market for analog semiconductors is highly diversified, with small to medium companies often focusing on chips for very specific applications.

General-purpose processors (x86) for laptops, desktops, and servers are essentially controlled by Intel (US) and AMD (US). *Nvidia* (US) controlled more than 80% of the market for ***artificial intelligence accelerators*** for cloud and data centers in 2020.[17]

In summary, the ***global semiconductor value chain*** is ***transnational***, relies on a ***high division of labor*** among companies and regions, and is defined by ***strong interdependencies*** and ***various chokepoints*** at the level of production steps, suppliers, and types of chips. Most importantly, no region can control all the production steps and necessary supplies for cutting-edge semiconductor manufacturing.

From the United States' and China's perspective, what are the relative strengths and the key chokepoints each faces in the semiconductor supply chain?

STRENGTHS OF THE U.S. SEMICONDUCTOR ECOSYSTEM

U.S. companies hold very strong positions in many areas of the global semiconductor value chain. Together with U.S. universities, they are also leading in many areas of semiconductor R&D.[18]

Electronic design automation (EDA): The three US-based EDA tool vendors Cadence, Synopsys, and Siemens EDA (formerly Mentor Graphics) essentially control the EDA market. Access to their chip design tools is indispensable for companies that want to develop (cutting-edge) chips. Although China is trying to invest in its domestic EDA ecosystem,[19] it is unlikely that Chinese EDA suppliers, such as X-Epic and Primarius Technologies, will be viable substitutes for Chinese chip designers any time soon.

Front-end manufacturing equipment: The US has some of the leading equipment vendors for certain process steps, such as etching, deposition, and process control.[20] U.S. equipment vendors Applied Materials, KLA, and Lam Research are among the largest vendors (by revenue) internationally and are crucial suppliers to most fabs.

Fabless and system companies (chip design): The U.S. integrated circuit (IC) fabless industry is more than three times larger by revenue than that of Taiwan and more than seven times larger than that of China.[21] U.S. system companies, such as smartphone suppliers (Apple), automotive manufacturers (Tesla), and hyperscalers (Google and Amazon), have also heavily invested in their own chip design capabilities over the past decade, further strengthening the domestic ecosystem. Because chip design is the production step with the highest value add, U.S. chip design companies (fabless and system companies) have the strongest overall position in the global semiconductor ecosystem.

Analog semiconductors: The largest analog semiconductor suppliers, such as Texas Instruments, Analog Devices, Skyworks Solutions, Maxim, and many more, are also based in the United States.[22]

This list is not exhaustive but is meant to show that beyond individual companies, the US has a very strong presence in chip design (as a process step) and critical supplier markets, such as EDA, IP, and manufacturing equipment.

STRENGTHS OF THE CHINESE SEMICONDUCTOR ECOSYSTEM

Back-end manufacturing: Assembly, test, and packaging is certainly the process step where China has gained the most market share over the past 15 years. China's three leading OSAT suppliers account for 35% of the global OSAT market.[23] According to some estimates, China and Taiwan together account for roughly 60% of global back-end manufacturing capacity.[24]

Front-end manufacturing (mature nodes): Although there are no cutting-edge fabs (<10nm) in China, mainly due to U.S. export restrictions on certain types of manufacturing equipment, China has substantial manufacturing capacity in mature nodes. ***Figure 1*** shows that China has the highest front-end manufacturing capacity (measured in "wafer starts per month," wspm) for ≥180nm process technologies, compared to all other countries. For fabs between ≥40nm and <180nm, China has the second highest installed capacity, after Taiwan.

Although fabs with 40nm nodes are not used for anything close to a modern processor, they are crucial for analog and discrete semiconductors as well as microcontrollers. Fab capacity at 40nm, 60nm, 90nm, 130nm, and 180nm has also been identified as the most constrained[25] and unlikely to change in the future.[26] Additionally, China is investing the most in these mature nodes compared to all other countries.[27] It is highly likely that in the future foreign countries will increasingly rely on mature node manufacturing capacity within China.[28] ***Figure 2*** shows the accumulated equipment spending by country: Between Q1 2017 and Q1 2022, manufacturing equipment worth $94 billion was shipped to China (to Chinese and foreign fabs). During that period, more equipment was sold to China than to any other country (2.6 times more than to the US). Importantly, due to the U.S. export restrictions on cutting-edge manufacturing equipment (i.e., EUV scanners), none of the equipment shipped to China is for cutting-edge process nodes, only for anything >10nm. That means that China is building out trailing-edge (>10nm to <40nm) and mature node (≥40nm) capacity significantly more than any other country.

Chip design (hyperscalers, consumer electronics, and mobile): China has a quickly growing chip design ecosystem that is increasingly competitive. Similar to their U.S. counterparts, Chinese hyperscalers such as Alibaba and Tencent are investing in their in-house chip design units.[29] As Huawei is struggling, due to the U.S. export restrictions, other Chinese mobile and consumer electronics companies are becoming stronger. Unisoc, a Chinese fabless company focusing on mobile chipsets, gained substantial market shares in entry-level smartphones and tablets, for example, from Samsung.[30]

In summary, China's semiconductor industry is increasingly successful in all three production steps but struggles in supplier markets (IP, EDA, equipment, chemicals, and wafers). That said, the U.S. Semiconductor Industry Association (SIA) estimates, for example, that Chinese equipment vendors could achieve self-reliance in 40nm process technologies "over the next few years."[31]

What are the key features of the semiconductor supply chain that might make government intervention difficult?

Government intervention within the semiconductor ecosystem is not necessarily difficult, depending on the intended outcome. Some types of interventions are highly effective (if not efficient), such as controlling technology transfer. The following is an overview and brief assessment of the different types of government intervention and their efficacy.

Financial incentives (subsidies, grants, etc.): Government financial incentives play a role in the global semiconductor ecosystem, especially for capital-intensive front-end fabs. Because most of the investment costs are for equipment, subsidies can shift the time until the investment breaks even by more than a year.[32] This is especially relevant in periods of potentially low(er) utilization rates: The lower the utilization rate of a fab, the longer it takes until the fab reaches break even. Government subsidies effectively compensate for lower utilization rates and lower the investment risk.[33]

Restricting technology transfer (export restrictions and investment screening): Export restrictions have been placed on semiconductor manufacturing equipment and chemicals for many decades.[34] Although it is debatable to what extent these measures are effective and efficient to curb the technological development of China's semiconductor industry as a whole,[35] they are certainly disruptive for the targeted Chinese company.[36]

Lack of purchasing power: Although governments accounted for around 30% of semiconductor sales in the 1960s,[37] today government and military together account for just 1% of global semiconductor sales.[38] This lack of purchasing power makes it very hard for governments to intervene meaningfully or set incentives through strategic public procurement. They are simply not an important end-customer industry on a global scale.

Governments do not produce semiconductors; companies do: Governments are not part of the global semiconductor value chain; they do not produce semiconductors themselves and are not important end customers of chips. This is crucial to remember, because ultimately, governments can only create incentives and try to guide the market and value chain in a certain direction. It is up to semiconductor companies, and end-customer industries, to follow. As the semiconductor market is highly cyclical, companies will be more risk-averse during a downturn.

In summary, the efficacy of government intervention in the global semiconductor value chain depends on the type of intervention. However, most importantly, understanding the impact of planned interventions, including second- and third-order effects, is very hard in a value chain that is characterized by transnational division of labor, high market-entry barriers, and strong vendor lock-in effects. For example, the U.S. export restrictions on Chinese companies, such as Huawei and SMIC, led other Chinese semiconductor companies and end-customer industries (which feared they would be next in line for export control measures) to start stock-piling chips, materials, and equipment in early 2020—potentially exacerbating the impact of the global chip shortages.[39]

How have East Asian nation-states been so effective in concentrating supply chains in that region?

It is outside the scope of this testimony to provide a robust and exhaustive analysis of the different reasons why Taiwan, South Korea, Japan, Singapore, China, and Malaysia were able to grow a domestic ecosystem and/or attract semiconductor-related foreign investments. Importantly, all of these countries and their companies deployed relatively different strategies and were successful in different production steps and supplier markets.

Looking at Taiwan and South Korea (the two countries with the most advanced manufacturing technologies and very dominant companies in various areas, such as memory chips, mobile chipsets, contract manufacturing, and advanced packaging), industrial policy and government incentives certainly played a role. However, among policy makers in Europe and the US (and potentially elsewhere), five aspects are often underestimated.

The first is ***smart business decisions by companies***. An example is ***Samsung's*** decision to not only produce memory chips but also develop and manufacture their own chipsets for music players and mobile phones since the late 1990s. The resulting better utilization of Samsung's fabs created a competitive advantage early on.[40] Another smart business decision was made in 2005, when Samsung decided to offer under-utilized fab capacity as foundry services to external customers.[41] Today, Samsung is the second largest foundry by revenue.

Another example is ***TSMC*** in Taiwan. TSMC was the first pure-play foundry; they invented the business model. The selling point of any pure-play foundry is that they do not design their own chips and thus, are not in competition with their customers. This is very different from the foundry services offered by IDMs, such as Samsung or (in the future) Intel. Fabless companies must collaborate very closely with foundries to best develop future chip designs on a particular process node. If you are closely collaborating with a competitor, questions of IP protection and trust quickly arise.[42]

The second is the impact of ***continued currency undervaluation*** of the New Taiwan dollar (NTD) and South Korean won (KRW) against the U.S. dollar.[43] The deliberate currency undervaluation through different government interventions keeps the prices of exported goods and services comparatively low, making them potentially more attractive in the international market. The undervalued NTD makes it cheaper for foreign chip design companies to rely on TSMC, UMC, and many other Taiwanese foundries for contract manufacturing.[44] Some scholars argue that Taiwanese companies benefitted perhaps more from the consistently undervalued NTD over the past few decades than from other industrial policy measures.[45]

The third is the ***strength of ecosystems that grew for more than three decades***. It would be naïve to think that countries such as South Korea and Taiwan became semiconductor hubs solely because of government incentives, and that if those incentives were matched by other (Western) regions, the supply chain would "re-shore." These countries are much more than manufacturing hubs after more than three decades of continued growth. They play a crucial role in global semiconductor R&D[46] and have established talent pipelines and well-functioning bureaucracy in direct support of the semiconductor industry. However, they also benefit substantially from regional cluster effects.[47] These benefits make it highly likely that East Asian countries, especially Taiwan and South Korea, will continue to play critical roles within the global semiconductor ecosystem—beyond mere manufacturing locations—far beyond this decade.

The fourth is ***conscious business decisions by Western chip suppliers and end-customer industries***. Western companies also played a role in shifting the global semiconductor value chain toward East Asia. To control capital expenditures, most Western semiconductor companies have established front-end or back-end fabs over the last two decades in countries such as Malaysia, China, and Singapore. If end-customer industries, such as automotive, mobile, and ICT, are not incentivizing geographic diversification through strategic procurement decisions (being willing to pay more), not much will change.

The fifth is that ***the chip shortages are not a result of overdependence on East Asia***. Since 2020, the global semiconductor value chain has been struggling with multiple shortages occurring concurrently in different production steps and supplier markets for different reasons. For some of these constraints, the semiconductor industry itself is to blame, but a large share of supply disruptions stems from poor purchasing and management decisions in end-customer industries.[48] More manufacturing capacity in the US would not have alleviated the shortages in the automotive industry, as one example. To say that "current dependencies on Asia created the chip shortages" is simply not true.[49]

What is "resilience" with respect to the semiconductor supply chain? How much re-shoring, near-shoring, and ally-shoring is feasible in your view? How much is about leveraging strategic interdependence, or the complex interdependencies across the global value chain, to manage vulnerabilities?

When developing long-term industrial and trade policy addressing challenges in a transnational, complex value chain, such as semiconductors, being clear about and distinguishing between long-term policy goals is essential. If one agrees that autarky in semiconductors is neither feasible nor desirable, then policy intervention and long-term initiatives should be assessed in terms of three areas. They can then be prioritized, and conflicting goals identified.

THREE AREAS FOR ASSESSING SEMICONDUCTOR POLICY

For a more comprehensive discussion of the three areas and how they can inform policy decisions vis-à-vis China's semiconductor strategy, please see endnote 11.

National security. As a foundational technology, chips are a prerequisite for today's weapon systems, and governments have an interest in ensuring supply security and strengthening the military's capability to access and develop this technology. Another aspect is denying an adversary access to technology with military utility (controlling technology transfer).

Global supply chain resilience. As every sector depends on access to chips, and the value chain will continue to be transnational, policy measures should also aim to strengthen global supply chain resilience. Are there single points of failure? How quickly can the global supply chain recover from external shocks, such as natural disasters?

Technological competitiveness. The semiconductor ecosystem is highly competitive and innovates with first-mover advantages and a "winner-takes-all" market.[50] Industrial policy can also aim to strengthen the domestic ecosystem to gain a competitive advantage and be able in the long term to continue to innovate and develop new technologies.

Policy makers can assess initiatives that focus on particular *production steps*, *supplier markets,* or *types of semiconductors* through the lens of the three areas. The following are examples.

Example 1 – Back-end manufacturing. Around 60% of the global back-end manufacturing capacity is in China and Taiwan. At the same time, compromising a chip (implementing a hardware backdoor or "kill switch") during back-end processes is more feasible than during front-end manufacturing processes.[51] Thus, relying on Chinese back-end capacity comes with potential risks.

- From the ***national security*** standpoint, near- or ally-shored back-end fabs are preferable to back-end fabs located in China. Substantially re-shoring back-end capacity to the US most likely will not be economically viable due to the significantly lower profit margins, lower value-add, and higher labor intensity compared to front-end manufacturing.
- The increasing importance of advanced packaging (chiplets,[52] heterogeneous integration) also means that government support for back-end manufacturing would not just stem from national security considerations but also potentially address future ***technological competitiveness***.
- Increasing back-end capacity through near- or ally-shoring would have a limited effect on ***global supply chain resilience***. Although back-end capacity was (and partially still is at the time of writing) constrained and contributes to the chip shortages,[53] this production step is geographically less concentrated than, for example, cutting-edge front-end manufacturing.

Example 2 – Semiconductor-grade chemicals. Semiconductor manufacturing relies on many chemicals that often can be sourced from only a few suppliers due to high purity requirements. The noble gases neon and xenon are mainly sourced from Ukraine and Russia[54] and helium mainly from Russia and Qatar, to name just a few. Although semiconductor companies keep an overstock of these chemicals and gases, a supply disruption can have a direct impact on manufacturing capacity. Would investing in a national (or near-shored) reserve[55] for some of these gases be justified to strengthen supply security?

- There would be no impact on ***national security,*** because a chip cannot be compromised via the chemicals used during manufacturing processes.
- A national gas reserve also would not meaningfully impact the ***technological competitiveness*** of the domestic semiconductor industry.
- Such a reserve would strengthen domestic supply security and ***global supply chain resilience***, especially if governments incentivize industry to organize such a reserve as shared resources with joint investments.

MINIMAL VIABLE COOPERATION AND LEVERAGE

In a value chain characterized by transnational division of labor, securing leverage through interdependencies but also fostering cooperation may be a more sensible approach than striving for autarky or self-reliance. China is highly reliant on US-origin semiconductor technology today, but the Chinese semiconductor ecosystem will certainly continue to grow over the next decade. No matter what the US and its allies do, in the future, Chinese companies will have stronger positions within the global value chain than today. Thus, the policy question is, what is better: a Chinese semiconductor ecosystem that is mostly self-reliant but several generations behind the global cutting-edge or one that continues to rely strongly on Western technology but is competing successfully in some markets?[56]

Today, nobody can make cutting-edge chips without lithography equipment from Europe, photomasks and photoresists from Japan,[57] and etching equipment and software from the US. Then everything comes together in Taiwan or South Korea. Although Chinese companies do not play a strong role in cutting-edge semiconductor manufacturing, they have competitive positions in trailing-edge front-end manufacturing and back-end manufacturing, at the very least. Thus, going forward, U.S. and allied policy makers should focus on ensuring leverage through "minimal viable cooperation."

Ensuring leverage: Interdependency can support stability. Especially when looking at the global semiconductor ecosystem, a goal of industrial and research policy in the US and allied countries should be to ensure that, in the long term, U.S. and allied companies still control critical positions within the global value chain. This is mainly achieved by "running faster."[58] Doing so requires industrial and research policy that is also focused on "strengthening strengths" (such as cutting-edge U.S. chip design)[59] instead of indiscriminately providing financial support to anything related to chips and trying to copy what already exists in allied countries.

Minimal viable cooperation: Utilizing that leverage by exploiting chokepoints within the global semiconductor value chain will be possible only if there are interdependencies in the long term. Thus, even with the most restrictive trade policy, people within the US and allied governments should still think about avenues for "minimal viable cooperation" with Chinese companies and the Chinese market.

Assess how difficult it would be for the United States and China to achieve "resilience" given that both will be attempting to create asymmetrical dependencies and vulnerabilities?

The European Union (EU) defined resilience as "the ability not only to withstand and cope with challenges but also to undergo transitions in a sustainable, fair, and democratic manner."[60] With that overarching aspiration, "decoupling" from China would not be the aim of industrial and trade policy for one of the U.S. government's closest allies. It would be challenging, if the U.S. government's understanding of "resilience" is to avoid being dependent on the Chinese semiconductor ecosystem so that even in the long-term the Chinese government cannot exploit their industry's position within the global value chain. It would also be hard to operationalize such a definition of "resilience," as China has dominant positions within the *electronics* value chain, from rare earth metals (raw materials for semiconductor production) to printed circuit board production (the next downstream production step after back-end manufacturing)[61] and final assembly. If policy makers want to meaningfully strategize about how best to strengthen resilience (manage interdependencies, assess chokepoints, ensure leverage, and evaluate cooperation), a narrow view on the semiconductor value chain is ill-advised.

A suggested working definition of resilience in semiconductors for the U.S. and allied governments is "to withstand and cope with challenges that arise from interdependencies with China's semiconductor ecosystem." Those challenges are threefold, as previously stated: national security, global supply chain resilience, and technological competitiveness. Each might require different policy measures.

National security challenges arising from interdependencies with China's semiconductor ecosystem: U.S. and allied governments would need to ensure that their militaries do not depend on Chinese semiconductor manufacturing, as well as utilize export restrictions for technologies with clear military utility.

Global supply chain resilience challenges arising from interdependencies with China's semiconductor ecosystem: U.S. and allied governments would need to ensure that there are very limited single points of failure within the Chinese ecosystem. An example is the severe supply chain disruptions due to China's lock-down of Shanghai as part of their "zero COVID" strategy.[62] Strengthening the supply chain's resilience against these types of disruptions would require the participation of end-customer industries (strategic overstocks, instead of just-in-time delivery) as well as cooperation with allied governments.

Technological competitiveness challenges arising from interdependencies with China's semiconductor ecosystem: China's chip design ecosystem will continue to grow and will become increasingly competitive.[63] This means that, in the future, U.S. companies might increasingly rely on chips designed by Chinese companies. To what extent this poses a threat to U.S. technological competitiveness depends on the sector and type of chip. However, the only meaningful way to address that challenge is through long-term industrial and research policy that incentivizes companies to "run faster." As staying at the global competitive edge in semiconductors takes 18 times more R&D resources today than in the 1970s, this can be accomplished only through collaboration with like-minded partners.[64]

In summary, "resilience" in semiconductors should not be interpreted as essentially decoupling from China. Instead, the overarching policy goal for the U.S. and allied governments should be to "withstand and cope with challenges that arise from interdependencies with China's semiconductor ecosystem." This is achievable in the long term but will require consistent and nuanced policy intervention at three areas: national security, global supply chain resilience, and technological competitiveness. Failing to clearly articulate which of these goals a government intervention is aiming for makes it significantly harder not only to coordinate with allies but also to receive the necessary support from the industry.

What specific tools should the U.S. government leverage to build resilience into semiconductor supply chains?

Build up knowledge. To strengthen resilience, coordinate with allies, and manage risks stemming from interdependencies with China's chip ecosystem, the U.S. and allied governments need a deep and holistic understanding of the global semiconductor value chain. This type of knowledge partially exists in export control and investment screening units within governments. To continuously map the value chain and assess interdependencies and chokepoints, governments require institutionalized resources—units that focus solely on long-term mapping of the semiconductor value chain (and potentially other technology value chains in the future). One-off reports[65] and requests for information[66] are not sustainable and should be used only as a starting point. This does not mean that governments should try to micro-manage the value chain and struggle with companies for business confidential information. Industry associations, market analysts, and the financial sector have a wealth of information that, in the first step, governments could build on to establish a mapping framework (including their own data pipelines) that encompasses trade, financial, and market data, including company competitiveness. This could then be augmented with targeted requests for information from companies to fill gaps. Although supply chain *monitoring*, as currently discussed within the EU–US Trade and Technology Council (TTC), should be the responsibility of semiconductor and end-customer industries, strategic, long-term government *mapping* would support existing policy tools (investment screening, export restrictions, sanctions, and subsidies) and inform potential international partnerships.

Understand the long-term impact of export restrictions on your own industry. If the ultimate goal is to curb the technological advancements of China's semiconductor ecosystem at all costs, it makes sense to exploit the dominance of U.S. (and allied) equipment vendors and EDA vendors through export restrictions. However, this comes with potentially significant downsides. First, the semiconductor industry is highly R&D intensive: Equipment suppliers spend 10–15% of revenue on R&D, and EDA suppliers more than 30%. At the same time, China is currently the most important market for equipment suppliers, accounting for more than 30% of equipment sales. Lost sales due to export restrictions negatively impact future R&D to stay at the cutting-edge. How can we compensate for that? Second, if it is not about complete decoupling, and U.S. and allied equipment and EDA suppliers are supposed to stay—at least to some extent—in the Chinese market, export restrictions (if applied broadly and indiscriminately) could be perceived as a business continuity risk by Chinese customers incentivizing efforts to "de-Americanize" supply chains.[67] Third, broad application of export restrictions also fuels China's efforts to develop local alternatives to alleviate chokepoints in the long term.[68] This is not to say that export restrictions are not a viable tool but potentially to the detriment of the long-term competitiveness of the domestic industry.[69]

Coordinate and collaborate with allies. It is unfortunate if groups within the U.S. government truly believe that the US should "move to making chips in America, not friend-shoring."[70] Making chips without relying on ally-shoring for front-end or back-end manufacturing would not strengthen the United States' resilience or be economically viable. The U.S. government should continue and intensify cooperation with like-minded international partners regarding how best to strengthen the resilience of the global semiconductor value chain and work on a shared understanding of what role governments play within the semiconductor ecosystem. In that regard, exchanges with allied governments (such as within the EU-US TTC,[71] with South Korea as part of the planned "Supply Chain and Commercial Dialogue,"[72] or with Japan on "Basic Principles on Semiconductor Cooperation"[73]) are good starting points.

None of this will work without end-customer industries. Semiconductor companies are suppliers of end-customer industries, such as automotive, consumer electronics, ICT, etc. If efforts to restructure the global semiconductor value chain to increase resilience are mainly based on governments "pushing" in contrast to end-customer industries "pulling," the efforts are destined to fail in the long term. Semiconductor suppliers are more likely to invest in domestic manufacturing capacity if there is a market for it: if their customers ask for chips that were manufactured in an "allied" supply chain and are willing to pay a premium. Thus far, in the US and in the EU, much of the efforts surrounding re-, near-, and ally-shoring come from governments and semiconductor suppliers. This is not sustainable without a much more substantial "pull" from end-customer industries that ultimately would need to pay for it.

The Commission is mandated to make recommendations to Congress. What other policy recommendations would you make based on the topic of your testimony?

This is a marathon, not a sprint. If policy makers, both in the US and Europe, are serious about strengthening the resilience of the global semiconductor ecosystem, it will take much more than a decade of continuous and consistent engagement with the semiconductor industry and end-customer industries to elaborate goals, build trust, and understand industry needs. If companies think that this is simply the current *Zeitgeist,* and policy makers soon move on to other areas, not much will change.

The author would like to thank the U.S.–China Economic and Security Review Commission for the opportunity to testify. He would also like to thank Martin Chorzempa for valuable feedback and Julia Hess and Helena Winiger for their help. You can find SNV's previous analysis of the global semiconductor value chain here: https://www.stiftung-nv.de/en/project/geotech/publikationen

Figure 1: **Front-end capacity as of December 2020 in million wafers per month [source: IC Insights]**

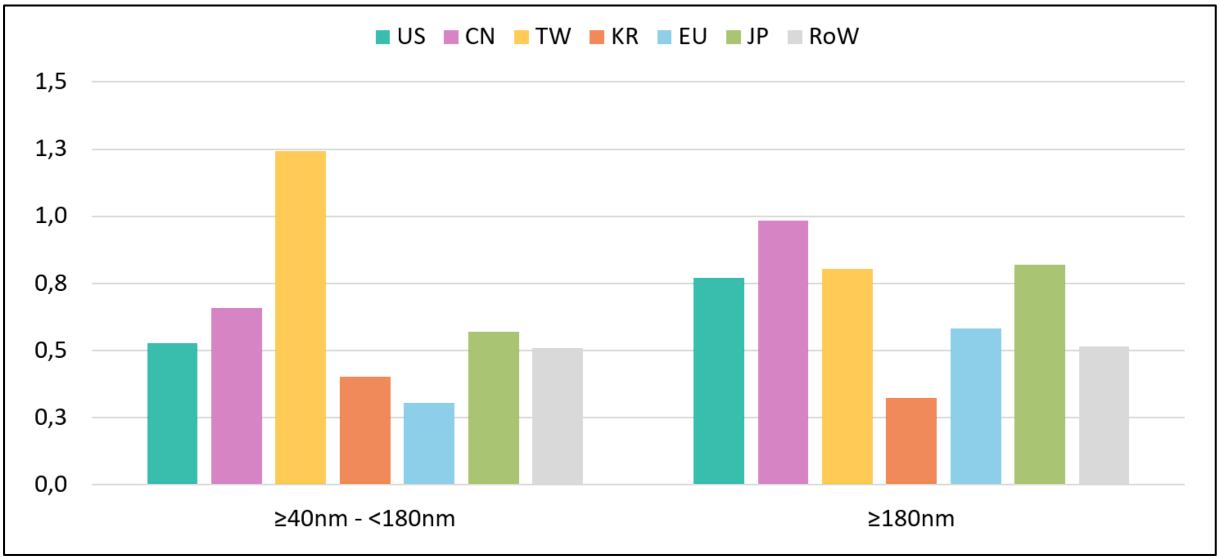
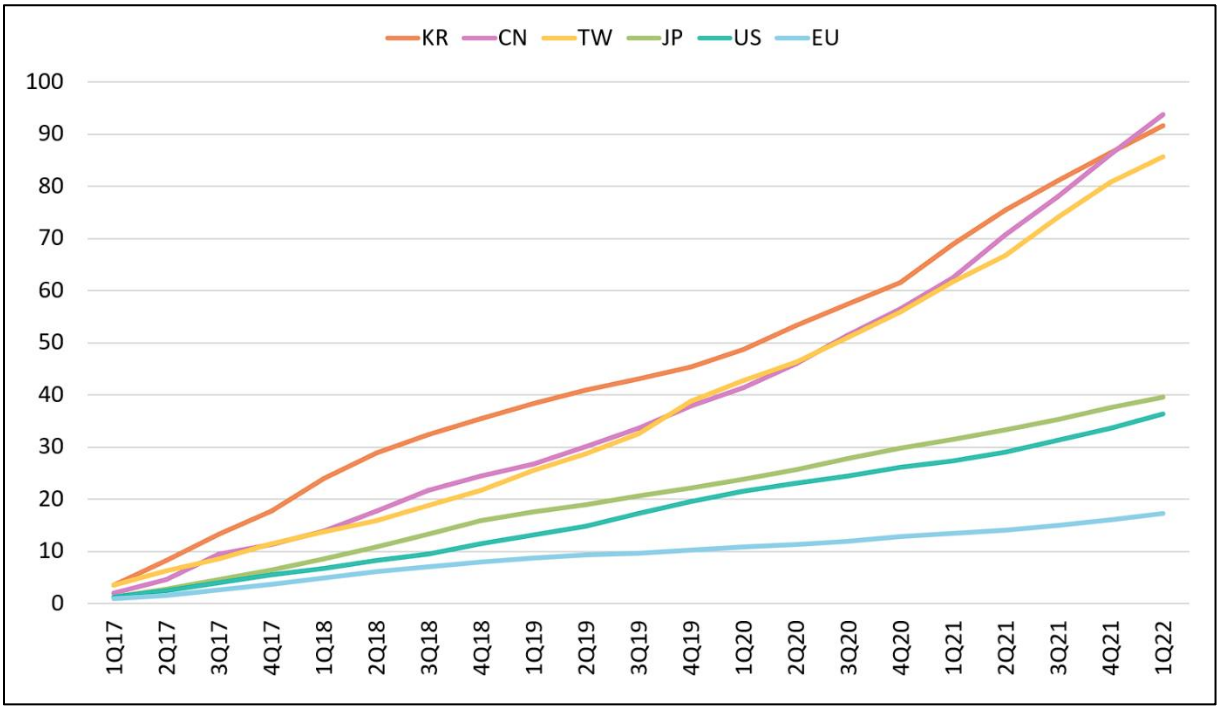


Figure 2: **Accumulated SME spending by destination (country) in USD billion [source: SEMI]**



References

[1] Antonio Varas, Raj Varadarajan, Jimmy Goodrich, and Falan Yinug. 2021. "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era." SIA x BCG. https://www.semiconductors.org/wp-content/uploads/2021/04/SIA-BCG-Report_Strengthening-the-Global-Semiconductor-Supply-Chain_April-2021.pdf.
[2] Luffy Liu. 2019. "Countdown: How Close Is China to 40% Chip Self-Sufficiency?" EETimes. https://www.eetimes.com/countdown-how-close-is-china-to-40-chip-self-sufficiency/.
[3] SIA. 2022. "China's Share of Global Chip Sales Now Surpasses Taiwan's, Closing in on Europe's and Japan's." https://www.semiconductors.org/chinas-share-of-global-chip-sales-now-surpasses-taiwan-closing-in-on-europe-and-japan/.
[4] Jan-Peter Kleinhans and Julia Hess. 2021. "Understanding the Global Chip Shortages. Why and How the Semiconductor Value Chain Was Disrupted." Stiftung Neue Verantwortung. https://www.stiftung-nv.de/sites/default/files/understanding_the_global_chip_shortages.pdf.
[5] Harald Bauer, Ondrej Burkacky, Peter Kenevan, Stephanie Lingemann, Klaus Pototzky, and Bill Wiseman. 2020. "Semiconductor Design and Manufacturing: Achieving Leading-Edge Capabilities." McKinsey. https://www.mckinsey.com/industries/advanced-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities.
[6] SIA. 2021. "Comments on Notice of Request for Public Comments on Risks in the Semiconductor Supply Chain." 86 Fed. Reg. 53031 (Sept. 24, 2021). https://www.regulations.gov/comment/BIS-2021-0036-0114.
[7] Jan-Peter Kleinhans and Nurzat Baisakova. 2020. "The Global Semiconductor Value Chain: A Technology Primer for Policy Makers." Stiftung Neue Verantwortung. https://www.stiftung-nv.de/sites/default/files/the_global_semiconductor_value_chain.pdf.
[8] Dylan Patel. 2021. "Advanced Packaging Part 1 – Pad Limited Designs, Breakdown of Economic Semiconductor Scaling, Heterogeneous Compute, and Chiplets." https://semianalysis.substack.com/p/advanced-packaging-part-1-pad-limited?s=r.
[9] SEMI. 2021. "SEMI Comments to Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain Notice of Request for Public Comments." 86 FR 14308. https://downloads.regulations.gov/BIS-2021-0011-0053/attachment_1.pdf.
[10] Pandaily. 2021. "Top 10 Semiconductor Equipment Suppliers in China." https://pandaily.com/top-10-semiconductor-equipment-suppliers-in-china/.
[11] John Lee and Jan-Peter Kleinhans. 2021. "Mapping China's Semiconductor Ecosystem in Global Context: Strategic Dimensions and Conclusions." Stiftung Neue Verantwortung x MERICS. https://www.stiftung-nv.de/sites/default/files/chinas_semiconductor_ecosystem.pdf.
[12] SEMI. 2021. "SEMI Comments to Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain Notice of Request for Public Comments." 86 FR 14308. https://downloads.regulations.gov/BIS-2021-0011-0053/attachment_1.pdf.
[13] Siltronic. 2022. "Siltronic AG: FY 2021 Conference Call Presentation." https://www.siltronic.com/fileadmin/investorrelations/2022/Quartal_1/20220309_Siltronic_FY_2021_Conference_Call_Presentation_01.pdf.
[14] TrendForce. 2022. "Localization of Chip Manufacturing Rising. Taiwan to Control 48% of Global Foundry Capacity in 2022, Says TrendForce." https://www.trendforce.com/presscenter/news/20220425-11204.html.
[15] WikiChip. 2011. "Intel Atom x3." https://en.wikichip.org/wiki/intel/atom_x3.
[16] IC Insights. 2022. "Top Three Suppliers Held 94% of 2021 DRAM Marketshare." https://www.icinsights.com/news/bulletins/Top-Three-Suppliers-Held-94-Of-2021-DRAM-Marketshare/.
[17] Omdia. 2021. "NVIDIA Maintains Dominant Position in 2020 Market for AI Processors for Cloud and Data Center." https://omdia.tech.informa.com/pr/2021-aug/nvidia-maintains-dominant-position-in-2020-market-for-ai-processors-for-cloud-and-data-center.
[18] Jan-Peter Kleinhans, Pegah Maham, Julia Hess, and Anna Semenova. 2021. "Who Is Developing the Chips of the Future?" Stiftung Neue Verantwortung. https://www.stiftung-nv.de/en/node/3085.
[19] Douglas Fuller. 2020. "Cutting Off Our Nose to Spite Our Face: US Policy towards China in Key Semiconductor Industry Inputs, Capital Equipment and Electronic Design Automation Tools." https://doi.org/10.2139/ssrn.3672079.

[20] SEMI. 2021. “SEMI Comments to Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain Notice of Request for Public Comments.” 86 FR 14308. https://downloads.regulations.gov/BIS-2021-0011-0053/attachment_1.pdf.
[21] IC Insights. 2022. “Chinese Companies Hold Only 4% of Global IC Marketshare.” https://www.icinsights.com/news/bulletins/Chinese-Companies-Hold-Only-4-Of-Global-IC-Marketshare/.
[22] IC Insights. 2021. “Texas Instruments Continues as World’s Top Analog IC Supplier.” https://www.icinsights.com/news/bulletins/Texas-Instruments-Continues-As-Worlds-Top-Analog-IC-Supplier/.
[23] SIA. 2022. “China’s Share of Global Chip Sales Now Surpasses Taiwan’s, Closing in on Europe’s and Japan’s.” https://www.semiconductors.org/chinas-share-of-global-chip-sales-now-surpasses-taiwan-closing-in-on-europe-and-japan/.
[24] SIA. 2021. “SIA Comments to Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain.” 86 Fed. Reg. 14308. https://www.semiconductors.org/wp-content/uploads/2021/04/4.5.21-SIA-supply-chain-submission.pdf.
[25] U.S. Department of Commerce. 2022. “Results from Semiconductor Supply Chain Request for Information.” https://www.commerce.gov/news/blog/2022/01/results-semiconductor-supply-chain-request-information.
[26] Dan Robinson. 2022. “You’re Fabbing It Wrong: Chip Shortages due to Lack of Investment in the Right Factories, Says IDC.” https://www.theregister.com/2022/01/28/idc_chip_shortages/.
[27] Ed Sperling. 2022. “Slowdown, But No Correction.” Semiconductor Engineering. https://semiengineering.com/slowdown-but-no-correction/.
[28] SEMI. 2022. “Chipping in for Equipment Suppliers: The Equipment Multiplier Effect on the Chip Shortage”. https://www.semi.org/en/blogs/business-markets/chipping-in-for-equipment-suppliers-the-equipment-multiplier-effect-on-the-chip-shortage
[29] Jan-Peter Kleinhans and John Lee. 2021. “China’s Rise in Semiconductors and Europe Recommendations for Policy Makers.” Stiftung Neue Verantwortung x MERICS. https://www.stiftung-nv.de/sites/default/files/chinas_rise_in_semiconductors_and_europe.pdf.
[30] Counterpoint. 2022. “Android Smartphone SoC Market: MediaTek Leads in Low-Mid Tiers, Qualcomm in Upper.” https://www.counterpointresearch.com/android-smartphone-soc-market-2021/.
[31] SIA. 2021. “SIA Whitepaper: Taking Stock of China’s Semiconductor Industry.” https://www.semiconductors.org/wp-content/uploads/2021/07/Taking-Stock-of-China%E2%80%99s-Semiconductor-Industry_final.pdf.
[32] Harald Bauer, Ondrej Burkacky, Peter Kenevan, Stephanie Lingemann, Klaus Pototzky, and Bill Wiseman. 2022. “Semiconductor Design and Manufacturing: Achieving Leading-Edge Capabilities.” McKinsey. https://www.mckinsey.com/industries/advanced-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities.
[33] Wolfspeed. 2019. “Cree Announces Update to Capacity Expansion Plan - Company to Build World’s Largest Silicon Carbide Device Manufacturing Facility in New York.” https://investor.wolfspeed.com/news/news-details/2019/Cree-Announces-Update-to-Capacity-Expansion-Plan---Company-to-Build-Worlds-Largest-Silicon-Carbide-Device-Manufacturing-Facility-in-New-York/default.aspx.
[34] Saif Khan. 2020. “U.S. Semiconductor Exports to China: Current Policies and Trends.” https://cset.georgetown.edu/publication/u-s-semiconductor-exports-to-china-current-policies-and-trends/.
[35] Douglas Fuller. 2020. ”Cutting Off Our Nose to Spite Our Face: US Policy towards China in Key Semiconductor Industry Inputs, Capital Equipment and Electronic Design Automation Tools.” https://doi.org/10.2139/ssrn.3672079.
[36] Alan Patterson. 2021. “Qualcomm, MediaTek Fill Vacuum HiSilicon Left in Smartphones.” https://www.eetimes.com/qualcomm-mediatek-fill-vacuum-hisilicon-left-in-smartphones/.
[37] Alex Williams and Hassan Khan. 2021. “A Brief History of Semiconductors: How the US Cut Costs and Lost the Leading Edge.” Employ America. https://www.employamerica.org/researchreports/a-brief-history-of-semiconductors-how-the-us-cut-costs-and-lost-the-leading-edge/.
[38] SIA. 2021. “2021 Factbook.” https://www.semiconductors.org/wp-content/uploads/2021/05/2021-SIA-Factbook-FINAL1.pdf

[39] Jan-Peter Kleinhans and Julia Hess. 2021. "Understanding the Global Chip Shortages. Why and How the Semiconductor Value Chain Was Disrupted." Stiftung Neue Verantwortung. https://www.stiftung-nv.de/sites/default/files/understanding_the_global_chip_shortages.pdf.
[40] Daniel Nenni. 2019. "A Detailed History of Samsung Semiconductor." SemiWiki. https://semiwiki.com/semiconductor-manufacturers/samsung-foundry/7994-a-detailed-history-of-samsung-semiconductor/.
[41] Ibid.
[42] Eric Knorr. 2003. "IBM's Foundry Challenge." EDN. https://www.edn.com/ibms-foundry-challenge/.
[43] Brad Setser and Dylan Yalbir. 2020. "Tracking Currency Manipulation." Council on Foreign Relations. https://www.cfr.org/article/tracking-currency-manipulation; Brad Setser. 2020. "Asian Intervention in the Foreign Exchange Market Is Back. Bigly." Council on Foreign Relations. https://www.cfr.org/blog/asian-intervention-foreign-exchange-market-back-bigly
[44] Digits to Dollars. 2022. "Are US Semis Too Expensive?" https://digitstodollars.com/2022/05/10/are-us-semis-too-expensive/
[45] Douglas Fuller. 2020. "The Increasing Irrelevance of Industrial Policy in Taiwan, 2016–2020." Taiwan during the First Administration of Tsai Ing-wen: Navigating in Stormy Waters, edited by G. Schubert and C-Y. Lee. http://dx.doi.org/10.2139/ssrn.3894525.
[46] Jan-Peter Kleinhans, Pegah Maham, Julia Hess, and Anna Semenova. 2021. "Who Is Developing the Chips of the Future?" Stiftung Neue Verantwortung. https://www.stiftung-nv.de/en/node/3085.
[47] Harald Bauer, Ondrej Burkacky, Peter Kenevan, Stephanie Lingemann, Klaus Pototzky and Bill Wiseman. 2020. "Semiconductor Design and Manufacturing: Achieving Leading-Edge Capabilities." McKinsey. https://www.mckinsey.com/industries/advanced-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities.
[48] Jan-Peter Kleinhans and Julia Hess. 2021. "Understanding the Global Chip Shortages. Why and How the Semiconductor Value Chain Was Disrupted." Stiftung Neue Verantwortung. https://www.stiftung-nv.de/sites/default/files/understanding_the_global_chip_shortages.pdf.
[49] Intel. 2022. "Briefing Note on the EU Chips Act to the Committee for Economic Affairs and Climate of the House of Representatives of The Netherlands." https://www.tweedekamer.nl/downloads/document?id=14af5a6b-82c0-4962-857b-5a6eb69943ba&title=Position%20paper%20Intel%20t.b.v.%20rondetafelgesprek%20Europese%20Chips%20Act%20d.d.%2011%20mei%202022.docx.
[50] Harald Bauer, Ondrej Burkacky, Peter Kenevan, Stephanie Lingemann, Klaus Pototzky, and Bill Wiseman. 2020. "Semiconductor Design and Manufacturing: Achieving Leading-Edge Capabilities." McKinsey. https://www.mckinsey.com/industries/advanced-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities.
[51] Tiago Perez and Samuel Pagliarini. 2020. "A Survey on Split Manufacturing: Attacks, Defenses, and Challenges." IEEE Access, 8, 184013–184035. https://doi.org/10.1109/ACCESS.2020.3029339.
[52] Ryan Smith. 2022. "Universal Chiplet Interconnect Express (UCIe) Announced: Setting Standards For the Chiplet Ecosystem." Anandtech. https://www.anandtech.com/show/17288/universal-chiplet-interconnect-express-ucie-announced-setting-standards-for-the-chiplet-ecosystem.
[53] Jeong-Soo Hwang. 2021. "Chip Shortages Spread to Backend Firms, Disrupting Supply Chains." The Korea Economic Daily. https://www.kedglobal.com/semiconductor-shortages/newsView/ked202102150017.
[54] Alexandra Alper. 2022. "Exclusive: Russia's Attack on Ukraine Halts Half of World's Neon Output for Chips." Reuters. https://www.reuters.com/technology/exclusive-ukraine-halts-half-worlds-neon-output-chips-clouding-outlook-2022-03-11/.
[55] Will Phillips. 2022. "Helium Supply Crunch Looms as US Alters Storage Strategy." Chartered Institute of Procurement and Supply. https://www.cips.org/supply-management/news/2022/february/helium-supply-crunch-looms-as-us-alters-storage-strategy/.
[56] Paul Triolo. 2021. "The Future of China's Semiconductor Industry." American Affairs. https://americanaffairsjournal.org/2021/02/the-future-of-chinas-semiconductor-industry/.
[57] Samuel Goodman, John VerWey, and Dan Kim.2019. "The South Korea-Japan Trade Dispute in Context: Semiconductor Manufacturing, Chemicals, and Concentrated Supply Chains." SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3470271.
[58] "I think U.S. ought to pursue to run faster, to invest in R&D, to produce more Ph.D., master, bachelor students to get into this manufacturing field instead of trying to move the supply chain, which is very costly and really non productive. That will slow down the innovation because—people trying to hold on

their technology to their own and forsake the global collaboration." TSMC Chairman Mark Liu on CBS's "60 Minutes." https://www.cbsnews.com/news/semiconductor-chip-shortage-60-minutes-2021-08-29/.
[59] Chris Miller, Jordan Schneider, and Danny Crichton. 2021. "Labs over Fabs How: The U.S. Should Invest in the Future of Semiconductors." Foreign Policy Research Institute. https://www.fpri.org/wp-content/uploads/2021/03/semiconductors-report-final.pdf.
[60] European Commission. 2020. "2020 Strategic Foresight Report: Strategic Foresight – Charting the Course Towards a More Resilient Europe." COM(2020) 493 final. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0493&from=en.
[61] Calumet Electronics Corporation. 2021. "Comment on Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain." 86 FR 14308. https://downloads.regulations.gov/BIS-2021-0011-0090/attachment_1.pdf.
[62] Grady McGregor. 2022. "A Semiconductor CEO Explains How Shanghai's 7-Week Lockdown Is Crippling His Supply Chain and Fueling Inflation." Fortune. https://fortune.com/2022/05/14/china-covid-lockdown-shanghai-supply-chain-inflation-semiconductor-shortage/.
[63] Jan-Peter Kleinhans and John Lee. 2021. "China's Rise in Semiconductors and Europe Recommendations for Policy Makers." Stiftung Neue Verantwortung x MERICS. https://www.stiftung-nv.de/sites/default/files/chinas_rise_in_semiconductors_and_europe.pdf.
[64] Nicholas Bloom, Charles Jones, John van Reenen, and Michael Webb. 2019. "Are Ideas Getting Harder to Find?" https://web.stanford.edu/~chadj/IdeaPF.pdf.
[65] The White House. 2021. "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth." 100-Day Reviews under Executive Order 14017. https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.
[66] U.S. Department of Commerce. 2022. "Results from Semiconductor Supply Chain Request for Information." https://www.commerce.gov/news/blog/2022/01/results-semiconductor-supply-chain-request-information.
[67] Douglas Fuller. 2021. "China's Counter-Strategy to American Export Controls in Integrated Circuits." China Leadership Monitor, Spring 2021 Issue 67. http://dx.doi.org/10.2139/ssrn.3798291.
[68] Elizabeth Xiao-Ru Wang, Sophie Yang, and Stephen Cacciola. 2020. "An Economic Analysis of the Effects of Stricter, Unilateral US Export Controls for Electronic Design Automation Technology on Chinese Design." Compass Lexecon report commissioned by Cadence. https://downloads.regulations.gov/BIS-2021-0011-0040/attachment_2.pdf.
[69] Douglas Fuller. 2020. "Cutting Off Our Nose to Spite Our Face: US Policy towards China in Key Semiconductor Industry Inputs, Capital Equipment and Electronic Design Automation Tools." https://doi.org/10.2139/ssrn.3672079.
[70] Elliott Smith. 2022. "'Downright Scary and Untenable': Commerce Secretary Warns U.S. Needs to Secure a Future for Its Chip Industry." Interview with Gina Raimondo, Secretary of Commerce. https://www.cnbc.com/2022/05/25/gina-raimondo-warns-us-needs-to-secure-future-for-chip-industry.html.
[71] U.S. Department of Commerce. 2022. "U.S.-EU Joint Statement of the Trade and Technology Council." https://www.commerce.gov/news/press-releases/2022/05/us-eu-joint-statement-trade-and-technology-council.
[72] The White House. 2022. "United States-Republic of Korea Leaders' Joint Statement." https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/21/united-states-republic-of-korea-leaders-joint-statement/.
[73] Japan Ministry of Economy, Trade, and Industry. 2022. "FACT SHEET: First Ministerial Meeting of the Japan-U.S. Commercial and Industrial Partnership (JUCIP)." https://www.meti.go.jp/press/2022/05/20220506002/20220506002-1.pdf.

OPENING STATEMENT OF KRISTIN VEKASI, ASSOCIATE PROFESSOR, POLITICAL SCIENCE AND SCHOOL OF POLICY AND INTERNATIONAL AFFAIRS, UNIVERSITY OF MAINE

COMMISSIONER BOROCHOFF: Thank you very much, sir. And now we will hear from Ms. Vekasi.

DR. VEKASI: Co-Chairs Borochoff and Goodwin, members of the Commission and staff, thank you very much for your invitation to testify today on supply chain security in critical rare earth elements. And I apologize I could not be there in person. Today, I'm going to talk about risks in the sector, suggest some possible policies the United States might pursue, including particularly lessons from Japan's approach.

Today, China holds the commanding position in the global rare earth supply chain from mining to processing to end uses. China currently controls 50 to 60 percent of global rare earth mining, 80 to 90 percent of the market in the intermediate processing stage where the elements are separated and refined into medals and alloys, and at least 60 to 70 percent in downstream manufacturing for products like permanent magnets. It's estimated that in coming decades, demand for rare earths will increase by an order of 4 to 8 at least, especially for rare earths that are used in permanent magnets like neodymium or praseodymium.

Increases in demand are largely due to great technologies where neodymium-iron-boron permanent magnets are used for electric vehicle and wind turbine motors. These materials and technologies are ubiquitous, not just in green energy, also health and defense sectors as well as, of course, consumer electronics. A supply crunch here would cause noticeable disruptions.

That kind of supply crunch is pretty easily imaginable. Industry insiders have indicated that in recent years, the world has used around 3,000 more tons of neodymium per year than is currently produced. That's about 10 percent over.

Even China is importing some rare earths from bordering Myanmar as their supply falls short of domestic demand. In short, the world needs more industry ready rare earths. The supply chain is getting more vulnerable.

Rare earth elements as you probably know are not geologically rare. The map of existing and potential mines that I provided in my written testimony shows possible mining sites in abundance and almost every continent. While there are supply chain vulnerabilities and risks, none of them are related to the supply of mining sites.

They arise from three things, first, a willingness to bear high environmental externalities. Rare earth mining and post-processing is environmentally toxic. And while there have been advancements in cleaner mining, especially in China, it is far from perfect.

Second, technological expertise and separation in refinement is, in fact, somewhat rare. Whether from ore concentrate or recycling efforts from so-called urban mining, building considerable expertise that you need to mine -- needed in the rare earth midstream requires long-term investment in basic research and talent development. The third vulnerability comes from a lack of a transparent price index, and this relates to the sort of monitoring and transparency we just heard about.

So this creates a barrier to new entrance to the rare earth market. It can be difficult to attract financing without reliable and transparent price information that would allow companies to predict return on investment, make reasonable forecast of insolvency risk. Most Chinese new market entrants are smaller firms without deep capital reserves. They have hard budget constraints.

The failure rate in the sector for new market entrants is very high. It's over 95 percent. Over the past four decades, China has effectively used market interventions and investment in expertise to become the singular major global player. I know there's some discussion of this, this morning.

Market interventions have included expert quotas, now production quotas, nationalization, and consolidation of the industry. And most recently, even more consolidation, creating a vertically integrated mega-firm under top level state administration. This mega-firm now controls some 30 percent of the global market and focuses on heavy rare earths.

China also invested heavily in basic research from the 1980s on. And these efforts have really paid off. They train the most students. They have deep talent pipeline. They have dedicated research centers, academic journals, and newsletters that help move publicly funded research to Chinese companies.

China holds by far the most patents in rare earth-related technologies, especially for rare earth permanent magnet technologies. So China, in short, is resilient along the full supply chain. They have large vertically integrated, competent companies, a deep talent pool. And even there, supply is starting to fall short of demand.

Japan recognized and took action on rare earth supply chain vulnerabilities more than a decade ago. After China allegedly restricted rare earth exports to Japan amidst a 2010 territorial dispute, Japan mobilized their private and public sectors. At the time, Japan was more than 90 percent dependent on China, they used industrial policy and public-private partnerships to decrease reliance on Chinese rare earths. And Japan has been modestly more successful than other countries in doing so.

Among other policies that I outline in my written testimony, the Japanese government provided direct subsidies and business support through partnerships with a state-owned enterprise called the Japan Oil, Gas, and Metals Corporation. And they managed to build a Japan, Australia, Malaysia supply chain that goes from end to end to supply automotive permanent magnets. This public-private nexus and use of industrial policy has been key for Japan's efforts in securing a diverse and resilient supply chain. By late 2017, Japan was importing approximately 30 percent of its rare earths from Southeast Asia and less than 60 percent from China, and that trend continues today.

So building on this, I have three recommendations to help ameliorate supply chain vulnerabilities for the U.S. And the first is investment in full supply chain resiliency. Building on some comments from this morning, while a focus on the mining stage is tempting, we need to focus attention on the midstream and especially over the long term.

This is where the real chokepoint lies. And long-term thinking and innovation in this area can reap higher dividends for economic resiliency and national security. We can invest more in basic research, funding and opportunities for national labs, encourage public-private knowledge transfer. We can also do this in conjunction with other friendly countries including the Quad, Canada, the European Union, and build on some existing programs.

Second is to work on increasing price transparency. The United States government should direct the Department of Commerce to develop an international price index preferably in cooperation with China where a lot of this industry happens. It'd be great to have this for all 17 elements, but spot prices for neodymium and praseodymium are the most important.

The final recommendation is some public-private cooperation. So the U.S. could emulate Japan's model of public-private funding for new mining and separation facilities that help overcome these initial risks. It's likely that private companies will need to lean on Chinese expertise, though, to develop a real resilient U.S.-based rare earth industry.

The United States should recognize China's technical leadership in this sector, be pragmatic, and not prohibit private sector cooperation with Chinese commercial entities in order to be eligible for funding opportunities. And I'll repeat that, that in order to facilitate success, cooperation from China here is still essential. Thank you so much for this opportunity and your attention, and I look forward to answering your questions.

PREPARED STATEMENT OF KRISTEN VEKASI, ASSOCIATE PROFESSOR, POLITICAL SCIENCE AND SCHOOL OF POLICY AND INTERNATIONAL AFFAIRS, UNIVERSITY OF MAINE

Kristin Vekasi
June 9, 2022

Associate Professor
Political Science and the School of Policy and International Affairs
University of Maine

United States-China Economic and Security Review Commission
Hearing on "U.S.-China Competition in Global Supply Chains"

Executive Summary

- Risks in the rare earth sector arise from 1) high environmental externalities, 2) high level of technological expertise needed for separation and refinement, and 3) information failures.
- China has effectively used market intervention, industrial policy, and investment in expertise over the long-term to become the major global player in rare earths.
- Supply chain vulnerabilities arise from the market concentration in China. In coming years, China will be unable to meet their own rising domestic demand nor global needs, particularly for neodymium and other key rare earths needed for permanent magnets.
- The United States government can help ameliorate supply chain vulnerabilities in rare earths by:
    - Investing in basic research, increasing funding for national labs, and facilitating public-private knowledge transfer;
    - Increasing information transparency by developing an international price index, preferably in cooperation with China;
    - Emulating Japan's model of public-private funding for new mining and separation facilities that help overcome initial political and environmental risks.

Global Rare Earth Supply Chains – Developments and Challenges

Rare earths are not geologically rare. While China has approximately 30% of global rare earth reserves, they currently control 50-60% of global rare earth mining, and 80-90% of the market in the intermediate processing stage. Figure 1 in the appendix shows global rare earth mining production. They achieved this dominant position in the market through long-term investments in basic research, a mechanism to nurture a public-private pipeline, and the development of deep talent and expertise. In short, China's market position was determined by policy, not geography.[i]

The United States used to be the major global player in rare earths from World War II until the early 1990s. Following World War II, when India restricted rare earth imports to the United States as part of a broader industrial policy strategy, the United States government made large investments in basic research in the rare earth sector, as well as developing a mechanism to support a public-private pipeline of knowledge.[ii] The Rare Earth Information Center quarterly newsletter was a particularly effective mechanism for facilitating knowledge transfer from the national Ames Laboratory to private companies using innovations in rare earths in industry. However, as of the 1980s investments from the government had ceased, and basic research in rare earths greatly cooled. By the 1990s, this public-private investment mechanism had disappeared, while China had begun to effectively use very similar policies in order to facilitate the growth of their own domestic sector.

Today, China holds the commanding position in the global rare earth supply chain, from mining to processing to end-uses. The 17 elements in the rare earth group are mostly not rare: some are more abundant than copper, and they can be found across continents. For reference, Figure 2 in the appendix provides a map of existing mines and potential rare earth deposits around the world. This map is particularly important because supply chain vulnerabilities come from three things, none of them related to the supply of mining sites:

1. Willingness to bear high environmental externalities
2. Technological expertise in separation and refinement
3. Market risks introduced by information failure

Chinese policies have somewhat ameliorated the first factor, have excelled in the second, and the world is struggling with the third. We can evaluate the efficacy of China's policy on the ability to consolidate the domestic industry, control production numbers and eliminate illegal mining, standardize production procedures, and enforce environmental protections and other regulations.

There are a number of market and policy tools that China has historically used and continues to use to maintain their dominance in the rare earth industry. These include export controls, production quotas, state investment in basic research, nationalization of the industry, and most recently state consolidation into a vertically integrated mega-firm. As I have written elsewhere, Chinese dominance in the rare earth industry is a matter of policy, not geography.[iii]

Rare earth mining is highly polluting and bears high environmental and health costs for local communities. After they have been removed from the ground they must be separated, refined into oxides, and then made into metals and alloys before they are ready for industry. The secondary process is also highly environmentally damaging.[iv] Although the shift from the United States to China was *initially* enabled by China's lower environmental and regulatory standards compared to the US, it is not the case that China maintains their lead today for this reason. Over the past decade, China has increased introduced new environmental regulations, enforced existing ones, and innovated some cleaner mining and refining processes.

The process of separation and refinement is the area where China has invested a great deal of intellectual capital and state resources. Today, China's dominance in rare earths is due more to their investment in the separation and refining process than trade or industrial policies. When it comes to rare earths, much like other technologies, investment in basic research and training of the talent of tomorrow is where true future dominance lies.

China's Industrial Structure

China nominally tightened regulations in the early 2000s, but struggled because of the proliferation of illegal mines. In 2012, the central Chinese government started a process of consolidation sparked by a recognition of many of the negative social and environmental externalities in the industry as well as acknowledgement of increased future global and domestic demand for the minerals.[v] Instead of hundreds of small miners, the consolidation turned the industry into six regional state-owned conglomerates. In December 2021, there was further consolidation of the industry in the creation of the new mega-firm. The new China Rare Earth Group is the result of a merger of three large mining conglomerates and two research institutes. It will control China's heavy and medium rare earths, under the supervision of the State-owned Assets Supervision and Administration Commission of the State Council (the highest administrative level).[vi] It will control some 30-40% of global supply.

The main goals of the new mega-firm are rooted in the domestic political economy, including market consolidation under state control, matching supply to demand, and an emphasis on vertical integration and higher value-added domestic production. It may also lead to more price stability, although that is not guaranteed. Prices for rare earths have been increasing due to surging demand and constraints on Chinese producers, particularly due to increased enforcement of environmental regulations.[vii]

I anticipate in the future that the northern companies around the Baotou Mine in inner Mongolia will also be consolidated so China will have only two huge vertically integrated state-owned enterprises that control both rare earth mining and post-processing. The southern firm focuses on the heavy rare earth minerals, and the possible northern firm will focus on the light rare earth minerals (including neodymium).

China's Production Quota System

Previously, China used a system of discriminatory domestic versus foreign prices and export controls. In a case brought by the United States, European Union, and Japan, these export controls were found to be against China's accession agreement to the WTO in 2015. Following that decision, China did drop expert controls, and they were replaced by a system of production quotas that continued to limit supply and typically kept prices low and steady.

Production quotas for the regional conglomerates are set centrally by the Ministry of Commerce, and enforced by the local governments. In recent years, production quotas have failed to meet demand and are starting to stress China's domestic rare earths sector.[viii] Although an environmentally responsible and self-sufficient rare earth industry is a stated goal in China's recent five-year plans, domestic demand for rare earths has already outstripped domestic supply.

The 2016 “Rare Earth Industry Development Plan” published by the Ministry of Industry & Information Technology (MIIT) in conjunction with the 13th five-year plan, described many of these policies with specified targets for increased profitability and improvements in the high value-added segments of the industry, meeting higher environmental standards, and decreased production and smelting reflecting the goal of industry consolidation. One goal in the plan was to “improve mechanisms to keep the prices of superior minerals stable through limiting production.” The 13th five-year plan, in particular, focused on the shift in China’s political economy to higher value-added products with increased environmental sustainability. Goals included strengthening “geological environmental governance and ecological restoration in regions of intensive mineral resource mining” and “green mining”.[ix]

By the time the 14th five-year plan was announced in 2021, many, though not all, of the previous goals had been met or were in process. China had moved up the value-added chain, as evidenced by their large research and development investments and expertise in the intermediate stages of production. As of this writing, no detailed regulations of rare earths under the 14th five-year plan yet exist. Overall, however, the plan calls to “promote breakthroughs in advanced metals and inorganic non-metal materials such as high-end rare earth[s]…[to] accelerate the breakthrough in key technologies”. The plan is heavily focused on the newer industrial policy in China to shift towards higher value-added production, green technologies, and an economy more driven by domestic production *and* demand.[x] While rare earths are not the only mineral targeted in the plan, these minerals are central to these broader goals. Many of the objectives – electric vehicles, space technology, new materials, computing and more – will require a reliable source of rare earths for either Chinese producers or foreign producers based in China.

China imports rare earths, particularly those needed for permanent magnets. They also import unprocessed concentrate from the United States, which is then refined within China’s vertically integrated industry. As a US Department of Energy report notes, most rare earth imports into the United States are in finished products. Even as US mining production has increased in recent years (see Figure 1), China’s command of the midstream is unrivaled.

In recent years, China has also started to rely on rare earth mining in regions of Myanmar that border China. The imports from Myanmar come from poorly regulated mines in that country, and also potentially from Chinese ores that are illegally mined and laundered across the border.[xi] China’s increased efficacy in enforcing environmental regulation, the consolidation of the industry, and the production quotas have restricted supply and made mining and processing in China more expensive. There is also increased demand for rare earths for permanent magnets and catalysts, particularly driven by the fast growth of China's electric vehicle market. Even China faces supply chain vulnerabilities. For example, when Covid-19 policies temporarily closed the China-Myanmar border, the price of rare earths started to rise dramatically. These price pressures were relieved to some extent when the border reopened and may be further ameliorated by the merger of the large mega-firm.

Rare earths and permanent magnets

Demand for rare earths, particularly heavy rare earths that can be used in permanent magnets, is increasing and projected to increase more dramatically in the coming decades.[xii] As Figure 3 in the appendix shows, demand for rare earths, particularly neodymium, but also dysprosium, praseodymium, and samarium, are expected to increase dramatically in the coming years largely due to green technologies, particularly in the automotive industry where neodymium-iron-boron (NIB) permanent magnets are used for motors (the technology and mineral needs are similar for wind turbines). Neodymium is in MRI machines and lasers, and NIB magnets are found in computers, cell phones, and other electronics, in addition to the aforementioned wind turbines and motors. End uses span the health sector, green energy sector, defense, and everyday consumer products. NIB magnets are ubiquitous.

By 2025, one estimate predicts a total demand for major rare earth permanent magnet applications of 94,500 metric tons (see Figure 3). In 2020, global rare earth production was 240,000 metric tons, but this includes all 17 elements, not just the key ones. In conversation, industry insiders have indicated that in recent years, the world has used around 3,000 more tons of neodymium per year than is produced although given the lack of transparency the precise numbers are difficult to pin down.

China's investment in rare earth research and development and the extent of their expertise relative to other countries is evident in the permanent magnet industry and the allocation of patents, one indication of overall investment in research activity. Figure 4 in the appendix shows patents for permanent magnets overall, neodymium-praseodymium permanent magnets, and samarium-cobalt permanent magnets from 2001-2020. While in 2021 China received 48% of patents granted in permanent magnets overall, 99% of neodymium magnet patents and 86% of samarium-cobalt magnet patents were granted to China. While not necessarily an indication of mastery or command of the most cutting-edge technology, patent allocation does indicate expertise, training, and dedication of resources towards an industry. While I do not present the data here, patents in the rare earth industry overall show this same national trend.

Assessing Vulnerability

Relying on a single geographic source for any key material inherently introduces vulnerability in a supply chain, even without concerns about rivalrous politics. We have seen increased weaponization of trade and supply chains around the world over the past decade, including from China with rare earth elements. However, more than the intentionality suggested by potential economic coercion, geographically concentrated raw mineral supply chains increase vulnerability because there is simply an inability to nimbly respond to any crisis or a demand shock. The near certainty of increased future demand will exacerbate this vulnerability.

With the industry status quo, potential vulnerabilities include the following, listed from most to least likely:

- Supply-side shortages due to an undiversified market and booming demand limiting China's export potential and leading to increased costs or even potential shortages for both rare earth elements and downstream products, including permanent magnets. Given the ubiquity of these ingredients, this move would have downstream effects for consumer electronics, medical equipment, and green technology such as electric vehicles and wind turbines.
- Chinese export restrictions or other trade barriers of rare earth elements and downstream products in an aggravated US-China trade conflict, causing price increases and shortages in key segments of the supply chain similar to the above scenario.
- Restriction of key raw materials in the event of a territorial dispute or more severe kinetic conflict that could affect US military readiness in defense of our allies and partners.

Before I address potential tools for the United States government, I will provide a short overview of Japan's relatively successful approach to similar vulnerabilities.

Learning from Japan

After China allegedly restricted rare earth exports to Japan amidst a 2010 territorial dispute, Japan mobilized the private and public sector to build a more resilient supply chain. Japan's historical toolkit of industrial policy and public-private partnerships informed Japan's approach to ameliorate its over-reliance on Chinese rare earths, and Japan has been modestly more successful than other countries. Diversification activities included new economic partnership agreements, joint ventures, mining exploration, and rare earth processing plants throughout Asia, the Americas, and Australia. The Japanese government promoted diversification by improving relations with countries with domestic rare earth reserves through strategies such as diplomatic agreements, overseas development aid projects, and providing opportunities for firms to find overseas partners through economic tours or trade fairs. They also provided direct subsidies and business support through partnerships with a state-owned enterprise.[xiii]

The Japanese Ministry of Foreign Affairs pursued partnerships and new agreements in countries with rare earth deposits, but not the capacity, sufficient infrastructure, or domestic demand to safely mine and process. Japan pursued economic diplomacy with the United States, Australia, Mongolia, India, Vietnam and Kazakhstan, including efforts to secure strategic resources through overseas development aid and diplomacy. Not all of these efforts were successful. For example, efforts to start new mining in Mongolia and Kazakhstan largely failed.

Japan also used industrial policy. The Ministry of Economy, Trade and Industry (METI), and the state-owned enterprise Japan Oil, Gas, and Metals Corporation (JOGMEC) developed policies to promote more robust domestic capacity and diversify internationally. METI introduced subsidy competitions for the private sector for international diversification, developing technological alternatives, and the development of new recycling procedures. METI ran these policies in 2009, 2011, 2016, and 2021 (the 2021 call was a broader policy including PPE and other critical sectors in response to the pandemic).

The recipients of the METI money are largely small or medium-sized enterprises, but the real movers in the sector of critical minerals are large-scale enterprises, the trading companies that help secure their materials, and a state-owned enterprise that provides financial backing to these large companies. As a relatively resource-poor country, Japan established two state organizations in the 1960s to ensure a supply of oil and minerals. In 2004, these organizations were combined into the Japan Oil, Gas, and Metals Corporation (JOGMEC), which is under the jurisdiction of METI. While mineral extraction is a key goal, JOGMEC assists along the supply chain. Their goals are to promote early-stage exploration and advanced-stage metal mining, helping develop recycling technologies and metal alternatives. They also have a stockpiling program for rare earths. After private companies put in requests for assistance, JOGMEC helps initiate rare earth projects around the world, including in Canada, the United States, South Africa, Australia, Kazakhstan, Vietnam, and Brazil. These are done in partnership with Japanese general trading companies, which are larger companies that (among other roles) solve supply chain problem issues within the Japanese economy for other private firms. For example, JOGMEC and Sojitz are financing the Lynas Rare Earth Project in Australia, which is a key source of non-Chinese rare earths for Japan. With Toyota Tsusho they are helping guarantee a lithium project in Argentina.[xiv] While JOGMEC provides financing assistance for these projects, they are initiated by the general trading companies.

Japanese rare earth-related investments in Malaysia where Lynas processes the sediment from their mine in Australia are an example of diversification along the supply chain. The early days of this effort were fraught, and Japanese financing, including from JOGMEC and Sojitz, were needed to rescue Lynas from bankruptcy. The rescue enabled a non-Chinese supply of rare earths for Japanese producers, particularly of neodymium and praseodymium used in electric car batteries.

The public-private nexus and use of industrial policy has been key for Japan’s efforts in securing a diverse and resilient supply chain. By late 2017, Japan was importing approximately 30% of its rare earths from Asian countries other than China, a trend that has continued through 2021. Many of these come from Malaysia, showing the success of JOGMEC’s policies.

Vulnerabilities, however, still remain. Following the onset of the Covid-19 pandemic and severe supply chain disruption in China, Japan initiated new but similarly designed industrial policy to encourage diversification from China, either through reshoring or moving into a different overseas market. Through this process, at least three companies have received grants to develop rare earth-related companies in Vietnam and Malaysia.[xv] Japan is also pursuing cooperation with the United States and other allies (Canada, the European Union, and Australia) to maintain and develop expertise in the rare earth sector. They hold regular meetings to share research and strategies on critical minerals. Japan and the United States also pledged to jointly develop resiliency in critical minerals during a high-level summit in April 2021. Developing resiliency in critical mineral supply chains is also an element of the Indo-Pacific Economic Framework in which Japan is participating.[xvi]

Domestic and international interventions

In this section I assess possible interventions from the United States government, and their attendant risks. I focus on possible incentives for the private sector that encourage diversification and deepening expertise along the supply chain rather than restricting access to Chinese markets through tariffs or non-tariff barriers. At this point, the United States and partners lack the capacity to maintain a rare earth industry outside of China and cooperation with China is in our best interest.

Diversifying at the Mining Stage

Diversification at the mining stage, either by further increasing US mining or in third countries, is one possibility to reduce reliance on China and to respond to future increased demand. This strategy is somewhat high risk, for reasons I outline below. To mitigate initial risks, possible policy interventions are 1) guaranteed minimum purchasing from new mines, 2) public-private partnerships similar to the Japanese model where state financing eased initial risks and prices shocks, or 3) loan guarantees, subsidies, or tax breaks for new risky ventures. **Easing environmental regulations is not recommended** as the political, economic, and social costs from backlash against the project would likely eliminate any gains.

Opening new mines is not a short or simple process. In incentivizing new domestic mining, there needs to be a commitment to carry on throughout short-term price shocks, particularly for metals like cerium and lanthanum that are likely to experience more price volatility. If metals from successful mines are introduced, the market can be flooded with new supply, prices bottom out, and the mine will likely be unsustainable in the short term without external support or a deep-pocketed parent company. The large conglomerate companies in China are well-financed, have a soft landing pad untethered to hard market concerns, and can survive lower prices and turbulence in the market. Australian, US, and Canadian companies do not have that luxury, and often do not survive past the initial mining stages, particularly because the large mining companies (e.g. Australia's Rio Tinto) have stayed out of the rare earth market.

This phenomenon was particularly evident after the 2010–2011 rare earth price and demand crunch when the prices for some elements went up more than 75 times their original prices. The very high price point of specific elements made it temporarily profitable for new mines to open around the world. However, because the prices quickly crashed back to original levels, all of these new mining ventures quickly faded into insolvency. In one study of new entrants to the market, analyst James Kennedy found that of 400 publicly listed rare earth start-ups around the world from 2012-2019, only five of them had successfully achieved commercial production, and those who had were still dependent on Chinese financing and midstream processing.[xvii] The former American company Molycorp's experience with the California Mountain Pass Mine is instructive. The United States tried to diversify using its domestic reserves. The Mountain Pass Mine had closed in 2002 due to environmental concerns as well as unprofitability. When prices began to rise, and incidentally at the urging of US policymakers, Molycorp reopened the mine in 2012 only to declare bankruptcy in 2015 when prices collapsed to early 2010 levels.

These issues are exacerbated by information failure. The lack of a global spot price challenges new entrants to the market. It can be difficult to attract financing without reliable and transparent price information that would allow companies to predict return on investment or make reasonable forecasts of insolvency risk.

Diversification at the mining stage *is* important, particularly because of future anticipated demand. For any of these interventions, however, policymakers must be prepared for failure in many of the projects and willing to provide financial support for firms to survive price fluctuations or other unexpected challenges. To achieve diversification at the mining stage, policymakers must take a long-term view.

Diversifying in the Midstream

Midstream diversification – particularly including separation, processing, refinement, but also intermediate products like magnets – requires an additional set of tools and investments. Similar environmental externalities from mining exist at the midstream. It also requires more technical expertise, which takes more time and intellectual capital to develop than a new mine. Similar funding mechanisms may be necessary for midstream processing, and have been introduced by the previous administrations, as well as the Biden administration. The Department of Energy's new initiative for extracting rare earths from coal waste and ash is one example of how building midstream resilience might proceed.[xviii]

To pursue similar innovations, the United States could expand funding for basic rare earth research and prioritize public-private collaboration that will move the results of basic research into the private sector. For example, the Department of Energy or National Science Foundation can fund university- or national lab-based projects, prioritizing those that have secured joint funding from a private firm so discoveries can be tested and scaled in a commercial environment. The United States already has regular conferences with rare earth experts from Australia, Canada, Japan, and the European Union. The structure of funding could also encourage international collaboration with selected countries to develop a more robust sector outside China, and not just in the United States.

<u>Policy recommendations</u>

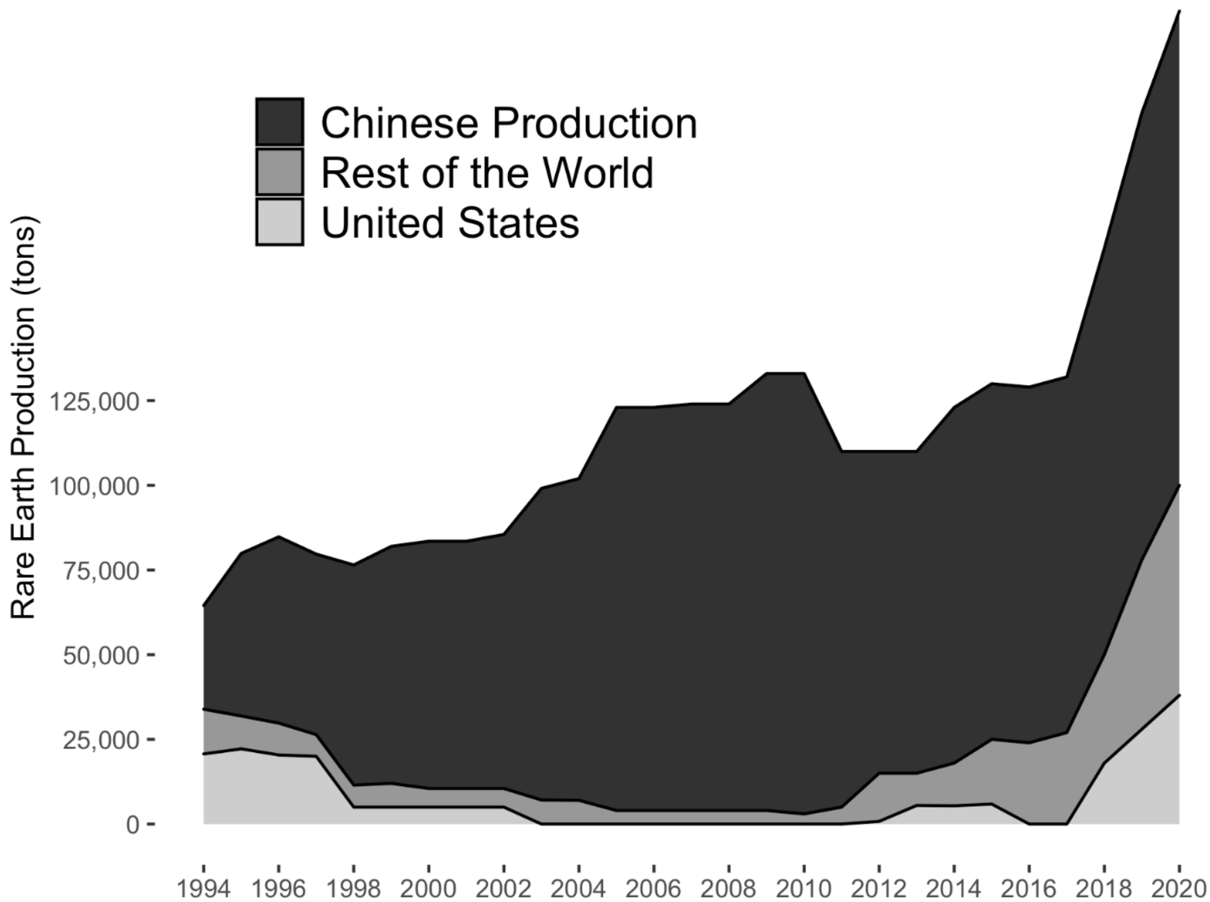
Full supply chain resiliency: The United States government can help ameliorate supply chain vulnerabilities in rare earths by diversifying along the supply chain. While a focus on the mining stage is tempting, attention to the midstream is likely to yield greater results. The midstream is currently more vulnerable and long-term thinking and innovation in this area can reap higher dividends for national strength and security. The United States should invest in basic research, increase funding and opportunities for national labs, and facilitate knowledge via public-private knowledge transfer. These efforts can be done in conjunction with allies that share similar concerns, including the Quad and the European Union, and can build on existing programs. Some of these efforts are ongoing, but should be increased.

Solving information failures: The United States government should direct the Department of Commerce to increase information transparency in rare earths by developing an international price index, preferably in cooperation with China. While known market prices for all 17 elements would be beneficial, spot prices for neodymium and praseodymium are particularly pressing. This task could also potentially be accomplished through cooperation with international organizations such as the International Monetary Fund. Price transparency would facilitate success for new market entrants.

Public-private cooperation: The United States should emulate Japan's model of public-private funding for new mining and separation facilities that help overcome initial political and environmental risks in the rare earth sector. Even with public funding, it is likely that private companies will need to lean on Chinese expertise to develop a resilient business model. The United States should recognize China's technical leadership in this sector and not prohibit private-sector cooperation with Chinese commercial entities in order to be eligible for opportunities. In conclusion, The US government should facilitate public-private cooperation in addition to cooperation with Chinese commercial entities.

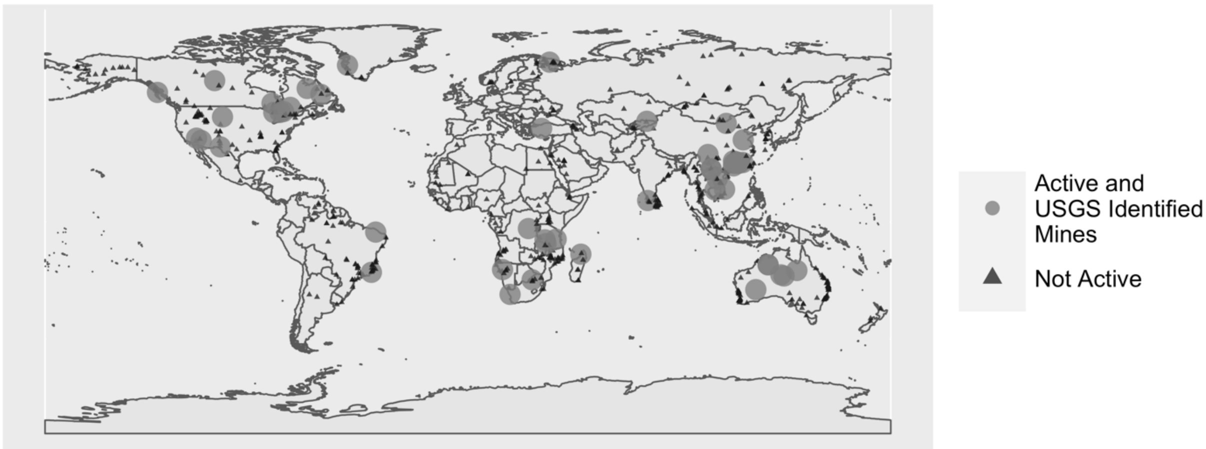
Appendix – Supporting Figures

Figure 1 Global Rare Earth Production, 1994-2020



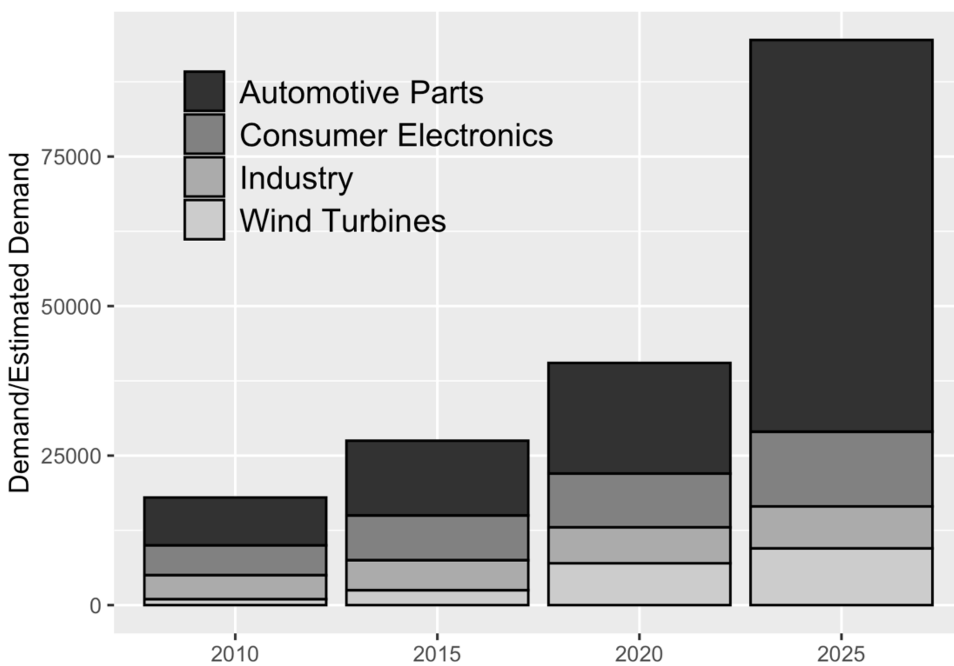
Data are from the US Geological Survey Annual Mineral Commodity Summaries and the author's calculations.[xix]

Figure 2 Global Rare Earth Mining Sites and Deposits



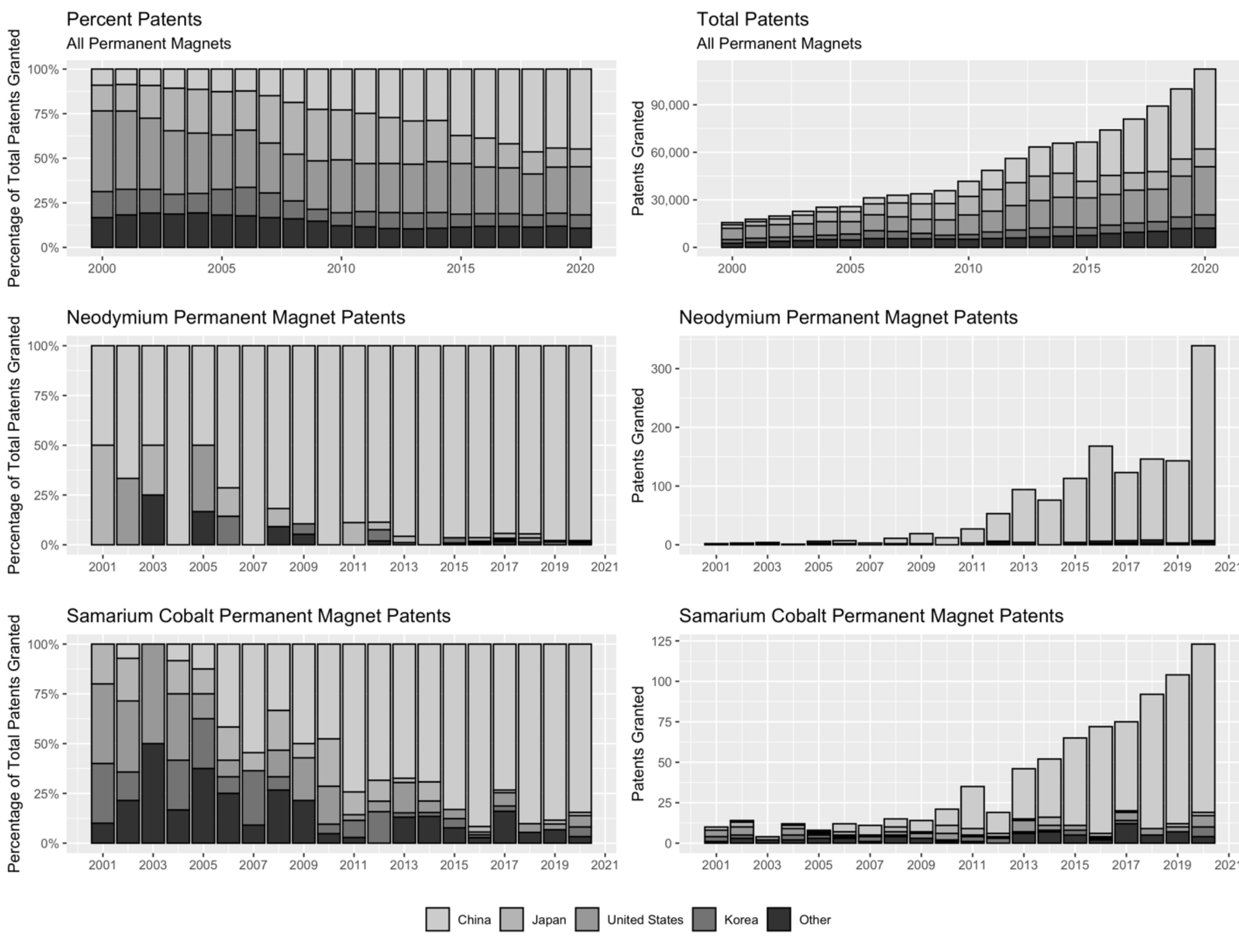
This map shows existing rare earth mines in addition to sites identified by the US Geological Survey as highly potential mining sites. Data comes from a USGS study by Labay et al. complemented by the author's own research.[xx] The primary takeaway from this figure is that rare earths are not geologically rare.

Figure 3 Current and Projected Demand for Permanent Magnets



Data were compiled from Statista by the author. Estimates come from a 2016 Quest Rare Minerals report. Similar estimates can be found in industry reports from Adamas Intelligence and the World Bank's Smart Mining report.

Figure 4 Global Patent Grants in Permanent Magnets, 2001-2020



Data for this figure comes from the Google Patent database, which includes published patents from offices in 105 countries, although the vast bulk of patents come from 15 countries.[xxi] The top five patent grant offices (the United States, Japan, China, Germany, and the European Patent Office) account for approximately 80% of total patents and the top three alone (the United States, Japan, and China) account for almost 70% of all patents granted. Over the past two decades, China's patent applications and grants have been steadily increasing across many sectors. In the cumulative data as of May 2022, China accounted for 38% of patent grants and 21% of patent applications.

[i] P. Henderson et al., "Rare Earth Elements. A Briefing Note by the Geological Society of London," in *Geological Society of London*, 2011, 1–13.
[ii] Joanne Abel Goldman, "The US Rare Earth Industry: Its Growth and Decline," *Journal of Policy History* 26, no. 2 (2014): 139–66.
[iii] Kristin Vekasi, "The Geoeconomics of Critical Rare Earth Minerals," *Georgetown Journal of International Affairs* 22, no. 2 (2021): 271–79.
[iv] Julie Michelle Klinger, *Rare Earth Frontiers: From Terrestrial Subsoils to Lunar Landscapes* (Cornell University Press, 2018).

[v] State Council, "Situation and Policies of China's Rare Earth Industry. , The People's Republic of China. 2012" (Information Office of the State Council, People's Republic of China, 2012).
[vi] Xinhua, "China Rare Earth Group Founded in Jiangxi-Xinhua," December 23, 2021, https://english.news.cn/20211223/d29675f608ef46f3a2d00106eeef2b2c/c.html.
[vii] Yeping Yin, "China's Rare Earth Price Exceeds a Historic High amid Booming Demand and Tight Supplies - Global Times," November 12, 2021, https://www.globaltimes.cn/page/202111/1238808.shtml.
[viii] Sun Yu and Tom Mitchell, "State Interference Threatens China's Control of Rare Earth Production," *Financial Times*, October 29, 2020.
[ix] 13th Five-Year Plan, "The 13th Five-Year Plan for Economic and Social Development of the People's Republic Of China (2016–2020)," Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, https://en.ndrc.gov.cn/policies/202105/P020210527785800103339.pdf.
[x] 14th Five-Year Plan, "第十四个五年规划和 2035 年远景目标纲要[China's 14th Five-Year Plan and the Long-Range Objectives Through the Year 2035 (Draft)]" (National Development and Reform Commission, March 4, 2021), https://www.ndrc.gov.cn/xxgk/zcfb/ghwb/202103/P020210323538797779059.pdf.
[xi] Tom Daly, "China Becomes World's Biggest Importer of Rare Earths: Analysts," *Reuters*, March 13, 2019, sec. Commodities, https://www.reuters.com/article/us-china-rareearths-idUSKBN1QU1RO.
[xii] Adamas Intelligence, "Rare Earth Elements: Market Issues and Outlook," Adamas Intelligence, September 28, 2020, https://www.adamasintel.com/unfathomable-rare-earth-demand-growth/; Kirsten Hund et al., "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition," *World Bank*, 2020.
[xiii] Kristin Vekasi, "Politics, Markets, and Rare Commodities: Responses to Chinese Rare Earth Policy," *Japanese Journal of Political Science* 20, no. 1 (2019): 2–20; Eugene Gholz and Llewelyn Hughes, "Market Structure and Economic Sanctions: The 2010 Rare Earth Elements Episode as a Pathway Case of Market Adjustment," *Review of International Political Economy* 28, no. 3 (2021): 611–34.
[xiv] JOGMEC, "JOGMEC Integrated Report 2020," 2020, http://www.jogmec.go.jp/content/300373866.pdf.
[xv] Mireya Solis, "The Big Squeeze: Japanese Supply Chains and Great Power Competition," *Joint U.S.-Korea Academic Studies*, 2021; JETRO, "第一回公募（設備導入補助型（一般枠・特別枠））における採択事業者について | 海外サプライチェーン多元化等支援事業のサービス," ジェトロ, July 17, 2020, https://www.jetro.go.jp/services/supplychain/kekka-1.html.
[xvi] "Fact Sheet: U.S.-Japan Competitiveness and Resilience (CoRe) Partnership," The White House, April 17, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/16/fact-sheet-u-s-japan-competitiveness-and-resilience-core-partnership/; "FACT SHEET: In Asia, President Biden and a Dozen Indo-Pacific Partners Launch the Indo-Pacific Economic Framework for Prosperity," The White House, May 23, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/23/fact-sheet-in-asia-president-biden-and-a-dozen-indo-pacific-partners-launch-the-indo-pacific-economic-framework-for-prosperity/.
[xvii] James Kennedy, "China Solidifies Dominance in Rare Earth Processing," *National Defense Magazine*, 2019.
[xviii] Department of Energy, "DOE Launches $140 Million Program to Develop America's First-of-a-Kind Critical Minerals Refinery," Energy.gov, February 14, 2022, https://www.energy.gov/articles/doe-launches-140-million-program-develop-americas-first-kind-critical-minerals-refinery.
[xix] USGS, "Mineral Commodity Summaries" (Washington, DC: United States Geological Survey, 2021).
[xx] K. Burger Labay et al., "Global Distribution of Selected Mines, Deposits, and Districts of Critical Minerals," 2017.
[xxi] Google, "Google Patents," accessed May 11, 2022, https://patents.google.com/.

OPENING STATEMENT OF HARRY MOSER, PRESIDENT, RESHORING INITIATIVE

COMMISSIONER BOROCHOFF: Thank you very, very much. And now Mr. Moser. I think your microphone might be off. We can't hear you. I'm sorry.

MR. MOSER: Is that okay? Yeah, thank you. Thank you for inviting me to testify. My purpose is to demonstrate that reshoring, especially from China, is essential to resilience, is already substantial, and can be further accelerated via industrial policy.

Reshoring has announced one million jobs in 12 years and can bring back one million more. Implementing my proposed government policies to level the playing field will bring the total to five million, a 40 percent increase in manufacturing and achieve full resilience. China has been the source of 44 percent of reshoring and is vulnerable now due to the perceived risk of decoupling.

The U.S. needs to reshore more from China while it still is our choice to reshore rather than wait till China is strong enough to decouple. We have a 1.1 trillion goods trade deficit. Appendix 8 shows that our trade deficit is more or less like a developing country rather than the arsenal of democracy.

We have trade surpluses primarily in commodity minerals and agricultural products and large trade deficits in most high tech products. The root cause of the problem is that the U.S. manufacturing cost or FOB price is not competitive. Appendix 1 shows a survey we did with Plante Moran and shows the company's source primarily, I'd say 70 percent based on price.

Appendix 2 shows that the Chinese price on average is 30 percent lower than the U.S. price. So there's a huge difference between the two. That's based on 180 cases of China versus the U.S.

U.S. is 10, 15 percent high relative to most developed countries like Germany, Switzerland, and so on. As long as that huge trade differential exists, our trade imbalance and resilience will not significantly improve. Appendix 5 shows that reshoring is succeeding.

We track reshoring plus foreign direct investment, FDI. And when we started in 2010, the sum of those two was about 6,000 manufacturing jobs per year announced to come back. And in 2021, it was 260,000 jobs just in the year.

The limiting factor to do even more is workforce availability. Through 2018, reshoring was driven by recognition of the logistical costs and inconvenience of offshoring and by rising offshore wages, especially in China. Since then, the trade war, tariffs, Russia's invasion of the Ukraine, and the increasing risk of decoupling with China have dramatically increased corporate recognition of the risks of corruption and thus their enthusiasm for reshoring.

There are two basic reshoring strategies that the country can follow. We believe both should be followed. First is to change perceptions. The companies source primarily based on looking at the price, the FOB price rather than looking at the total cost of ownership.

Appendix 10 shows that when companies switch from looking at price to looking at total cost and perhaps to recognize that there might be a 301 tariff in place that the percentage of wins by the U.S. goes from 8 percent to 32 percent to 46 percent. So just by getting the companies to do the math correctly to abandon their traditional policies of buying just on the basis of price, we can substantially reduce the trade deficit and achieve resilience. That's perception.

You might say reality is leveling the playing field. Reduce the actual factory price gap to make more products reshorable. Otherwise, we will -- if we fund the chip foundries, we'll find that if we don't have the assembly of the electronic products here in the states, we'll be dependent on China to buy our chips to produce the electronic devices to ship back to us. That's not a condition we want to be in.

It's very much consistent with what JP's comments suggested. In priority order, we support reshoring first, FDI, near-shoring, and then other friend shoring. Any of those will work.

Recommendations for government policy in priority order, first and always, skilled workforce. The biggest problem we have overall is the lack of quantity and quality of the tool makers, welders, precision machinists, et cetera, to drive the acceleration. One of the leading causes of that, I believe, Appendix 11 shows that these -- a very common figure that's on Department of Education and Labor websites, and it shows income going up with number of degrees quoted all the time, million dollar more lifetime income based on a college degree.

And yet they should have in there the income of people who've passed an apprenticeship or have four more credentials. And it turns out that those incomes were equivalent to that of a bachelor's degree. But our own Education -- Labor Department do not promote that.

We'd advocate having apprenticeship loans to get more students to go into apprenticeships, having fewer college loans, immigration of skilled workforce, reduce the value of the U.S. dollar, use MAC, the Market Access Charge, which was also recommended by Clyde Prestowitz in April. Keep immediate expensing of capital equipment to achieve competitive price and delivery.

Do not delay because of inflation. There's a lot of concern about inflation today. But about 30 percent of the goods now imported from China can individually be sourced in the U.S. without inflation if we can convince the companies to act based on total cost.

Maybe if price goes up a tenth of a percent one time, if they act based on price instead. Update the Commerce Department's ACE Toolkit. Provide some data on what the real risks are of things like decoupling.

For example, a recent Taiwanese population survey concluded that the probability of war with China is somewhere between 7 and 21 percent. If companies recognize that fact, they'd be more likely to bring their work back. Healthcare costs in the U.S. for a family average 16,000 dollars per year which is 8 dollars per hour which is higher than the Chinese average wage.

So we're spending more -- our companies are spending more on healthcare than the Chinese are spending on wages. We say control malpractice and negotiate all pharmaceutical prices. Achieve lower healthcare costs, lower inflation, and accelerated reshoring.

My written testimony covers five or six other areas. We think there's opportunities for success. And I appreciate the chance to present to you. Thank you.

PREPARED STATEMENT OF HARRY MOSER, PRESIDENT, RESHORING INITIATIVE

June 9, 2022

Harry Moser

Founder & President, Reshoring Initiative

Testimony before the U.S.-China Economic and Security Review Commission

Hearing on "U.S.-China Competition in Global Supply Chains"

Panel II: U.S. Policies to Bolster Supply Chain Resilience

Summary

- Reshoring is feasible and with FDI has already brought back about 1 million manufacturing jobs.
- The Chinese factory price is, on average, 30% lower than the U.S. price.
- There are two basic reshoring strategies. Both should be followed.
    - Change perspectives: Educate companies to source based on Total Cost, not just factory price.
    - Level the playing field: Reduce the actual factory price gap.
- The simplest measure of bolstered resilience is broad reduction of the trade deficit.
- Recommended government actions and policy changes will achieve balanced trade and increase U.S. manufacturing by 40 to 50% spread over 20 to 30 years, mainly limited by workforce availability.
- China has been the source of 44% of reshoring and is especially vulnerable now due to the perceived risk of decoupling and the rapid rise in Chinese wages.

Introduction

The purpose of this statement is to demonstrate that reshoring, especially from China, is essential, is already substantial and can be further accelerated by the recommended industrial policies.

The development of effective reshoring policy recommendations requires a clear understanding of the causes of offshoring. Companies source products and site their factories at least 70% based on FOB price/manufacturing cost ("price") comparisons of the offshore and domestic alternatives. (Appendix 1) Many of the chart's smaller categories are driven by price, e.g. the product is unavailable here because our industry was eliminated by low priced imports. U.S. price averages about 40% higher than Chinese price (Appendix 2) and about 15% higher than most other developed countries. Faced with domestic and offshore competitors accessing those lower prices, U.S. companies aggressively offshored, starting with Japan and Mexico, followed by S. Korea, India, S.E Asia and China. As long as that huge price differential remains, our trade imbalance and weak supply chain will not improve. To subsidize enough domestic production to overcome our $1.1 trillion 2021 goods trade deficit would cost about $330 billion/year. Probably more, since other countries would respond with more aggressive pricing.

There are two basic ways to attack the underlying lack of price competitiveness. The simplest should be to change perceptions, to educate companies to use Total Cost of Ownership (TCO) to quantify all of the costs and risks associated with offshoring. By switching to TCO, companies will see that about 20% of what they now import from China can be sourced domestically without raising prices or cutting profits. Appendix 10 shows the China price, TCO and TCO including a 15% Section 301 tariff for 180 cases comparing China sources to U.S. sources. The U.S. win rate goes from 8% to 32% to 46% just by doing the math correctly. A 20% reduction in imports would cut the goods trade deficit by 50%[i]. A more basic, certain approach would be to reduce the price differential, to level the playing field by instituting an industrial policy, including: massive transfer of resources from liberal arts university education to engineering, apprenticeships and credentials; 20 to 30% lower USD; not raising the corporate income tax; and implementing a well-designed border adjustment tax (BAT). Appendices 3 & 4 show how employment would respond to a mix of these actions. This policy would make the U.S. more like Germany that has equally high wage rates but achieved a 2020 trade balance of about +5.7% of GDP vs. U.S. -3.1%[ii]. Balancing trade would increase U.S. manufacturing by 40 to 50%, requiring 5 to 6 million more manufacturing employees at current levels of U.S. productivity.

Subsidies of a few essential industries such as chips and rare earth minerals are necessary because the U.S. has fallen so far behind. We applaud the administration for these actions. In the longer-term, subsidized industries will fail if they and their domestic customer industries are not price competitive.

It is essential to level the playing field vs. all or most countries, not just vs. China. Otherwise, work will flow from China to SE Asian factories, often owned by the same Chinese companies. China will be hurt moderately. The U.S. will be less dependent on China, but still vulnerable to disruption and militarization of the western Pacific and U.S. manufacturing will not be strengthened. Balancing our trade deficit with most countries will increase our manufacturing output and investment faster, providing the needed critical mass and productivity increases. Increasing our manufacturing broadly and quickly will eliminate supply chain gaps, reducing our dependence on China. Much stronger U.S. manufacturing is essential to achieve defense industry capabilities, reduced budget deficits enabling higher defense expenditures, improved income equality, and climate goals. The only way to increase manufacturing's share of the GDP is to import less (reshore) or export more. It is far easier to import less because importing/exporting adds 20 to 25% to the Total Cost of a product.

Trend, Drivers and Impact

Reshoring by U.S. headquartered companies plus foreign direct investment (FDI) by foreign headquartered companies has surged from about 6,000 jobs per year in 2010 to about 260,000/year in 2021. We forecast 400,000/year in 2022. (Appendix 5). No one tracks offshoring. We believe that new offshoring (closing U.S. factories and replacing with either factories or outsourcing offshore) has fallen dramatically since around 2010. The best evidence is the trend in manufacturing employment, consistent with an increased rate of reshoring and reduced rate of new offshoring. (Appendix 6). Dec. 31, 2021 employment was about six million higher than would have been projected before the Great Recession. Because of this positive trend, the goods trade deficit stayed flat at about 4% of GDP from 2010 to 2019 prior to an import surge driven by COVID. (Appendix 7).

The primary driver of offshoring is lower prices available offshore, especially in LLC countries but also in most developed countries. The lower LLC prices are primarily driven by lower wages. The difference in FOB prices is consistent with the wage differential and labor's share of manufacturing cost. Initially, very low wages attracted work to China. Today, China's faster response times and increasing technology and productivity also play a role. U.S. factories in China also sold to a rapidly growing middle class. A strong reshoring effort, coupled with China's slowing economic growth and shrinking population will help convince companies to shift more of their investment to the U.S.

U.S. government policies, or the lack of appropriate policies, have been the major cause of the trade deficit. These policies include: prioritizing degrees over skills training, allowing the USD to stay at uncompetitive levels, high corporate tax rates and regulations, high medical insurance expense paid by the employer, low duty rates, etc. A large goods trade deficit is not pre-ordained for the U.S. In contrast to the U.S., many of the top developed countries have trade surpluses: Germany, Ireland, Netherlands, Italy, S. Korea, Australia, Singapore, Switzerland, Belgium, etc.

Our resulting uncompetitive price structure drove offshoring, hollowing out U.S. manufacturing, reducing investment in automation and reducing the appeal of manufacturing careers. Until about 1980 the U.S. had at least balanced trade and was self-sufficient in a broad range of products and industries. Now, our trade profile looks more like that of a developing country than the Arsenal of Democracy. (Appendix 8). The U.S. has trade surpluses in a few high-tech categories such as aircraft and semiconductor manufacturing machinery, but mainly in commodities like minerals and agricultural products. The U.S. has large trade deficits in most manufactured products including most high-tech products. The U.S. lacks the industrial infrastructure to respond timely to a catastrophe such as COVID or to provide the increased materiel for an extended war. Defense Department reports show a growing list of needed raw materials and components that cannot be sourced domestically.

The current supply chain structure puts U.S. consumers at risk for availability of most goods other than food and at risk for their jobs. A disruption such as China decoupling would be economically devastating for the months or years it took companies to create or find alternate sources.

Reshoring, Nearshoring, Friend Shoring and FDI

The U.S. supply chain can be strengthened by any of four processes. In priority order: reshoring, FDI, nearshoring and friend shoring.

- Reshoring: Always the best choice, if economically feasible. Optimal impact on manufacturing, economy and domestic supply chain. Example: Two huge nitrile glove factories (PPE) funded by the U.S.: United Safety Technology, Inc. and Renco Corporation. Reshoring also increases U.S. purchases of raw materials and components from our trading partners, providing diplomatic advantage.
- FDI: Achieves the same benefit in terms of manufacturing and self-sufficiency, but more of the profits are lost to offshore and engineering is less likely to be here. About 50% of the 1.3 million jobs brought from offshore since 2010 have been due to FDI. FDI is often the best source of product and process technology when filling supply chain gaps. For example, the large FDI automotive assembly plants (BMW, Toyota, Mercedes, etc.) brought with them many of their suppliers from their native countries. Many EV battery plants have been either pure FDI or joint ventures with auto companies here. Example: GM and LG.
- Nearshoring: Essentially means Canada and Mexico, which are friends, so nearshoring is a sub-set of friend shoring. The biggest driver of jobs to the U.S. is proximity to the market, so nearshoring is more feasible than other friend shoring. Exports to the U.S. from Mexico are reported to contain 40% U.S. content vs. 5% for exports from China. Mexican wages are lower than Chinese wages. U.S. jobs are offshored to Mexico for the saving in wages and due to the availability of labor. Nearshoring from Asia to Mexico increases U.S. exports and makes supply accessible. Longer term, the nearshoring raises Mexican wages, reduces new offshoring to Mexico, and stabilizes our neighbor’s economy. Canada is an excellent source, but offers

little economic advantage vs. reshoring except for certain minerals and electricity intense manufacturing. Mexico is an excellent source for apparel and other assembly operations, including aerospace and automotive.

- Other friend shoring: Far better than sourcing from China but less preferable than any of the first three processes. Much offshoring has resulted from the U.S. providing privileged access to its market, sacrificing U.S. manufacturing to achieve its diplomatic and humanitarian goals: spreading democracy, pulling countries out of poverty, geo-politics, etc. via Most Favored Nation status and other favors. For example, China's Most Favored Nation status contributed to our loss of millions of jobs. So, friend shoring should be with friends without added benefits.

Reshoring is optimal if:

- The work can be done here profitably, based on TCO.
- Workforce can be made available.
- The needed technology and components can be available.

From a company's perspective, the industries/products best suited for substantial reshoring are those for whom the Total Cost of Ownership (TCO) for the products is lower here or can be made lower via workforce training, automation and product redesign for manufacturability. The characteristics of such products include:

- Low labor content, e.g. plastic injection molding, populating printed circuit boards and high volume machining of standard workpieces such as bar stock.
- High offshore freight cost and time vs. labor content, e.g. machinery (CAT has reshored production to new plants in Texas and Georgia) and commodity materials.
- A supply chain gap large enough that a new U.S. factory could be large and automated enough to compete with the imports.
- Section 301 25% tariffs apply. 50% of such products can be sourced domestically w/o raising prices or reducing profits if companies use TCO.
- Frequent product design changes.

- Volatile demand, e.g. some apparel.
- Risk of IP loss.

A good estimate of what products can be reshored is what have been reshored. Appendix 9 shows the mix of jobs reshored and FDI'd by NAICS code industry.

From the nation's perspective the characteristics of such products include:

- Competitive TCO and thus profitability, as above. Otherwise, the subsidies will be unsustainable.
- Filling a supply chain gap eliminates a bottleneck, enabling a flood of additional reshoring in the downstream and upstream supply chain, especially for growing markets, e.g. batteries for EVs. Steve Jobs was asked why Apple does not assemble products in the U.S. He answered that almost all of the components are produced in Asia.
- The product is essential for health and defense and not dependably available from a close-by friend shore, e.g. rare-earth minerals, PPE, pharmaceuticals.
- The product is sourced primarily from China.

Ideally, the industries and companies should not need to be approached to reshore. A well-designed, permanent industrial policy would level the playing field enough that the companies would decide to reshore in their own self-interest. In the short-term it is necessary to select and subsidize specific critical industries such as chips. In the longer-run the subsidized industries will fail if their manufacturing costs are not competitive and they do not find a growing domestic market. In a few years there will be an oversupply of chips since so many foundries have been announced worldwide. The U.S. is at risk of going from being dependent on China and Taiwan for chips to being dependent on China to buy our overpriced chips to assemble into infotainment systems, medical devices and servers to ship to us. The solution is to level the broad industrial playing field, to have a tide that lifts all, or most, U.S. industries.

China has played a huge role in offshoring, 33% of our goods trade deficit, and in jobs brought back, about 44% of reshoring and 15% of FDI during 2010 to 2021[iii]. Since China is an adversary, it is especially unwise to be dependent on them and to fund their growth and military via our consumer and industrial spending. China got a big head-start by devaluing its currency, especially in 2003 to 2013. China has subsidized industries and stolen IP. Balance with China must be restored. China is concerned by U.S. supply chain actions. I was interviewed May 27 by a Beijing reporter for Caijing, a leading Chinese business and economics magazine. The reporter asked me to show how the U.S. could reshore, especially chips, despite our "70% higher cost" and skilled labor and engineering shortages. A recent article by noted geo-political expert, George Friedman, observed that China has not yet reached the critical mass needed to grow based on domestic consumption instead of exports[iv]. The U.S. needs to reshore more from China while it is still our choice to reshore rather than wait till China chooses to decouple.

However, the other 67% of our trade deficit has similar negative impact on our economy. The U.S. has a trade deficit with 9 of our top 10 trading partners, all except the United Kingdom[v]. Balancing our Chinese trade deficit would leave a $700+ billion deficit. Getting out of China is essential, but is just the first priority in eliminating our deficit.

Congress and the administration are currently placing a high priority on reducing the rate of inflation. Delaying reshoring is not a logical conclusion. About 30% of goods now imported from China (0.3 X $506B = $152B in 2021[vi]) can individually be sourced in the U.S. without raising prices or cutting profits (Appendix 10) if companies acted and priced based on TCO. If companies continue to source and price based on FOB prices, CPI would increase about 0.1% one time. If all or most of the 30% is reshored immediately prices will temporarily rise because the country lacks the capacity to increase manufacturing by about 8%. Factories can be added in a few years. Recruiting and training the engineering and technical workforce is the larger, longer-term, problem.

Enabling Companies to Reshore

There are a range of actions companies should take and information they need to be able to accelerate reshoring:

- Develop the skilled workforce: Much more aggressively recruit and train the skilled workforce which is needed to increase output, productivity and competitiveness.
- Adopt TCO: About 60% of companies make sourcing decisions based on wage rates, FOB (factory) price or Landed Cost (price plus duty and freight). By doing so, instead of sourcing based on Total Cost of Ownership (TCO: Landed Cost plus carrying cost of inventory; risk of IP loss, disruption and stocking out; travel cost; etc.) companies ignore about 20% of relevant costs and risks. By switching to TCO, companies will see that about 20% of what they now import from China can be sourced domestically without raising prices or cutting profits. Companies also use TCO to convince customer companies to stop importing and buy from them. (Example: Morey Corp used TCO to win a $60M order for PCBs vs. China)
- Obtain Information: TCO calculation requires two types of information that are not readily available. Making the data available would accelerate the use of TCO and reshoring:
    - Company data that is not sorted by product or supplier. For example: quality and warranty costs, travel, inventory carrying cost, engineering support. ERP system providers such as Oracle or SAP could incorporate TCO and collection of needed data in their systems. One company excuse would be eliminated.
    - Risks, especially geo-political risks. It is almost impossible for the procurement staff to estimate risks, e.g. the probability of decoupling by China, one of the largest factors driving reshoring today. If professional estimates of the probabilities of the most impactful risks could be publicly, readily available, ideally from non-governmental sources, companies would be able to justify including the risks as factors in their decisions. The Reshoring Initiative is including expected value calculations of the impacts of these risks in the revised, free, online TCO Estimator but does not have a source for such probabilities. (Example: Geopolitical Futures recently published the results of a Taiwanese population survey of the probability of war with China. Seven percent strongly agreeing there will be war and

21% partially agreeing[vii].) For many companies, China decoupling would be either devastating or existential. If companies accept that decoupling is possible, they will be much more likely to reshore, nearshore or friend shore.

- Invest in automation: Take a longer-term focus, investing more in automation. S. Korea and China invest more in robots than does the U.S. despite their lower wage rates. China invests 3X as much in CNC machine tools as does the U.S. To be competitive despite high wages, the U.S. needs to be more productive than our LLC country competitors. Chinese productivity has been rising at 6 to 8%/year. U.S. productivity at less than 1%/year. As the reshoring surge continues, capacity utilization will rise above 80% and investment should accelerate. Companies will have the demand to justify investment and the cash to afford it.
- Fill supply chain gaps: Understand the existing large supply chain gaps so they can evaluate the feasibility of filling those gaps.
- Reduce cost and time to quote and deliver: Adopt lean, Critical Manufacturing Path Time (MCT) and Quick Response Manufacturing (QRM) methods that have the potential to reduce manufacturing costs by 10% and delivery times by 50%. Some companies claim that they can get product from China by ocean freight faster than from local U.S. suppliers. There are cases of Chinese companies providing prototypes before the U.S. competitor provided a quote.
- Achieve efficient assembly: Find domestic suppliers that can efficiently produce assemblies. Many companies shut their U.S. assembly plants when they offshored, often to contract manufacturers. It is easy to find U.S. machine shops and foundries that make components. It is much more difficult to find automated assembly shops. (Example: RE:Build Manufacturing's strategy is to offer complete solutions for reshoring[viii].)

Recommendations for Government Action

The biggest obstacles to reshoring are the same forces that drove offshoring: Un-competitive manufacturing cost (Appendix 2), shortage of skilled workforce and failure of companies to source based on TCO. As explained, the objective should be to reshore a broad range of industries by reducing these obstacles. This is a "teach them to fish" opportunity. With incentives, companies will need incentives forever. With a level playing field, companies will reshore in their own self-interest. We recommend the following actions, highest priorities first:

- U. S. government: The U.S. is still the largest market in the world. If the government were as clearly committed long-term to solving our supply chain imbalance as the Fed was to achieving stability during COVID, companies would rush to reshore. The federal government needs an industrial policy instead of what has been, in effect, a deindustrialization policy. Specific policy changes needed:
    - Skilled workforce. National Association of Manufacturers (NAM) forecasts a shortage of 2.1 million manufacturing employees by 2030[ix]. Accelerated reshoring could double that number. Aggressive action is needed now to increase the quantity and productivity of our workforce:
        - The largest barrier to having a strong workforce is recruitment of quantities of competent trainees. Massively shift resources from liberal arts post-secondary degrees to engineering degrees and apprentice programs. Create apprentice loans so the apprentice can borrow $5 or $10/hour worked, allowing the apprentice wage paid by the company to be low enough so that the company does not lose money on training the apprentice. Smaller companies believe they lose money and then lose the graduate apprentice to big OEMs that can afford to pay more. Have the employer pay off the loan over 5 years after the apprenticeship if the worker stays. For roughly what the U.S. should write off on college loans each year the country could enable a world class manufacturing apprenticeship program.
        - Accurately display the career advantages of apprenticeship vs. degrees. There are many postings on the Departments of Education and Labor websites extolling the unique value of

degrees. Example[x]. The postings show income rising with number of degrees and often have headings such as "Bachelor's degree yields $1 million more lifetime income than a high school degree." The figures never show that apprentice graduates have incomes comparable to bachelor's degree holders. You have to dig into footnotes to find that about half of the "$1 million" goes away if you adjust for family socio-economic status, being able to start earning 4 or 5 years sooner and avoiding tuition costs. This government data is the basis for guidance counselors, articles, advertisements, politicians and studies encouraging more students to attend universities. In reality, about 30% of university graduates (primarily with liberal arts degrees) are in jobs that do not need a degree, while severe shortages of skilled tool makers, welders, precision machinists, etc. limit our ability to achieve self-sufficiency by reshoring or FDI.

    - Increase immigration of engineers and skilled technicians.

- Reduce the value of the USD. It is generally agreed that the USD is consistently 20 to 30% overvalued since it is the primary reserve currency[xi]. Eliminating that overvaluation would dramatically reduce the price competitiveness gap, driving reshoring, FDI and exports. The Market Access Charge (MAC), developed by Dr. John Hansen and the basis for Senators Tammy Baldwin and Josh Hawley's *The Competitive Dollar for Jobs and Prosperity Act* introduced in 2019, is one means to this end.

- Do not raise the corporate income tax rate, at least on manufacturers.

- Keep immediate expensing of capital investments, at least for manufacturers. Automation is key to achieving competitive price and delivery. The country will lose more jobs to Chinese automation if it does not invest than it will to U.S. automation if it does.

- Make the Section 301 tariffs permanent. The 25% tariff makes about 15% of imports from China more profitably sourced here based on Landed Cost and over 50% based on TCO. Reshoring will accelerate if the tariffs are made permanent. Cancelling the tariffs would not make a measurable difference on inflation. Inflation lagged over a year behind the tariffs. The total revenue from the tariffs is less than 0.3% of U.S. personal consumer expenditures[xii].
- Alternatively, implement a border adjustment tax (BAT) on all imports. Regressive impacts can be minimized by funding the repeal of state and local sales taxes and using any balance to fund Social Security and Medicare.
- Take a clear role in enabling reshoring:
    - Appoint an office to be responsible for reshoring. Around 1019 Commerce's SelectUSA started to assume that role but seems to now be focusing only on FDI.
    - Commerce developed the ACE (Assess Costs Everywhere) Toolkit around 2012[xiii]. The site contains useful tools and data to motivate reshoring. Needs updating, expanding and promoting. The site says "Last updated: 03/20/2018." Much of the relevant data is from 2012. Provide access to non-government estimates of relevant risks, such as of decoupling by China, as discussed earlier.
    - Promote cases of reshoring. Free national publicity would motivate more companies to act.
- Cooperate with Mexico and Canada to attract work from Asia to N. America. Mexico had a $92 billion trade deficit with China in 2021 despite having lower wages. Help Mexico reduce its deficit with China rather than increase its $165 billion trade surplus with the U.S.[xiv] Doing so will also make Mexico a more resilient part of our supply chain.

- Fill supply chain gaps: Identify large gaps. Invite domestic companies and current foreign suppliers to fill the gaps. Great role for SelectUSA. The Reshoring Initiative can help.
- Mandate the use of TCO within the government and by all government contractors.
- Get the consumer involved. Require country of origin labeling (COOL) on all products in stores or offered on the internet. Consumers strongly prefer U.S. products. Make it easy to turn preference into action.
- The Labor and Commerce Departments' Trade Adjustment Assistance (TAA) programs help workers and companies who have been hurt by imports. Broaden TAA's mandate to help the companies proactively use TCO for sourcing and selling before the jobs are lost.
- EB-5: Make reshoring a preference under the EB-5 Immigration Investor Program. Since 2008, the EB-5 Program has generated about $30 billion in capital investment. However, only 1.6 percent of the investment money goes into manufacturing. The biggest share goes into housing, restaurants, hotels, and other non-tradable services that are already generally in good supply. The program would do much more for the U.S. economy if the qualifying investments were limited, or at least prioritized, to manufacturing, especially to filling supply chain gaps.
- ESG: Take advantage of the strong trend towards ESG (Environmental, Social and Governance.) The SEC is working on regulations for funds claiming to be ESG or climate change focused. The SEC should require that such funds require companies to disclose where products sold in the U.S. are manufactured. Our study shows that supplying aluminum die castings from China to the U.S. generated at least 25% more emissions that sourcing in the U.S. Recognition of the environmental impact of offshoring would open companies to reshoring.

- Medical costs: In the U.S. medical costs are extremely high, largely paid by the employer, and raise the company burden rate/overhead, contributing to our lack of price competitiveness. The average employer cost for family insurance in 2021 was over $16,000/year, about $8/hour, which is higher than average Chinese wage rate[xv]. Start reducing medical costs by controlling malpractice litigation and by negotiating pharmaceutical prices. Achieve lower healthcare costs and reshoring. That's a twofer!
- Encourage aggregation of demand to drive the domestic supply chain. Example: Companies want to source castings here instead of from China. Having local castings will enable local product assembly. U.S. casting prices are high and capacity not available. Foundries will not expand for one middle-size customer. We are seeking to aggregate demand commitments for similar castings to motivate a foundry to invest in a modern, automated facility. Manufacturing Extension Partnerships (MEPs) could assist in the effort. Similar actions could work in other product categories.

- State and local governments:
  - Drive skills training programs.
  - Support reshoring: Utah just announced the $10 million [Manufacturing Modernization Grant]program to enable reshoring and other manufacturing investments.
- Trade associations:
  - Document reshoring successes and promote reshoring.
    - American Foundry Society (AFS) on May 27, 2022 posted a training session to help its members convince customers to reshore[xvi].
    - Association for Manufacturing Technology (AMT) has funded a large program *Supply Chain Reinforcement* including *Rebuilding and Reshoring the Supply Chain* to motivate its members and customers to reshore. AMT is also a lead

sponsor of the annual National Metalworking Reshoring Award[xvii].

Conclusion

Companies have already reshored or FDI'd about one million jobs, demonstrating feasibility. Nevertheless, the U.S. supply chain is unsustainable. This statement recommends actions by government and companies to accelerate the trend and make the U.S., once again, self-sufficient. Substantial policy and behavioral changes are required.

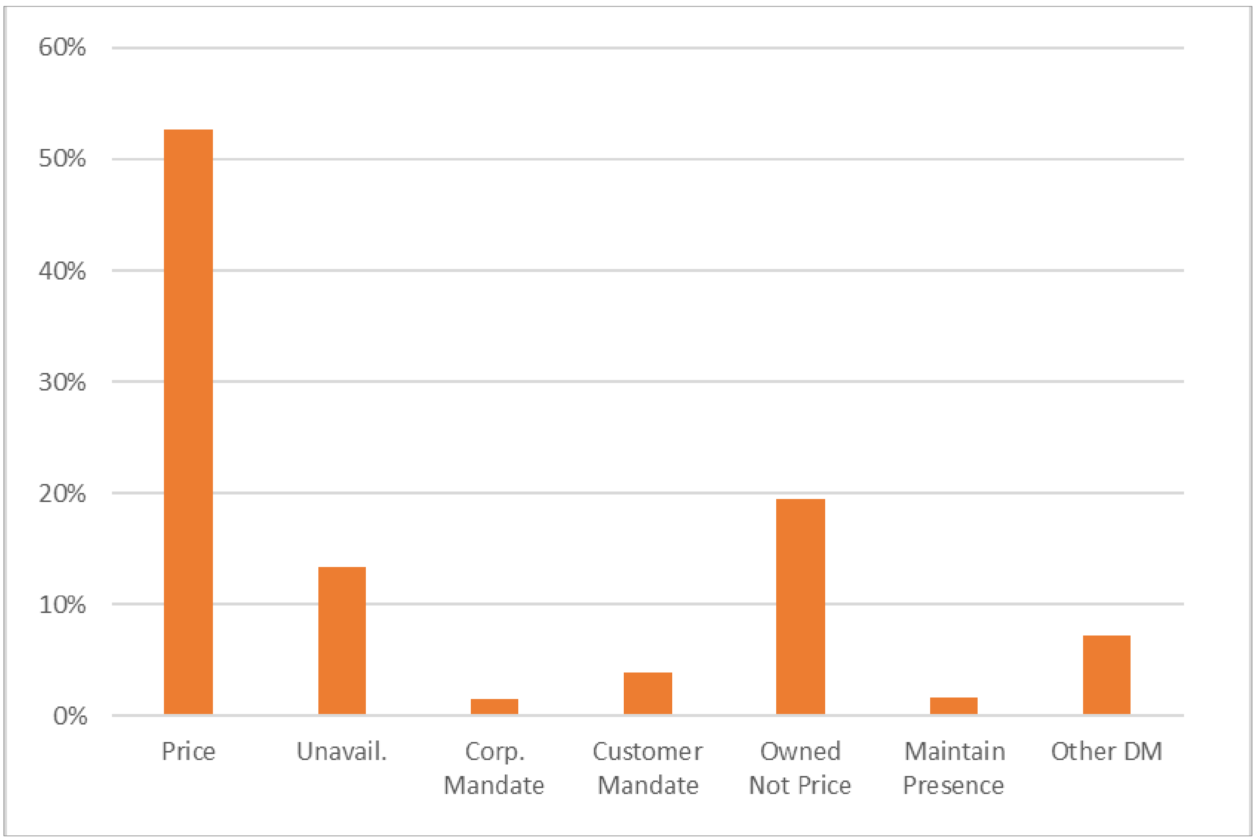
Reshoring Initiative

The non-profit Reshoring Initiative drives U.S. reshoring and FDI by documenting and promoting the trend. We also provide tools to help companies find and convert reshoring opportunities into domestic manufacture. We work with EDOs, MEPs, SelectUSA, trade associations and companies. Sue Helper, then Commerce Chief Economist, now at NEC, described us as the seminal force in reshoring.

Appendices to Harry Moser's Testimony at the 6/9/22 Hearing on

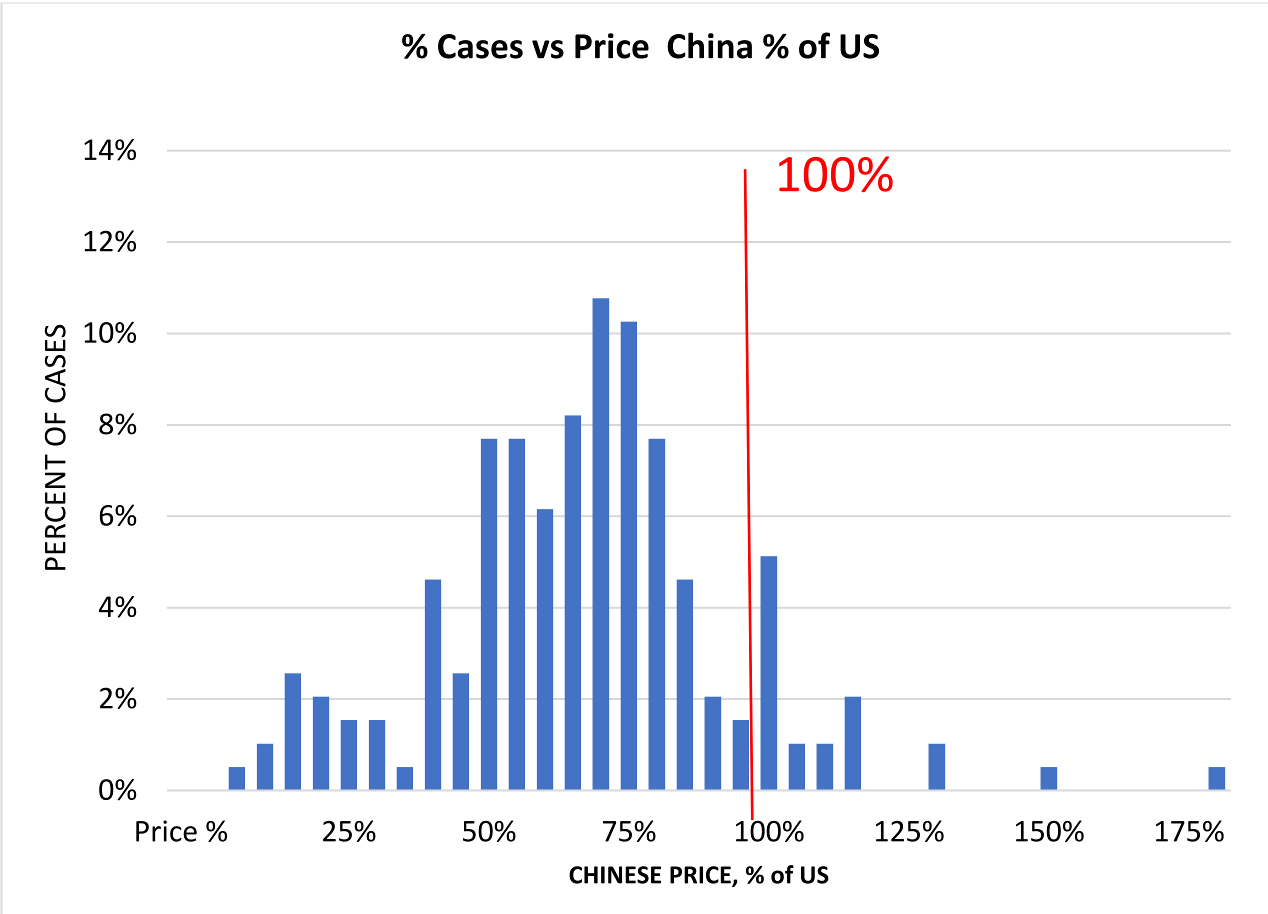
"U.S.-China Competition in Global Supply Chains"

APPENDIX 1: Price Drives Offshoring



Source: Plante Moran/ Reshoring Initiative survey of manufacturers and distributors, 1Q2018

APPENDIX 2: China FOB Price % of US



Source: Reshoring Initiative

APPENDIX 3: For the Government: Competitiveness Toolkit

Policy	Model	Δ Price Advantage	Time to Implement, Years
Skilled Workforce	Germany and Switzerland	5%	10 - 20
15% Corp. Tax rate	Ireland	2%	1
15% BAT	≈ the World	15%	1
$ Down 20%	≈ the World	10%	3
Less Regulations	?	3%	5
Healthcare Costs Down 30%	Germany	3%	15
100% use TCO		10%	4
Make duty rates =		3%	3
Innovate / Automate			
Total		51%	

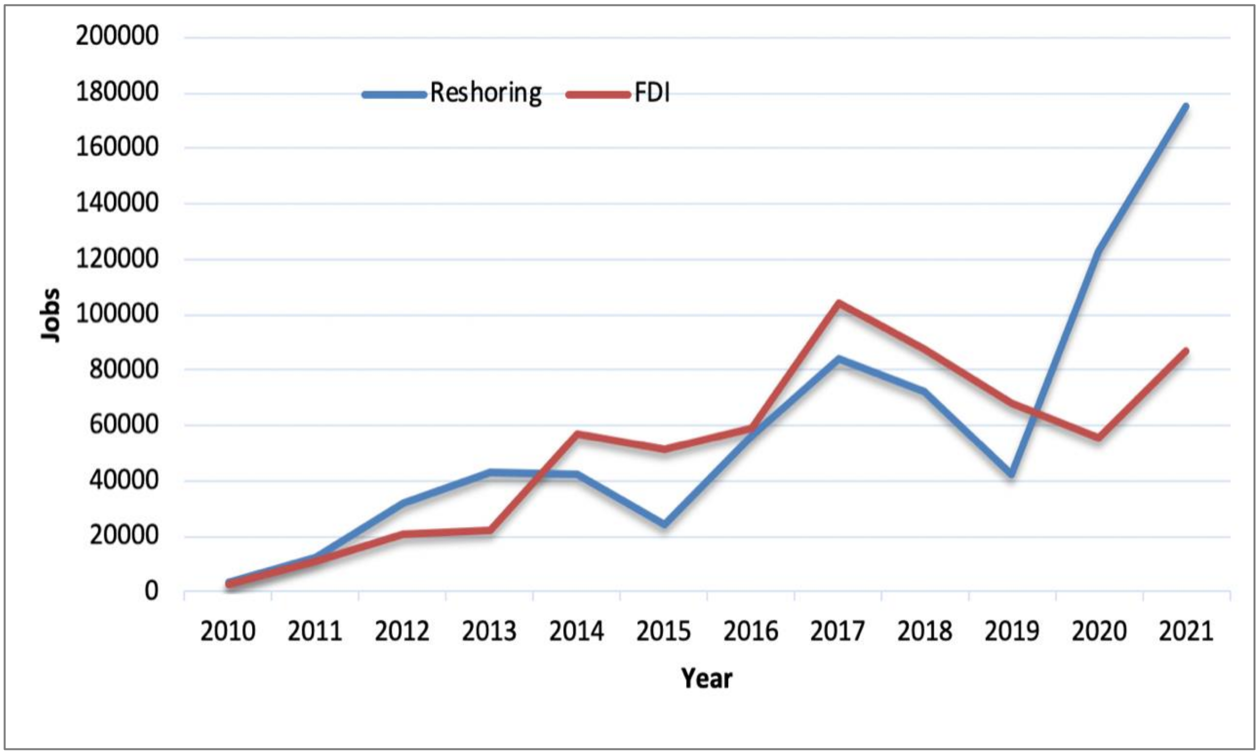
Source: Reshoring Initiative

APPENDIX 4: 1% Price Reduction → > 150,000 Mfg Jobs.

Desired Goods Trade Deficit, % Reduction	Number of Mfg. Jobs Brought Back	Required Δ U.S. Price if Price Used	Required Δ U.S. Price if TCO Used	Time to Steady State, Years
20%	1 million	-10%	0%	10
40%	2 million	-15%	0%	15
60%	3 million	-20%	-5%	20
80%	4 million	-25%	-10%	25
100%	5 million	-30%	-15%	30

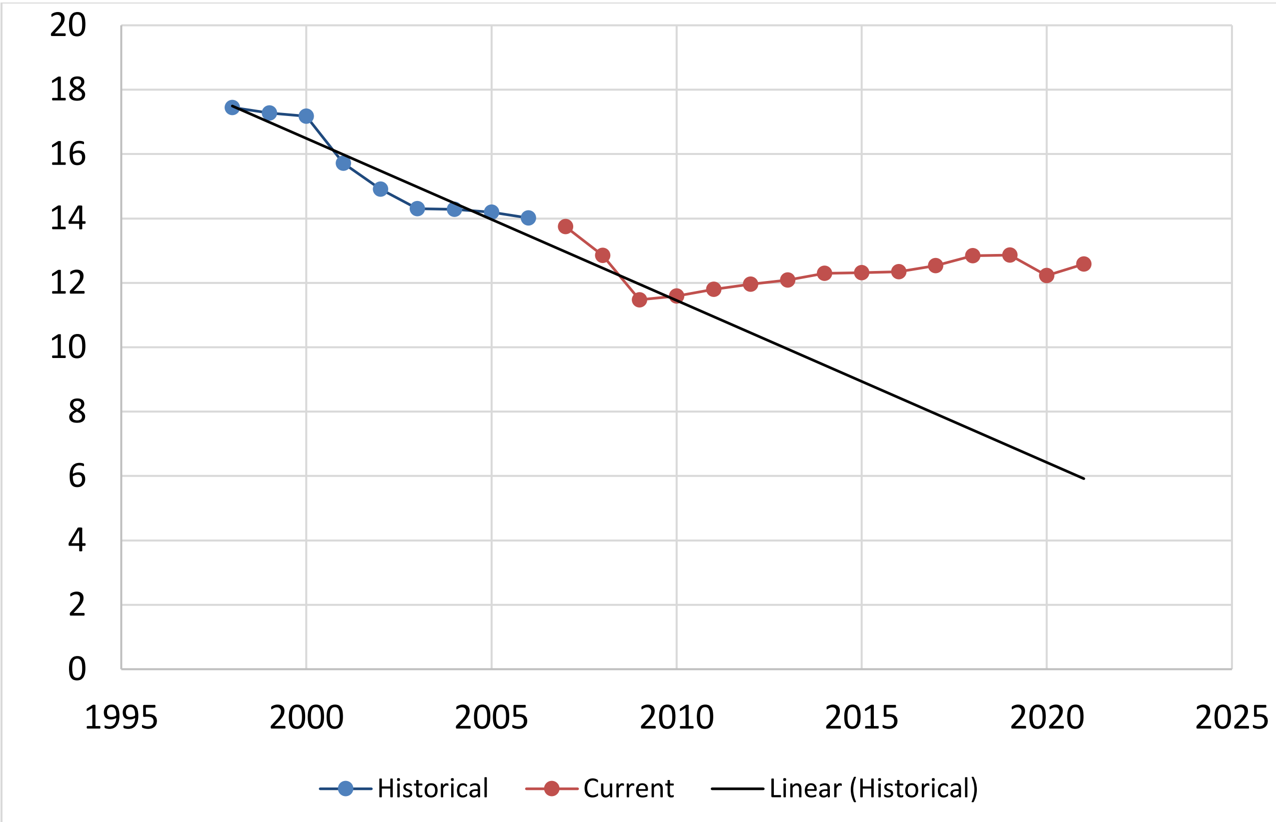
Source: Reshoring Initiative

APPENDIX 5: Reshoring and FDI: Manufacturing Jobs/Year



Source: Reshoring Library Database

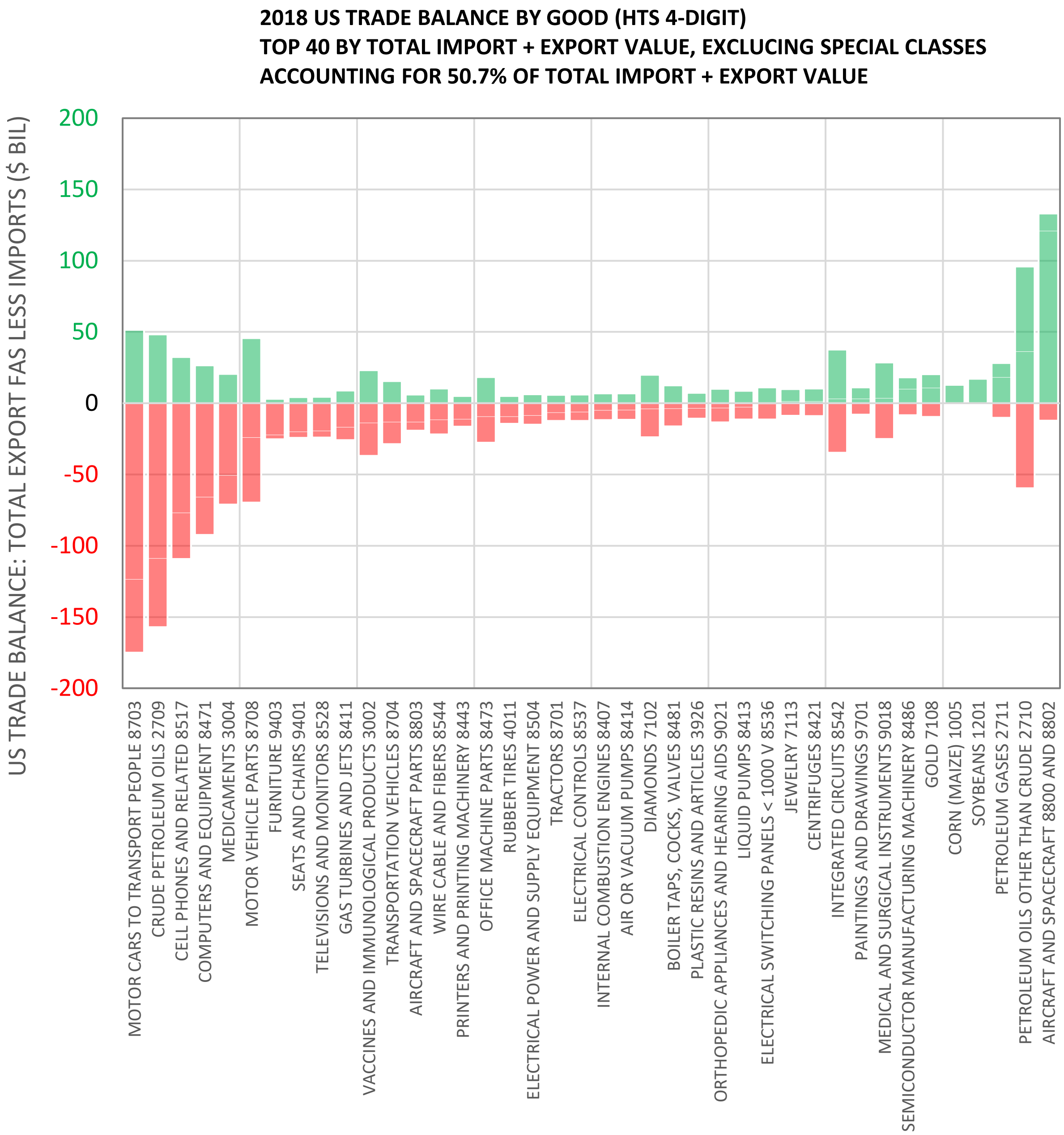
APPENDIX 6: BLS Manufacturing Employment, Millions



APPENDIX 7: Good Trade Balance as a % of U.S. GDP (1970-2019)

Source: BEA trade data, FRED GDP data

APPENDIX 8: U.S. Trade Balance by HS Good

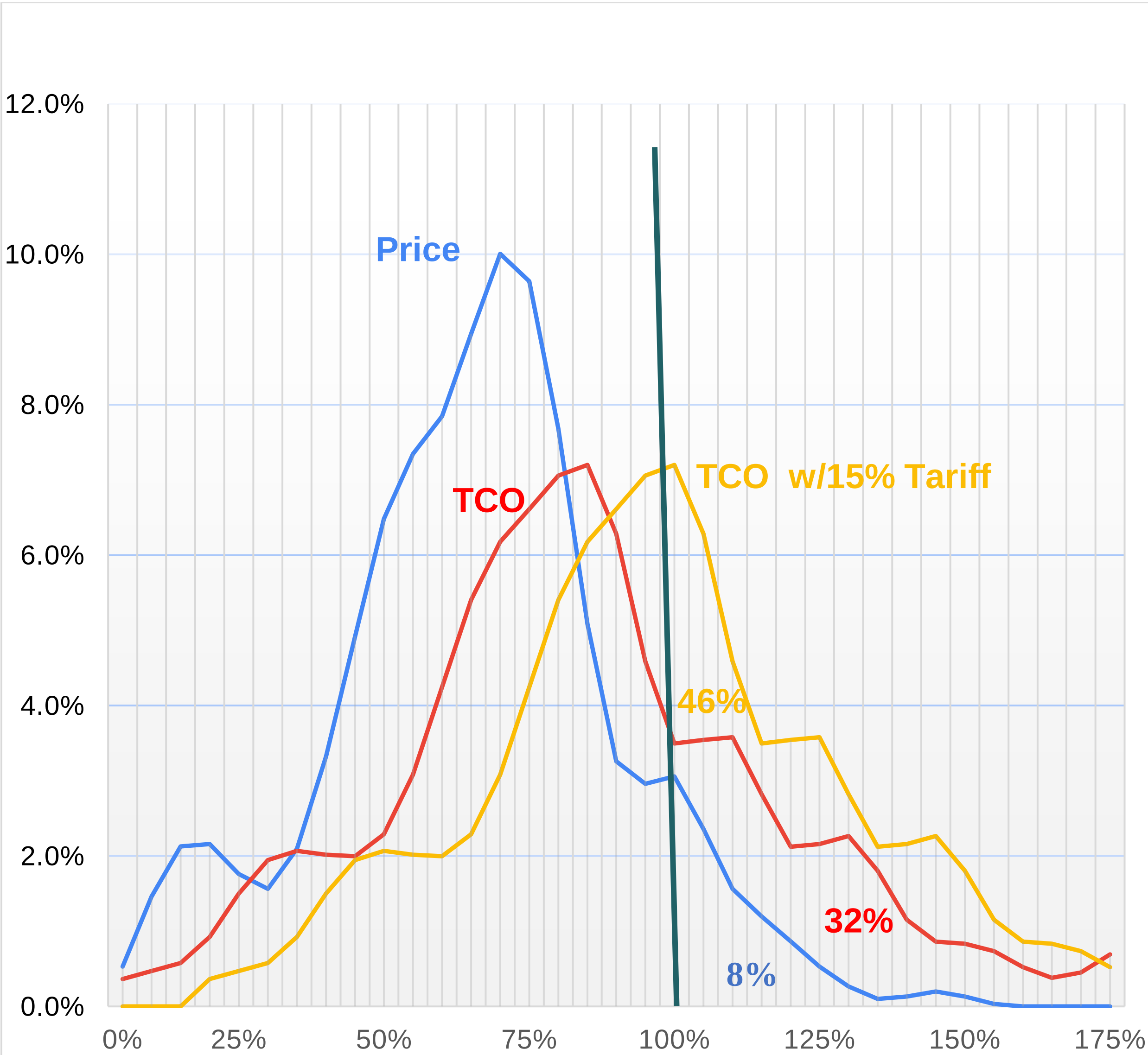


Source: US International Trade Commission via Jack Kirr

APPENDIX 9: Reshoring & FDI by Industry 2010 to 2021

Rank	Industry	Jobs	Companies	% of Total Jobs
1	Transportation Equipment	368522	1285	27%
2	Computer & Electronic Products	184496	800	14%
3	Machinery	152659	893	11%
4	Medical Equipment & Supplies	139451	1191	10%
5	Furniture and Related Products	85416	685	6%
6	Primary Metal Products	78294	495	6%
7	Electrical Equipment, Appliances & Components	60434	611	4%
8	Apparel & Textiles	50797	826	4%
9	Chemicals	48326	587	4%
10	Plastic & Rubber Products	47766	184	4%

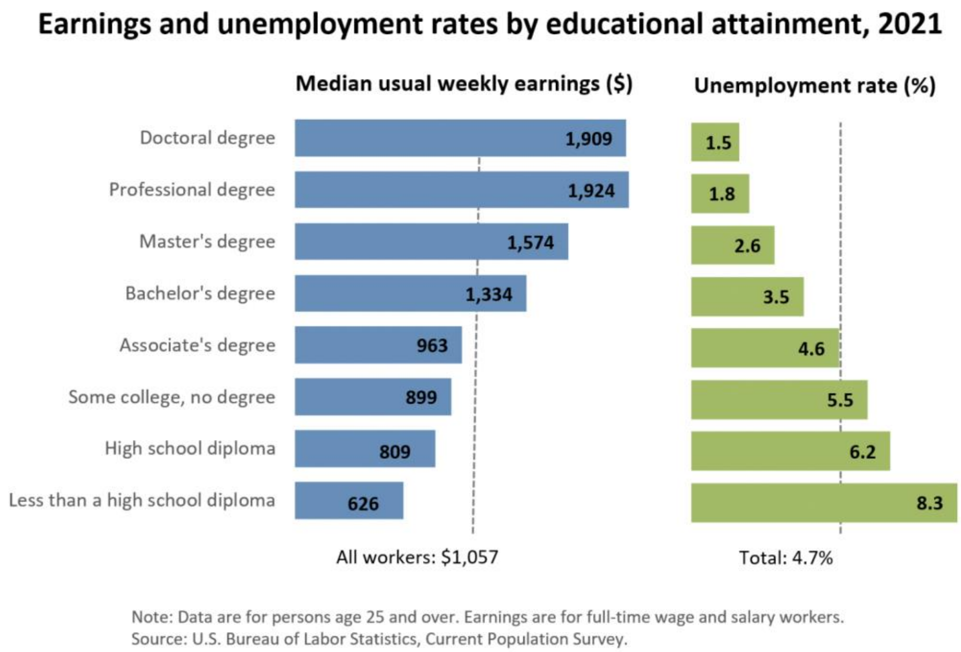
APPENDIX 10: Chinese Price and TCO, % of U.S.



Source: Reshoring Initiative TCO user database

APPENDIX 11: DOL Chart

Education pays



References

[i] Monthly U.S. International Trade In Goods And Services, March 2022, Census/BEA, https://www.census.gov/foreign-trade/Press-Release/current_press_release/ft900.pdf, 5/30/22
[ii] Foreign Trade, Census, https://www.theglobaleconomy.com/rankings/trade_balance/, 5/30/22
[iii] Reshoring Initiative 2020 Data Report, Reshoring Initiative, https://reshorenow.org/blog/reshoring-initiative-2020-data-report/
[iv] A New, Old Global Reality, Friedman, George, Geopolitical Futures, https://ggc-mauldin-images.s3.amazonaws.com/uploads/pdf/20220527_OMS_Taiwan-Friedman.pdf, 5/30/22
[v] Top Trading Partners - March 2022, Census, https://www.census.gov/foreign-trade/statistics/highlights/toppartners.html, 5/30/22
[vi] Trade in Goods with China, Census, https://www.census.gov/foreign-trade/balance/c5700.html#2021, 5/29/30
[vii] The Long Fight to Control Taiwan, Geopolitical Futures, https://geopoliticalfutures.com/the-long-fight-to-control-taiwan/?tpa=NmE3MWM3ODA4ZmRiMmU1MjU1YTFiMDE2NTQ3ODg5MjU5OTFkNDc&utm_source=newsletter&utm_medium=email&utm_term=https://geopoliticalfutures.com/the-long-fight-to-control-taiwan/?tpa=NmE3MWM3ODA4ZmRiMmU1MjU1YTFiMDE2NTQ3ODg5MjU5OTFkNDc&utm_content&utm_campaign=PAID%20-%20Daily%20Digest, 5/29/30
[viii] https://www.rebuildmanufacturing.com/
[ix] 2.1 Million Manufacturing Jobs Could Go Unfilled by 2030, NAM, https://www.nam.org/2-1-million-manufacturing-jobs-could-go-unfilled-by-2030-13743/?stream=workforce, 5/28/22
[x] Education Pays, BLS, https://www.bls.gov/emp/chart-unemployment-earnings-education.htm, 5/28/30
[xi] Scott, Robert, 11/24/20, Memorandum on U.S. trade and manufacturing policy, Economic Policy Institute, https://www.epi.org/publication/memorandum-on-u-s-trade-and-manufacturing-policy/
[xii] Scott, Robert and Hersh, Adam, 1/19/22, Tariff increases did not cause inflation, and their removal would undermine domestic supply chains, Economics Policy Institute, https://www.epi.org/blog/tariff-increases-did-not-cause-inflation-and-their-removal-would-undermine-domestic-supply-chains/
[xiii] ASSESS COSTS EVERYWHERE, Department of Commerce, https://acetool.commerce.gov/, 5/28/22
[xiv] Workman, Daniel, World's Top Exports, https://www.worldstopexports.com/mexicos-top-import-partners/, 5/28/22
[xv] Walker, Elizabeth, 3/29/22, How much do employers pay for health insurance?, PeopleKeep,https://www.peoplekeep.com/blog/cost-of-employer-sponsored-health-insurance
[xvi] American Foundry Society, https://onlive.afsinc.org/using-total-cost-of-ownership-to-buy-and-sell-castings-smarter
[xvii] IMTS/AMT, https://www.imts.com/read/articles/type/Read/1/tab/all-articles/category/Supply-Chain/63

PANEL II QUESTION AND ANSWER

COMMISSIONER BOROCHOFF: Thank you very much. As is our custom as we rotate between the questions asked by Commissioners, we go alphabetically in the first one, and we're going to go in reverse alphabetical now. So Commissioner Wong?

CHAIRMAN WONG: Thank you, Mr. Chairman.

COMMISSIONER BOROCHOFF: I could've said Chairman Wong.

CHAIRMAN WONG: My question is for Mr. Kleinhans. I listed and read your testimony with interest. I'm curious. You talk about collaborating with allies and creating kind of a network on semiconductors.

And recently President Biden was in South Korea where a main focus of the summit he had with the new ROK President Yoon was on semiconductors. He had a big event at the Samsung headquarters in and around Seoul, I believe. And a big component of that was announcements of Samsung investments in fabrication facilities in the United States.

But as you say, it's foreshadowing a more robust, perhaps more complex partnership between the U.S. and the ROK. To the extent you can speak to that, I'm wondering what ideally a U.S. ROK semiconductor partnership would look like beyond, as you say, moving manufacturing at Samsung is doing into the U.S. What are the other ways in which they can build joint resilience?

And if we have time, I'd also like you to talk about your recommendation on the need to have, as you say, an end user demand pull to make this sustainable supply chain among allies. How do we, in fact, create that pull and that demand? I mean, is that subsidy? Is that folding this into -- I don't know if you call it ESG standards?

Is that mandates? Is it -- I don't know -- or just disseminating information about this so it is widely understood, perhaps some advantages to paying more for semiconductors from an ally in this sphere. If you can touch on all of those in the time you have, I'd love to hear about it.

MR. KLEINHANS: Thank you very much for the question. South Korea is an interesting case and I think also a great example for path dependency and future interdependence. Samsung in South Korea and SK hynix in South Korea are the two largest DRAM memory chip manufacturers.

And memory chips are a commodity and it's very hard to enter this market. So for the foreseeable future, I would argue both U.S. and Europe will continue to depend on South Korean memory chips. There's no way around this.

So going forward, I think it's, first of all, very important to engage with South Korea. I think it goes far beyond just ensuring that Samsung or maybe also SK hynix or other companies build fabs outside of South Korea. I think another low hanging fruit is to talk about supply chain mapping, what I said before, to cooperate with like-minded allies with international partners to better map and understand the value chain because most likely the South Korean government together with the South Korean companies know other things than the U.S. government and the European government about the supply chain and about their particular chokepoint and value chains.

In 2019 -- and John VerWey's an expert on that more than I am. But in 2019, there were export restrictions from Japan against South Korea, specifically on semiconductors. So the South Korean government knows very well about chokepoints and interdependencies within the ecosystem.

So that, for me, is a very low hanging fruit of more cooperation to better understand together the value chain. Another thing is since memory chips are a commodity, they are necessary in every single thing you can think of. So the connected car also depends on memory chips.

The smartphone, the PC, everything relies on memory chips. So just because of that fact, I think a closer collaboration with South Korea is quite essential. To your last point looking at the 45 seconds I have left, the end user or the end-customer industries, I think that's an excellent question.

And at the end of the day, it will be a mix of the things that you have mentioned. I think through ESG, also to what Mr. Moser said, to push them for a more realistic approach to procurement and a more honest approach to procurement looking at the total cost of ownership. But also a very simple thing, if we look at the chip shortages, forcing them for better supply chain management.

So telling them a simple thing, if you have a single source of supply, you have to explain why you only have a single source of supply for this particular input and why you're not multi-sourcing. So looking at and pushing them for better supply chain management I think is another incentive for them to also look for more domestic manufacturers. Thank you very much.

COMMISSIONER BOROCHOFF: Thank you. Commissioner Wessel.

COMMISSIONER WESSEL: Thank you all for being here. And Harry, it's good to see you. As I recall, our first work together was back in '09-'10. And I think you were at Obama's inshoring program many -- probably 2010, 2011. So you've been an advocate, an accolade on reshoring, inshoring for many years. Your testimony is very helpful.

I want to go a little farther on it and understand what tool we make recommendations to Congress. I think there's a general agreement there are supply chain risks. How one rates them and what supply chains specifically one wants to secure in some way is still in debate.

But we don't need more reports. We need action. Last year, this Commission recommended that Congress look at outbound investment screening to look at what critical supply chain investments were being made in China and whether, first of all, to get the information because we don't have a 360 view but also potentially to mitigate or protect, stop, et cetera, those investments being made.

A proposal like that was introduced in the House and Senate and is now pending in the conference on the USICA/COMPETES bill. So I'd like each of your reactions to using that as a tool to help ensure that we do no more harm, the Hippocratic Oath, on trade policy. Second, and Harry, I think you can help here because you worked on the ACE Toolkit as I recall with Department of Commerce.

When I talked to companies here that would like to reshore, and I make them aware of your work, TCO, et cetera, they don't feel they have a partner in the U.S. government, a place they can go like you can in other governments where they will help you understand what access to resources, including financing or anything else that might be available. So your views on that. And finally, Harry, the TCO approach, total cost of ownership approach, asks Wall Street to look a little bit beyond today's EBITDA numbers, right?

They're looking at life cycle and some other things. What tools like ESG reporting role that the SEC is involved in or other approaches could we potentially look at to get TCO to be a more effective tool and integrated into corporate decision making? So Harry, do you want to start?

MR. MOSER: Is that on?

COMMISSIONER WESSEL: Yes.

MR. MOSER: You hear it okay? Yeah? First on the ACE Tool, it was launched I think in 2012. I helped them a bit on it, and it's a good tool as our material, as other people's material. But it was last updated on 2018, and there's a lot that could be there. Like I suggested, estimates of risks of various kinds because risks are hard to find.

COMMISSIONER WESSEL: Is there a place that a small manufacturer that would like to reshore or like to maintain their operations here can go to? I'm not aware of --

MR. MOSER: No.

COMMISSIONER WESSEL: -- sort of a one stop shop. Okay.

MR. MOSER: There's no good data, and data would help. This Select USA tried to also go into Reselect USA. And it seems to have forgotten that, and it's back to just FDI. So I recommend that Select USA or another office pick up the mantle for reshoring.

Concerning total cost of ownership and tools needed, I've tried to get SAP and Oracle and groups like that to simplify the gathering of the data, the warranty cost, the travel cost, the various kinds, and aggregate them to specific products and specific suppliers so that it'd be easy for the company for the purchasing person to see those costs and make an easy decision.

COMMISSIONER WESSEL: Yes, but a follow-up question. As I understand it, SAP and Oracle platforms are very expensive.

MR. MOSER: Yes.

COMMISSIONER WESSEL: And so SME is more on the small side. They're not using those systems. How would you --

MR. MOSER: Dynamics. There's a lot -- there's everywhere from big to small, the systems. And I've tried to get many of them to do this without success. They mentioned ESG. One of the simplest measures of environmental action would be, where do you make the product and where do you sell it?

We did a study of an aluminum die casting and making it in China and shipping it here has 25 percent to 50 percent more environmental impact than just making it here. So I would recommend that the SEC and their ESG guidelines, one of the questions should be, where do you make it and where do you sell it? And that should calculate into some kind of a negative if it's in the wrong direction.

COMMISSIONER WESSEL: Okay. Thank you.

MR. MOSER: Thank you.

COMMISSIONER BOROCHOFF: Commissioner Scissors.

COMMISSIONER WESSEL: If the others -- I'm sorry -- could respond for the record, please. Thanks.

COMMISSIONER SCISSORS: John, it's good to see you. Thanks for the trade data work. I happen to have done the same thing last week trying to get the chemicals used in the essential medicines to match up with our trade statistics. It didn't work very well.

This is a tough topic. We have an example with what Mike was just talking about. It goes in a whole bunch of directions, and the directions can be very particular. I mean, like, the equipment used to make the equipment that's used in the product in the supply chain.

And because we know each other, I feel free to say your testimony did that too and went a whole bunch of directions. We're not going to get -- and I aim this as much as myself as anyone else. We're not going to get the magic supply chain solution here. It's just not going to happen.

You said two things, one in your written and one in your verbal testimony. One was, like, more copper output. It was an illustration, but you picked that one out. And then you talked about interagency coordination. Every time I hear that, I'm, like, okay, that's just never going to happen.

You get one step. And this is -- I'm trying to make this idiosyncratic to you. You and have had exchanges about this. You've been thinking about it a long time. This is not supposed to be perfect.

You, John, get one thing to do and it can be economic. It can be bureaucratic, whatever you like, financial, that you think is going to give us a lot of bang for the buck for improving supply chain resilience. Maybe it's one sector. Maybe it's across sectors.

But I just want you to pick one because I really read your testimony closely because we know each other. And at the end, I'm, like, really, you're going to end up with copper and interagency coordination? If that's what you want, then tell me why. But if not, give us one step.

MR. VERWEY: Sure, I'll give you one example from the semiconductor industry in particular which I know better than the copper industry. Fabs exert gravitational pull on their suppliers. So when you build a leading edge fabrication facility, you're not getting just a leading edge fabrication facility.

You're getting the ecosystem of chemical suppliers, material suppliers, mask suppliers, equipment suppliers, they fill that factory. In addition, you're also getting the workforce that goes into that factory and high skilled jobs that come with it. And you're getting a demand signal from customers in response to having built that factory.

So you're getting a -- by investing in a manufacturing asset like that, you're doing something that's both market based and that there are properly aligned incentives for suppliers to move closer to their customer. And then you're also getting better visibility into the end use and end uses of the consumers of those chips. So if I get one shot, that would be a relatively good investment, and it also is responsive to economic and national security concerns.

COMMISSIONER SCISSORS: So let me challenge that by going the exact opposite direction. I'd rather have the constitutive materials that go into the semiconductor production process, right, because I'm going to start at what I consider to be the top of the supply chain. Of course, I'm biased with my language now.

But the other end of the supply chain, and then I have a chokehold over your fab. It's great that you gathered all that stuff up. But I got the constitutive materials. And now you can't operate it, and your workforce is idle and so on.

Why would you -- why do you -- I take your point. The fab can draw that. But so can -- as we see with rare earths, the Chinese having rare earth mining and then pulling rare earth refining. So can starting at the other end. So why would you focus on the output side, the final product side, and not the required materials and minerals in some cases?

MR. VERWEY: Sure. To take your example and make it a little bit more specific, I think the other end of the spectrum would be the equivalent of establishing a silica mining and refining operation. That would be the very front of the front end in a semiconductor manufacturing process. And that would be advantageous for both the solar industry which consumes what's known as nine-11s or eleven-9s silicon, silicon that's purified to a certain degree, whereas the chip industry consumes a degree of silicon that's even more purified.

But, theoretically, increasing production of both would satisfy solar and chip demand. The difference there is a mining operation as my co-panelist pointed out requires large amounts of patient capital and comes with very high risks. I think she mentioned that there's a 95 percent failure rate for some of these operations whereas the case for a leading edge fab is much more well understood.

And though it does also require large amounts of patient capital, there's a market case for it right now insofar as you have suppliers like Apple telling their contract manufacturers that they need more capacity. And there's more capacity coming online that's responsive to that. Mining conversely doesn't have the same incentive structure and thus lacks some of that desirability.

COMMISSIONER SCISSORS: Thanks.

COMMISSIONER BOROCHOFF: Thank you. Commissioner Mann, if you're with us. Can't hear you.

COMMISSIONER MANN: Can you hear me now?

COMMISSIONER BOROCHOFF: Yes.

COMMISSIONER MANN: A question is directed to Mr. Kleinhans, although I welcome thoughts from others. Commissioner Wong asked precisely the question I was going to ask, and I'd like to pursue it a little more which is you're interesting suggestion the focus be on end users. And my question is, first of all, would that be effective.

But second of all, how would that work in the United States. How would the United States government turn or induce a focus on end users? And anticipating that you could fairly say, you're not an expert on the United States, I would also ask, how is it working in Germany? Is Germany doing that?

MR. KLEINHANS: Thank you for the question. Maybe to put it into perspective, to me, it's interesting that there is the -- I think across the Atlantic, there is the recognition that there's a lack of transparency within the semiconductor ecosystem that both regions need to substantially -- or want to substantially invest in manufacturing capabilities. But what is in my opinion often forgotten is that with semiconductors, we talk about a supplier industry.

The semiconductors are a means to an end. The end up in a car. They end up in the smartphone. And someone makes a very conscious purchasing decision, where to manufacture a chip, at what cost, and whether or not to design it themselves or to use fabulous companies such as Qualcomm or Nvidia or Samsung to design that chip.

So currently both in the -- my impression from afar, both in the U.S. chips debate and the EU chips debate, the focus is very much on the semiconductor industry. But we need the end-customer industries at the table. And a simple question such as at what point -- what is the cost difference between manufacturing in the U.S. compared to manufacturing in Taiwan that you as an end customer can live with to make a purchasing decision in favor of the new fab in the U.S. or in Europe?

Because especially if we talk about contract manufacturing, so the stuff that TSMC in Taiwan, UMC in Taiwan, Global Foundries in the U.S. and in Singapore and Europe is doing, it's about the cost of the location. And if you cannot bring the end customers on the table and get a very specific answer to the rather simple question I would say, you will have a hard time to come up with sustainable business cases for these newly established fabs in the future. I think from a government perspective, the worst case that would happen is that we now subsidize the hell out of an industry and in ten years' time we realize that some of these fabs are not utilized as well as possible because ultimately from a cost perspective, it might be -- and a hypothetical here -- it might be more cost efficient to still order the chip from TSMC Taiwan instead of TSMC Arizona just as one example.

So that's why I think the big purchases of chips and those are the smartphone manufacturers, those are consumer electronic manufacturers. Those could be providers, hyperscalers, every single cloud provider that you can think of are currently investing or since many years already investing on chips, be that Amazon or Google and others. The automotive manufactures ask them, what would it take for you to be interested in manufacturing or ordering chips from a domestic fab? And so far I would say in this debate their voices have been rather silent.

COMMISSIONER MANN: Thank you. Do any of the other witnesses have thoughts on this issue on end users?

MR. VERWEY: I'll briefly add until recently, the conversation was, how can we convince large international firms to build chip factories in the U.S. and Europe? JP's point is important that now the conversation needs to be a little bit more focused, who's going to buy those chips in the event that we build the factories here?

COMMISSIONER BOROCHOFF: Are you complete, Commissioner Mann?

COMMISSIONER MANN: Complete, thank you.

COMMISSIONER BOROCHOFF: Okay. Thank you very much. Commissioner -- Chairman Goodwin.

COMMISSIONER GOODWIN: Thank you, Mr. Chair. Dr. Vekasi, I wanted to touch on your testimony about diversifying the supply chains for rare earth. It's not only at the mining stage but also in the midstream as you put it. And you focus on some of the incentives that can be put in place to do just that.

In passing, you mentioned a Department of Energy project that would fund some refining capacity here in the United States. Would you to expand on that project a little bit? But also if you're familiar with another DOE project that would help to identify feedstock in acid mine waste, obviously, it's a particular and keen interest to me being from West Virginia. And NETL has funded a project with researchers at West Virginia University and Virginia Tech to help identify these reserves in acid mine waste.

And some of the researchers testified at a Senate Energy Committee hearing just this past March and extolled a lot of the virtues of their initial findings, including the fact that you're dealing with existing environmental waste, not generating additional mine waste, and because the rare earths have already been extracted from hard rock. The process is a little bit easier. And some identified reserves are as concentrated as some other reserves that we've identified around the country. So talk a little bit with your familiarity with those projects, their viability, and how important it is to help diversify not just the refining process, the administering process, but also that initial feedstock and finding perhaps an alternative feedstock.

DR. VEKASI: Yes, thank you so much for that question. So I think that -- thinking about those DOE projects is a really valuable way to think about diversification generally. And that particularly the -- I'm a big fan of the West Virginia project, and I don't know what the long-term viability of that is going to be as I am a political scientist, not a chemist or a geologist.

So I would leave that to those with other expertise. But I absolutely agree with you that looking at places where the rare earths are more concentrated as well as places where there already has been considerable environmental degradation from past industrialization is exactly the kind of thinking that we need to pursue. This will help us develop new technologies that might be used in other places.

There's also some projects that are happening in Utah that are somewhat similar with where there has been past mining and there might be some rare earths extracted from that project. And that we should be looking more and more at different places where we can use these sites to extract more rare earths. Now so I think that those -- that not all of them will succeed.

Sometimes the technology will not pan out. But it is -- even if 50 percent of them succeed, I think that's really good rate. And so you should prepare yourself for failure, but I think that a lot of these projects could succeed.

Thinking about some of the other refinement projects, I'm a little -- I have some skepticism because some of these projects have been proposed before. And we haven't seen a lot of action on it. So until they open their doors, some of them, I've been hearing about for five to ten years, and we still haven't had a ribbon cutting ceremony.

So I have a little bit more skepticism that will we'll see action on that. There does seem to be a little bit more right at this particular moment because there's so much focus on supply chain vulnerability generally. But I still want to see.

COMMISSIONER GOODWIN: Yeah, thank you. The acid mine project certainly seem exciting because you have the opportunity to treat an existing source of pollution in addition to helping provide some of these critical metals. I want to return to a conversation we had this morning about rare earths where I referenced your testimony.

And the suggestion was that some central planning in China did not contribute to their rise in the sector. Instead, it was more due to local competition and incentives. And perhaps despite that central planning, you took a contrary view in your written testimony which you touched on. And I just wanted you to expand on that a little bit more.

DR. VEKASI: Absolutely. Thank you for that question. So this morning we heard that maybe top-down industrial policy wasn't a big factor and that China succeeded in rare earths despite the policy. I think that I do disagree with that.

I absolutely agree that there are many illegal mines and that some, 50 percent of the industry was illegal mines early on. That said, early investment in talent was a top-down policy. And there are different waves of industrial policy.

So what happened in China in the 1980s and '90s with low costs and environmental pollution did shift mining there. But the reason China is dominant today is because of centralized industrial policy, export quotas, production quotas, and particularly this long-term investment in R&D and talent. And that's why we see a chokepoint in the midstream, and that's where I really think the United States needs to focus today in order to have some more resilience and catch up with our supply needs.

COMMISSIONER GOODWIN: Thank you.

COMMISSIONER BOROCHOFF: Vice Chairman Glas.

VICE CHAIR GLAS: Thank you all so much for your testimony. I'm going to turn to Ms. Vekasi to follow up on some of your testimony to all of us and Mr. VerWey. A couple things, I've learned a lot about rare earths over the last several years.

This is obviously a very active conversation with Congress and the administration right now and the importance of it. You talked about the financialization or maybe even lack of capital and the lack of success, right? There's a high risk associated with these kinds of investments.

But I didn't hear you talk about some of the concerns about mining here in the United States, right, and how much some of these projects are being slowed down because of, quote, environmental concerns in areas of the country. And that may be a reason why we're not seeing ribbons being cut. And I recognize that our clean energy future is largely being dominated by China for certain elements and projects.

And it really pains me to feel like the clean energy future includes major environmental degradation from mines that are not going to be compliant like the ones here in the United States from environmental regulation. So can you -- and Mr. VerWey, you also mentioned that EPA needs to be an active partner in this. How do we promote next generation responsible mining in the United States, because we need these minerals for -- whether it's our defense interest or for the clean energy future.

DR. VEKASI: Thanks so much for that question. I'll start off here. And one of the things working in this field is it's absolutely a trade-off. And when we think about building -- about green technologies, we need to acknowledge that there are also these high environmental costs which tend to be very localized with communities where the mines are or where the post-processing plants are.

And what we've done previously is we've outsourced that. And we've outsourced those negative externalities of pollution. And so today I do think that there's a big role that the United States can play in trying to have good environmental standards and say, okay, well, here's -- maybe set standards of how rare earth mining or other mining for critical minerals might be done globally.

And the World Bank is doing really good work on this, trying to set some of the standards with their smart mining reports, et cetera. I think one of the ways we can do that which would match some of China's incentives is to increase transparency in pricing and also in environmental standards. So China is much, much cleaner in their mining than they used to be.

But there still are a lot of problems and they do struggle with monitoring. And I do think that if there was a mechanism internationally to share more information and to have more transparent mining, at least for the big actors, starting with the big actors, then China would be somewhat eager to take the lead or cooperate with the United States. I think that's a place we could find common ground, and that would help ameliorate some of these environmental problems. I'll pass it over to Mr. VerWey.

MR. VERWEY: Thank you. Yeah, the question of how to promote responsible domestic mining and increase production is challenging. And environmental externalities are the number one tradeoff by far. I think there are several other challenges, and the EPA has an important role to play with respect to permitting as does the Army Corps of Engineers, the Department of Interior, and several other agencies that are not necessarily thought of as traditional stakeholders in the supply chain world.

The reason for that is for a project to receive federal funds triggers a series of reviews, especially NEPA reviews which can take up to four years. And just getting that process started is what we should be talking about in general because really from -- if we were to start a mine today, it wouldn't be operational and profitable for almost a ten-year period in a lot of cases. And that assumes that we are proceeding quickly. I think to your point, we also need to proceed carefully and do so in a way that minimizes environmental harm and local harm on communities.

And two interesting options that come to mind with that are first there is some interesting technologies that capture waste and byproducts of mining that are not sufficiently scalable because there's no commercial market for this right now. But basically capturing the byproducts that come with establishing a mining operation and operating that mining operation could be something that would feed into making it more profitable and making it also more environmentally friendly. Simultaneously, I think recycling has promise in terms of using existing mining operations, going to the tailings question earlier and deriving some minerals resilience from existing operations. Thank you.

COMMISSIONER BOROCHOFF: Commissioner Friedberg.

COMMISSIONER FRIEDBERG: Thank you very much. I have a couple questions for

Mr. Kleinhans. You made the very interesting point at the start of your testimony that there are different kinds of objections for addressing supply chain issues. And in particular, you distinguish between national security concerns which I think you defined as relatively short term or immediate concerns about risk of compromise and then competitiveness concerns which are longer range and have to do with loss of capacity.

So my question is, first, couldn't you say isn't there a broader definition of national security that would encompass competitiveness? And I guess that's sort of a theoretical or definition question. But the more practical question is if there are different policies required to achieve these different goals, are they in some sense contradicting or are they additive? Is there any reason why you couldn't be doing things that would address both?

My second question is the third try at this point about incentivizing industry to consume locally produced chips, one tool presumably for doing that would be tariffs which we haven't talked about. Is the probably with that that you would have to impose those on friendly countries as well as on China and in particular on Taiwan? Isn't Taiwan really the core of the concerns because of its potential vulnerability imported from Japan or South Korea presumably would be less of an issue for us and for countries in Europe?

MR. KLEINHANS: Thank you very much for those questions. Regarding national security encompassing technological competitiveness, you talk to a European here. And the concept of national security, I would say, it's rather narrowly defined historically in Europe.

And that's why I think also when looking at the EU-U.S. Trade and Technology Council and other forum where the U.S. and Europe talk together about supply chain or technology challenges, I think it's important to understand where both parties are coming from. I'm by no means an international relations expert nor a national security expert. But I think just on the policy level, it's worth it to differentiate between technological competitiveness and simply to ensure that going forward your companies prevail on the international market, and that's a hard national security.

So that's why also in my testimony I try to distinguish between the two because indeed -- and that's to your second point -- you end up with conflicting objectives. You end up with a reality that you cannot optimize all three of them. One example, if we are worried about national security in the sense that who can compromise the chips that end up in our military, or is there even in consumer electronics or national critical infrastructure a kill switch or a backdoor?

Then it's actually not useful or not very useful to simply look at front end manufacturing. Then you would need to invest also in back end manufacturing in printed circuit boards and then final assembly because these steps are all significantly easier to compromise than front end manufacturing. At the same time with these production steps, you talk about production steps that have very low value added that are not very innovative and that have high -- or that are very labor intensive.

So not necessarily interesting production steps if you're worried about technological competitiveness and if you are worried about market shares. If you're interested in that, then chip design should really be a focal point because chip design has around 50 percent of value addition and significantly more than any other of the following downstream production steps. So the other thing is one example out of countless in the semiconductor industry where you have to be very clear about your objective.

You cannot have both. If you subsidize front end or back end manufacturing, I would argue you do very limited things for your technological competitiveness. You might do the absolute right things for your national security.

To your last point, I'm also by no means a trade or tariff expert. But since this is now the third question regarding how can we incentivize end customers or end-customer industries, it shows to me that this is an underestimated angle to the whole debate. And it simply shows that on both sides of the Atlantic, the governments have very strongly focused on the supply chain itself and underestimated that they talk about a supply chain, a supplier ecosystem. And we should really more engage and more push for the end-customer industries to be committed and, at the end of the day, pick up the bill.

COMMISSIONER FRIEDBERG: Your answer to the first question, it seems to be me suggests that it's not that the policies that you would need in order to achieve these different goals are contradictory. It's just that they would be expensive. If you wanted to pursue both goals, you'd have to spend a lot of money at all stages of the process.

MR. KLEINHANS: You are right. But at the same time, you can only spend every tax dollar once, right? And the interdependencies in the back end are even worse than in the front end. For printed circuit boards for substrates, we are already today highly, highly dependent on Chinese manufacturing to the point that it's not just a cost difference but that the more advanced products are in the Chinese market.

And there are very interesting statements to the BIS request for information from last year regarding risks in the semiconductor value chain where U.S. PCB and substrate manufacturers make the point that this industry has been neglected for many years. And again, from a technological competitiveness perspective, rightfully it was neglected because it had very little value addition. From a national security perspective, it is very dangerous because you can compromise chips through those production steps rather easily. Thank you.

COMMISSIONER FRIEDBERG: Thank you.

COMMISSIONER BOROCHOFF: Commissioner Fiedler.

COMMISSIONER FIEDLER: I am giving my time over to Commissioner Wessel for follow-up on this questions.

COMMISSIONER WESSEL: Thank you, Commissioner Fiedler. And my frustration has no bounds really today. While we were talking, I went back and looked at rare earths. And this Commission had a research product on that in 2004.

We've been dealing with rare earths since 1996 with the purchase of Magnequench, the subsequent removal of all the equipment. I believe it was in 2002 from Valparaiso, Indiana despite an agreement that the technology would never be moved. And we had China in its, I guess, 863 program identify rare earths as one of the exotic minerals that are critical.

As our staff and our Commissioners have pointed out year after year, China tells us what they want to do. We just don't really -- either we can't read it or we don't listen or we don't believe them. I think we have to believe them.

But let me go back, Jeff, thank you, to following up on the outbound investment issue because, again, we have a number of critical supply chain studies that have been done. We have some of us, I won't say all of us, believe that the administration has been slow to identify some of the technologies that should be subject to export controls and review through inbound investment screening CFIUS. We now have this issue of being able to say, let us gain the data to understand what we are sending, what technologies investments we are sending to China, and then create an opportunity first to have the visibility into it so we do a better job ongoing.

Second, if there are investments that create risks, try and mitigate them just as we do with CFIUS. But if there's something that rises to the level of directly challenging U.S. national security interests, understanding that is a changing definition, we should be able to do it. Can each of you tell me your thoughts on that, whether that should be part of the toolkit so that again we don't continue to talk about this problem for another five years, ten years and continue to feel like we -- not feel like -- continue to have a few tools to address it? Harry, do you want to start?

MR. MOSER: Could you give me that again, a little shorter?

COMMISSIONER WESSEL: Shorter is, what do you think of an outbound investment review mechanism that requires companies other than normal business transaction which would be defined to report to the U.S. government on their investments in China? And if those investments pose a security threat, first, to see how to mitigate them, or number two, potentially prohibit them?

MR. MOSER: I think it's a logical thing to do. I would not oppose it. I always come back to companies will do what's in their own economic self-interest. And finally, if it's in their interest to invest somewhere other than here, they're going to invest somewhere other than here. And therefore, to me the overriding issue is to make sure that here is a place where they'll be most profitable with the investments.

COMMISSIONER WESSEL: No argument. I think we all want that.

MR. MOSER: Yeah.

COMMISSIONER WESSEL: But that is not necessarily within our control

(Simultaneous speaking.)

COMMISSIONER WESSEL: -- resource-wise or otherwise. Others? Comments?

DR. VEKASI: I'll jump. So I'll just address the rare earth industry. I think that kind of policy might've been helpful in 1996. It might've been helpful in 2004.

At this point in time, doing that sort of policy in the rare earth sector I think would be counterproductive for U.S. companies. Wherever they're manufacturing, we mostly import rare earth related products from China in finished form, not in raw form at this point. But I think that there might be a space for outbound investment screening in other sectors.

COMMISSIONER WESSEL: But just to follow up on rare earth, the separation and production is moving around the globe. It's not just in China. We're doing more recycling here in Texas as I recall, et cetera.

DR. VEKASI: Yes, that's true. And in my written testimony, I outline how Japan has really diversified their separation and refining as well. And I think that's really beneficial. But we would -- if we cut China out of that through an outbound investment screening process, then it would be counterproductive for --

COMMISSIONER WESSEL: It wouldn't mean we wouldn't buy from them. It would just means we would not further enable them. Okay. Others?

MR. KLEINHANS: I'm a little bit torn between yes and no because on the one side, the tool itself is the logical continuation of FDI screening. It's just the other way around. At the same time, we have seen and I would argue expounding application of export restrictions and FDI screening, not just for the sake of national security but also for the sake of technological competitiveness.

So the tool itself I think could be a step in the right direction. But the application of it, there I see question marks, the broader -- in the future, the broader the application would be. And just connecting it to a previous point, I think to make the best use of such a tool, it would be crucial to have simply to be honest substantially better understanding within government of the value chain.

That doesn't just go for outbound investment screening but for FDI screening, export restrictions as well. Also to John VerWey's point before, I think before broadening the application of those tools, government should really invest in a more robust understanding and a continued and institutionalized understanding and mapping of the value chain because without that, you're kind of fishing in the dark. And it would be a took that is radically applied to some cases and not to other without a broader strategic background behind it.

COMMISSIONER WESSEL: Thank you.

COMMISSIONER BOROCHOFF: Commissioner Cleveland.

COMMISSIONER CLEVELAND: Thank you. I think I want to follow up on Commissioner Wessel's question from a slightly different perspective which is that at this point we have multiple lists, multiple agencies, multiple efforts underway to look at expert restrictions and whether it's end user based or critical technology. And I'd be interested in your thoughts as to why it is we have not successfully mapped what is in our national security interests and what the barriers or impediments are to harmonizing DoD, Commerce, whoever else is playing in this game because I think that absent that, an outbound investment commission, committee, whatever the structure is, is shooting in the dark. So that's my first question.

But Mr. VerWey, a very specific question for you which may pertain to this. In your oral testimony, you raised concerns that China is now responsible for about one-third of U.S. imports of critical technology. And you specifically point to a review of the -- your analysis of NAICS codes that indicates 40 percent of U.S. imports of storage batters were from China. But the appendix that you attach to your testimony providing 2017 to '21 data on categories I believe you selected as to reflecting our reliance on China shows that in every one of the categories except storage batteries, our reliance on China has declined.

So first of all, are we raising alarm about storage batteries which I think is a serious concern? And that is inconsistent with the balance of data. Or could you elaborate on the significance of the -- and they're fairly significant declines in the reliance on China when it comes to these categories you selected.

MR. VERWEY: Yeah, great question. So to your latter point, I too was interested to observe that decline. In fact, from 2017 to '21, the import reliance decline from 40 percent to 36 percent for critical technology industries, my read of that is that it's kind of a quirk of the way the NAICS codes are organization.

They batch harmonize tariff schedule codes within -- multiple codes within one NAICS code. And there's a lot of nuance that needs to be added when interpreting them as a result. So I provided an example of how you could break that out, specifically with respect to batteries which when done, four batteries showed more of a direct import dependence that's much higher than the broader category NAICS code would suggest. I think part of that might also be a bit of trade diversion. And that is reflected in, for example, the semiconductors and related device category which declined significantly from 2017 to '21.

COMMISSIONER CLEVELAND: You've anticipated my question.

MR. VERWEY: And I would be curious to dig more into that because there's probably a broader story there about firms choosing to go outside but near to China in response to government action. To your first question regarding the critical technology lists and why we have -- I think in Appendix F, I have six of them listed. But there are at least a few more floating around.

I don't have a very easier, satisfying answer there. But I've been tracking all of the lists for a very long time because it is of interest that we keep coming up with new ones. Most interesting to me is that every one of these lists has at least four technologies that they all share which are AI machine learning, biotechnology, quantum information science, and microelectronics. And I feel like that is a good starting point for thinking about if we were to engage in the process of mapping supply chains and then tracking vulnerabilities and assessing risks and determining vendors and net import reliance, those four technologies would be a viable starting point based on their shared status on these lists.

COMMISSIONER CLEVELAND: Any other thoughts on why it is we haven't been able to successfully merge, harmonize, come up with a consensus list from any of the other witnesses? My last question has to do with if we presumably select those four areas because I'm not sure they're individual technologies, the Center for Security and Emerging Technologies has reported on chokepoints that China has identified. And depending on the part of the report, there are either 14 or 35.

But they have identified areas where they feel a significant vulnerability. Has anybody mapped or done a side by side of what China identifies as their vulnerabilities and these areas that we view as critical to our security that we might very well want to exercise additional restrictions as Commissioner Wessel suggests? Is there that mapping of what they identify as vulnerabilities and what we identify as critical?

MR. VERWEY: I saw that report as well. And the answer is no, not to my knowledge. But maybe other panelists are aware.

COMMISSIONER CLEVELAND: Okay.

DR. VEKASI: So I'm currently working on that research right now. That's one of my current projects. And so I'm comparing China, the United States, South Korea, and Japan and the different things that they identify.

And I can't give a quick overview of that. I'd be happy to follow up with some more detail. But those four are all identified by all four of those countries, and there are other considerable overlap. So we kind of see the same end goals coming from a lot of -- and same risks identified from a lot of different countries, although the different components and parts of the supply chain that are viewed as risks or vulnerabilities of course are different for those different countries.

COMMISSIONER CLEVELAND: When do you anticipate your research being completed?

DR. VEKASI: Initial drafts in the next year and academic publishing is slow. But I'm happy to share early findings, of course.

COMMISSIONER CLEVELAND: Okay. Thank you. And Mr. Moser, I'll have a question for the record for you. I don't want to demonstrate how ignorant I am on math in terms of your recalculation. But if you'll be patient, I'll have something for you for the record. Thank you.

COMMISSIONER BOROCHOFF: Thank you. I won't be last. I see that Commissioner Bartholomew has joined us. Alphabetically, I'm up. So I'll just ask my question.

Mr. Kleinhans, when you make the statement that we should be looking for pull rather than push, I think that's a great business strategy. And when we ask them, what is it going to take to make you want to reshore, I think what everyone is saying is there's one giant word, cost. There are probably others, but costs at the moment is that one that everyone talks about.

And Mr. Moser, you list in both what you said and in your testimony -- your written testimony things like health insurance. I would add human rights. You mentioned environmental concerns. The things that in America all businesses are required to spend money on.

So my real question is to go back to you Mr. Kleinhans, I'm going to ask both of you a little bit about this. Go back to you. When you say segment, is it a national security concern? Is it a technological competitive edge? I'm assuming I haven't said anything you don't know.

So are you suggesting that in order -- after talking to these folks, we're probably going to have to just decide to ignore some of the things that everyone is forced to do on behalf of national security? In other words, maybe then the environmental will be ignored or the health insurance will be ignored or it'll be subsidized? And are you saying the same, Mr. Moser? How do you get past health insurance as an example?

MR. MOSER: What we suggested our health insurance -- I suggested the

COMMISSIONER BOROCHOFF: Right.

MR. MOSER: -- litigation and pharmaceutical. Pharmaceuticals has been a popular topic recently. So I'm a businessman.

COMMISSIONER BOROCHOFF: Me too.

MR. MOSER: I look at what actually causes businessmen to make decisions and real cost, real actual cost to help them to be competitive.

COMMISSIONER BOROCHOFF: Don't disagree with you. But I can just tell you that at least -- I've owned my own business 40 years. And I have watched the major costs in my business quadruple, go up 1,000 percent on some of them as you probably have seen. And the question is, is it feasible in your mind that there are a lot of people trying to fix the cost of medical care. And thus far, it has just continued to go up.

So I don't think we're going to say it'd be better if you're not insured. So I don't know. I don't know we get past things like the environmental cost and the human rights issues that we just have in our country.

MR. MOSER: It's a combination of reducing the real costs like with healthcare and skilled workforce, more productive, better skilled workforce, but at the same time asking the companies to at least consider the societal impacts of what they do.

COMMISSIONER BOROCHOFF: Okay. So you're asking them to be good guys. I got that.

MR. MOSER: To some extent, like the Business Roundtable came out and said, no longer just shareholders but also a community, supplier, and employees. And what's the best way to deal with all three of those is to reshore and bring work back to the country.

COMMISSIONER BOROCHOFF: I'm in agreement with that. And look, I love what you do and I would love to reshore everybody. I'm just looking at this pragmatically listening to you all today.

The medical industry has pharma, but it's also got the docks and it's also got the insurance companies. And to lower costs, you have to find a way to get all three of them to just do the right thing. Or you have to mandate it from a government level which is not my favorite idea either. So I was curious. I think that one is baffling to me how to fix.

MR. MOSER: All of these things, you're not going to take one big gulp that's going to do the whole thing. You're going to get a piece here and a piece here. You put enough of them together and you -- if the companies believed that the country was committed to getting the real cost down --

COMMISSIONER BOROCHOFF: Yeah.

MR. MOSER: -- and if they believe that there's an existential risk of importing a lot from China because they could be cut off completely and be out of business if they got cut off completely, then they will take the effort to do the math and figure out that there is a significant portion of the work that they can bring back without hurting their own profitability or raising prices.

COMMISSIONER BOROCHOFF: I agree with this statement that if they think there's an existential threat, you'll see a lot of people step up that today would not do it. We've seen it every time that happens in America. I totally agree. Mr. Kleinhans, do you have a comment about what they're going to say or what we should do when they say it?

MR. KLEINHANS: Maybe just two points on that. First, I think at least for the semiconductor industry, there's not really good data out there on the actual cost gap. The data both in the U.S. and Europe that we currently rely on comes from industry associations or commissioned reports from semiconductor companies.

I don't think that's the best source for policymaking. So far, for example, subsidies in the semiconductor ecosystem, there is a single OECD study from 2019. But beyond that, I would argue we don't know the actual cost gap yet because there's very limited independent data and that in my view necessitates government again to step up and produce that data, for example, through simply better research and internal capacity.

Second point, I think the danger of focusing too much on reshoring is that it becomes hypocritical to talk about ally shoring because at the end of the day if you're serious about restructuring the value chain, it will not work with reshoring. It will only work with ally shoring. And ally shoring at the end of the day means that you are fine that your ally gets a piece of the cake.

So in that sense, certain production steps that are labor-intensive may never be viable to reshore to the U.S. or to Germany, but maybe to other ally countries with lower labor costs. The same goes for a variety of production steps within the semiconductor ecosystem. And there I simply think we have to be honest what we talk about. If we are serious about restructuring the value chain, this will not work without ally shoring. And then we have to define that for the foreseeable future certain production steps will not come back to the U.S., or to certain countries within Europe for that matter.

COMMISSIONER BOROCHOFF: And in the case of the rare earth mining discussion that several of you and in particularly you, Ms. Vekasi, have talked about, the fact of the matter is that it's extremely toxic to do mining of rare earths. There's not a way to do it within any conceivable expense-related way that makes sense. Basically what you were saying, Mr. VerWey, that the only way that would work is if we somehow managed to convince China that, gee, you need to spend a whole lot more money and do yours right so that we can do it here too.

I mean, when you offshore things that go against the public fabric to try to bring it back is a very difficult thing, unless it is, in fact, a national security, lives are at risk, the whole country is going to have a serious problem if we don't do it. And I think that's the message that I heard from you today. And that's a decision that has to be done by policy. So thank you for your answers. Commissioner Bartholomew.

COMMISSIONER BARTHOLOMEW: Thank you very much. Thank you to our witnesses for their testimony and sharing their knowledge on these topics. Supply chain resilience is certainly a popular topic these days. A lot of people focused on it.

I'd like to return us back to the China piece of it. Dr. Vekasi, two things that you said I'd like to hear if the Chinese companies are disproportionately benefitting. One is the lack of transparency and pricing. Can you explain why there's such a lack of transparence and accounting? And do we think that benefits Chinese companies?

The second thing is you mentioned a lack of talent and expertise here to do some of these things, particularly in terms of rare earths. Where did the Chinese experts get their expertise? Is it from hands on work that they've been doing in China?

Have they been going to foreign universities and getting trained in the knowledge that they need to have? And then for all three of you if there's time, I'm interested in now that the Chinese have sort of identified their vulnerabilities if there are opportunities for us to exploit some of those vulnerabilities. Dr. Vekasi, let's start with you.

DR. VEKASI: Thanks so much for those questions. So in terms of lack of transparency in pricing, I actually think this is a negative for Chinese companies as well. And I'll explain that.

So one of the reasons that we see such a lack of transparency is there's no industry group or industry association that has any sort of centralized reporting. So there's no international rare earth group. You tell us how much you paid for praseodymium and you'll get these other benefits for membership of this industrial association.

And other mining industries do have those sorts of mechanisms. Rare earths does not. As a result of that, I actually think that rare earths are considerably underpriced and that there have been the -- there's maybe some benefits to the Chinese industry broadly from that underpricing because it makes it less profitable for other countries that might have higher environmental -- well, China has fairly high environmental standards for rare earth mining today compared to the past.

But higher cost countries can't complete. And when they do start new mines, then one of those 17 elements will flood the market. The prices will plummet. The mine will go bankrupt. And it's a really high risk environment, particularly at the beginning.

Now if there was more price transparency, I do think that the prices would marginally go up and they would also stabilize to some extent. And that could benefit -- I think that would benefit the Chinese companies as well as international companies. So I think this is actually a net win here, that particular mechanism. And there has been some interest from China in doing so. Well, they haven't pursued it. So that appears to be mixed benefits.

In terms of where China got expertise, this was identified as an industry that they wanted to build in the 1980s. And there a couple of education programs, domestic education programs. Some people did go abroad and study at American universities.

There's a lot of scientific exchange in the 1980s between the U.S. and China. And the people that were trained in the United States went home. So there was that to some extent. That was common in a lot of different sectors at that time.

But since then, these are really domestic programs there. And China emulated what the United States had done in the 1950s and '60s. They set up journals as well as these newsletter systems that disseminated knowledge from national labs and nationally funded programs to Chinese commercial entities in rare earth.

And a lot of that was in refining, in separation, as well as downstream technologies like magnets. There's all sorts of different uses. There are hundreds, thousands of uses of the 17 elements.

COMMISSIONER BARTHOLOMEW: Thank you. And then to the others, maybe to start with, options or possibilities for us to exploit some of the vulnerabilities that the Chines government is concerned about and has identified.

MR. MOSER: I guess that's on. I think it's sort of at a fundamental level that you should recognize that China still needs technology and investment from outside of China. And a lot of the companies that went to China did so at least in part to sell to that rapidly rising middle class.

And to the extent that we can create a vision and an acceptance to the fact that China is not going to grow at ten percent a year. It's maybe going to grow one percent a year. So that market isn't going to be growing astronomically into the future and get our growth up from two percent to three percent or four percent. Companies will decide that given that difference in growth and given the risks of being in China that they will not want to the put the technology, the money, et cetera, into investments in China. So I think we can sway the decisions by the companies to invest here rather than there.

COMMISSIONER BARTHOLOMEW: Thoughts from any of our other witnesses?

MR. KLEINHANS: Maybe --

COMMISSIONER CLEVELAND: Dr. Vekasi, anything? Oh, sorry. Go ahead.

MR. KLEINHANS: Maybe just one note regarding the semiconductor value chain, I would argue the U.S. government is already exploiting vulnerabilities through export restrictions. And the export restrictions on extreme ultraviolet steppers. So the particular type of manufacturing equipment that is necessary for cutting edge semiconductor manufacturing is not allowed to be shipped to China. And because of that, we already know that as long as this export restriction exists, Chinese fabs, be that SMIC or Hua Hong or others, will not be able to advance something like beyond 10 or 7 nanometers. And that's a clear vulnerability of the Chinese ecosystem that is currently exploited through U.S. export restrictions.

COMMISSIONER BARTHOLOMEW: Thank you. Anyone else?

DR. VEKASI: I'll just chime in briefly to say that one risk with exploiting vulnerabilities that we've seen over and over again with Japan and South Korea and the semiconductor issue, with China and Japan and the rare earth issue is when you exploit a vulnerability, there tends to be a response and the vulnerability disappears. So when you choose to use a vulnerability, whether that's weaponization or a more mild use of exploiting a vulnerability, then it needs to be at the right time and that the payoff needs to be high enough because the vulnerability will probably disappear.

COMMISSIONER BARTHOLOMEW: Great. Thank you very much.

COMMISSIONER BOROCHOFF: Thank you. We have a little bit of time left and a few Commissioners want to make a follow-up question. So Commissioner Wessel?

COMMISSIONER WESSEL: Thank you. And Commissioner Cleveland and I were just commenting on the inordinate focus on rare earths. But I'm going to compound it because I think China has preyed on U.S. vulnerabilities, our vulnerability being short attention span and focus on short term profits over long-term economic security and results.

Only to say that we had a rare earth mine, Mountain Pass, out in California. I should point out that former Democratic leader Harry Reid's father worked at that mine for a number of years. Because of predatory pricing by the Chinese that a facility was put into bankruptcy.

Environmental costs were probably part of it. But it was more the continued predatory incursions into our market. We have four domestic rare earth mines with proven reserves here in the U.S., both light and heavy rare earths.

But until a couple of years ago, DoD procurement rules only require that they final magnets be produced in a trusted country. All of the minerals could come from wherever else. That was cleared up by Congress in the NDAA unanimously.

But again, going back to earlier comments, we don't seem to have a coordinated, aggressive approach to looking at the supply chain vulnerabilities, mapping them out, and then acting. This is the second time in five years we've done supply chain studies. The White House under President Trump did a lengthy study. We're doing it again.

So I guess to mirror my friend, Derek Scissors, I'm not sure there's a question here. But I think we have to -- if we're going to do anything significant on rare earths, we need to tell the whole story. And this is a deep 20-plus year story of failures here in the U.S.

COMMISSIONER BOROCHOFF: Thank you. Commissioner Cleveland.

COMMISSIONER WESSEL: Talk about rare earths.

COMMISSIONER CLEVELAND: No, unlike some of my colleagues, I actually have a question. So Mr. Kleinhans, you mentioned that we should focus on end user -- sort of an end user approach to assessing critical technologies. And I think you mentioned car and consumer electronics. I'm very interested in, Mr. VerWey, your comment that AI, quantum, biotech, and microelectronics are potentially beginning points for coming to a common understanding or framework of what we should be concerned about in terms of supply chain.

I'm wondering if any of you could actually talk about the topic of this panel which was U.S. policy with regard to supply chain resilience when it comes to biotechnology because we focus almost exclusively for reasons I don't understand on rare earths -- important, no doubt -- and to some extent on semiconductors. But we previously in this Commission have focused extensively on biotech, and granted that's a broad universe. But do any of you have any thoughts or comments on U.S. policies when it comes to supply chain resilience in the space of biotech?

MR. VERWEY: So I think biotech is a good candidate for some of the mapping that we've already talked about. It suffers from a definition problem. Biotech means many different things. To the Department of Agriculture, it refers to crop science and to the Department of Commerce it refers to something totally different.

So mapping what that ecosystem looks like that, what firms are competitive and what segments, what those vendors' market shares are is a really first step. And of the reports that I've read, that step has not been taken to really look granularly at different aspects of what constitutes the biotech ecosystem. With that said, as you know, there are certain things that are generally used across the biotech world.

Glove boxes are basically essentially in lab work. It's something that we don't make very much of in the United States. And that sort of chokepoint is a good starting point in terms of determining vulnerabilities. And then, again, you could carry that forward and think about, okay, what parts of U.S. government supply chains might be reliant on labs that are filled with glove boxes? What funding mechanisms do they have that could be directed to resolve that chokepoint, that sort of thing?

COMMISSIONER CLEVELAND: Okay. Thank you. Anybody else want to venture a guess on biotech?

MR. MOSER: I'm not a biotech expert by any means. But my observation is that the margins in all pharmaceuticals including bio are very high. The unit manufacturing cost is low. The selling price is high.

So of all the things that we're dependent on, it should be the easiest to bring back because almost the impact on the final profitability of the company would be minimal by bringing it back and the benefits for the country would be huge. So I think it should be a great place. But I believe the industry has been resistant to doing so.

COMMISSIONER CLEVELAND: Okay. I'm not sure I agree with you that it's possible to bring back some of the large chemical companies, partly for reasons that we've discussed in rare earths in terms of environmental and related costs to American companies' operations. Since we have time, Mr. Moser, I'm going to attempt to ask you a question. And if you don't understand it, it's my fault.

So talk about in your TCO model the possibility of a 20 percent differential as I understand it, that your model would not reduce price or profit. But through doing math differently, as I appreciate, you could present an argument for reshoring. And you stated in your testimony about bringing back I think up to a million jobs within the next several years. ITC has done a study that basically says that the loss of jobs is related to higher productivity, in essence, automation. So I'm curious how in your assessment of reshoring from China in particular and resilience of supply chains, how you have incorporated thinking about or calculations related to higher productivity.

MR. MOSER: We literally -- in our TCO estimator which is our free online software for doing the calculation, we start with the FOB price from the U.S. and the FOB price from the other country.

COMMISSIONER CLEVELAND: FOB?

MR. MOSER: Free on board, like, ex-works or factory price. Okay? You start with those two numbers. Let's say China is ten. The U.S. is seven. And the company says, well, that's obvious. We're going to go for seven.

And then the system has algorithms in response to companies' questions add in the duty and the freight and the carrying cost of inventory, the risk of stocking out and what that does to your profitability, the intellectual property risk. It's all these factors which are real. Some will appear in the current period.

Some like warranty costs might appear over an extended period or intellectual property risk might. So now our revised versions are coming out with as expected value calculations of these things based on the risk that the user believes there is of that happening. Okay? And we see that the companies -- many of the companies that have reshored, for example, a study was done by a professor, John Gray, at The Ohio State University.

And he found four companies that had offshored and then reshored. He asked them, why did you offshore? Well, the prices and the wages were so much lower. We couldn't afford not to.

And then said, why did you bring it back? Why did you change your mind? Because over three or four years, our experience was that there were so many difficulties, so many quality issues, so many complications, so many late deliveries, travel that the savings we were getting on the purchase price didn't make up for all those things.

So in effect, what the TCO estimator does is to help the user easily or as easily as possible quantify all those things so that they make the right decision the first time ideally and they don't go. Or it helps them to -- let's say they're motivated by risk of disruption, China, decoupling, all this kind of thing. But motivated by that risk to be willing to do the math and then see this, roughly 20 percent. Five or six studies around the world have come up with similar numbers. But that's a very real number.

COMMISSIONER CLEVELAND: But am I hearing that the model is more relevant to the potential of offshoring rather than reshoring?

MR. MOSER: No, it's equally good for both. The only difference is that once you've offshored, then there is a transitional cost to come back. You have the part being made over there, and there's a mold and there's a die and there's whatever. And you've trained the people over there to do it.

And now when you bring it back, China typically doesn't let you take the tooling back. And then the risk is they keep the tooling. They start making parts and compute with you in the future using your old tooling. Okay?

So the decision is easier and cleaner cut making the decision before it goes. But the people that have decided to come back have almost always mentioned something -- they mentioned the litany of woes that they had that drove them back. And now the biggest one added to that is the risk of disruption.

COMMISSIONER CLEVELAND: This may be better for the record. But I am curious as to so is it a one-for-one presumption in your model of a job that went over is a job that will come back. And how does productivity -- no?

MR. MOSER: We actually look at the -- we look at the jobs that are created here when it comes back. We don't look at the name. We don't go back and say -- and one thing I think is interesting to understand is that we talk about the reshoring of a market segment that doesn't have to be reshoring by the same company. Like, one company could have been making things here and then we lost that industry to offshore somewhere, anywhere. And then somebody starts making those things here again that market segment has been reshored.

COMMISSIONER CLEVELAND: And I don't want to -- Mr. Kleinhans, I think your observations about we have to be mindful of allies and partners in this whole equation is also important. So I don't want to subject it's either/or in terms of my perspective. Thank you. That's all.

COMMISSIONER BOROCHOFF: Before I call on Commissioner Friedberg, I just want to say, Mr. Moser, you just described almost exactly why it was explained to me that Toyota moved to Texas with a factor. Very similar reasoning. So it does work in a lot of cases. Commissioner Friedberg.

COMMISSIONER FRIEDBERG: Thank you very much. I'm going to split the difference between my colleagues and make it a brief comment and then ask a question. The comment is in response to Professor Vekasi's observation that if we exploit a vulnerability, it tends to disappear.

Seems to me that's true in some areas but not necessarily in others. And we heard this morning testimony that suggested that China's very expensive industrial policy is aimed at developing a capacity to build the highest end semiconductors is likely to fail. So that may be an example of a chokepoint and there may be others.

And so I suppose the characteristics that would identify them would be areas in which it would be very difficult for China to substitute and reduce the vulnerability. My question is for Mr. VerWey about mapping, and you referred to this a number of times, as did Mr. Kleinhans. What are we talking about here?

How big an enterprise is this? Are you imagining that it would focus only on particular sectors or that somehow it would be even broader? How much would it cost?

I mean, I know you can't answer that question directly. But would it be expensive? And who would have the responsibility for it? Is it U.S. government, agencies in the U.S. government? Is it the companies themselves? Could you explain?

MR. VERWEY: Sure. So the private sector does this to some extent already. To stick with the example of Toyota, they have very good visibility into where their rubber supplier is for the tires that go on their cars. So that would be an example of a raw material, part of their subsegment of their supply chain.

There are also subcomponents like the chassis or the raw steel. And then there would be components themselves like the dashboard and the electronics. And then you get to the finished product which would be the car, and then the end of life recycling stage where the OEM decides what can and cannot be reused.

And that becomes the raw material feedstock that they start all over again with. That sort of mapping could be done for theoretically any critical technology supply chain. And the biggest challenge is the fidelity of the information that is available or not available.

If there is high fidelity information, you can do some pretty interesting modeling and introduce if/then scenarios to tease out what sort of risks exist. If there is no, then you have to make some assumptions and it's more qualitative. I see that sort of capacity requiring the expertise of economists, industry analyst, accountants, statisticians, data scientists and working pretty closely together.

The closest instance where I saw that happen in the U.S. government was when I worked at the U.S. International Trade Commission which has an Office of Industries, an Office of Economics, General Counsel, that sort of thing. And I don't think that the ITC is necessarily where this sort of capability should live. But I think it contains many of the characteristics that would be responsive to doing these sorts of analyses.

In general, it would be advantageous to start with a few critical technologies and a relatively limited staff to essentially conduct a pilot project and see if this is viable. But determining co-dependencies across U.S. government equity holders, so defense industrial based supply chains that have the same vendor reliance as energy industrial base would be very welcome and could be accomplished by a relatively small group.

COMMISSIONER FRIEDBERG: Is the necessary information publicly available?

MR. VERWEY: In many cases, no. It is commercially available, but it is not publicly available. So if you are able to pay for it, you can get the information. But its paywalled generally in boutique firms that collect this information and sell it.

COMMISSIONER FRIEDBERG: And is it proprietary in some cases?

MR. VERWEY: There are terms and conditions attached which dictate how you can and cannot use it. Generally, those terms and conditions require that you aggregate the information when you're going to present it publicly.

COMMISSIONER FRIEDBERG: So the U.S. government could acquire this information?

MR. VERWEY: Yes.

COMMISSIONER FRIEDBERG: Thank you.

MR. MOSER: Could I comment on that? We offer a program called the Supply Chain Gap Program which is really what we're talking about. And we can identify HS Code products where there's a lot being imported, 100 million dollars a year or more, and nothing or almost nothing being developed -- produced here in the country. And then we've been offering that to states in the thought that they can identify the products that are significantly imported into their region.

And they pick the products that are of interest to them. And then we can tell them who the foreign suppliers are that are shipping the product in, and that go to them sequentially to convince one of them to come over here and build a factor in Michigan or Indiana or wherever it happens to be. So there's some sort of practical things that can be done on the ground to supplement the sort of national perspective.

COMMISSIONER BOROCHOFF: I want to thank everybody. That will complete our Panel II, and we were scheduled for 12:50. It's 12:48. I want to say thank you to our panelists, all of you. And we'll be reconvening at 1:40.

(Whereupon, the above-entitled matter went off the record at 12:49 p.m. and resumed at 1:41 p.m.)

ADMINISTRATION PANEL INTRODUCTION BY COMMISSIONER CARTE GOODWIN

COMMISSIONER GOODWIN: Good afternoon. Welcome back for our next panel. We will be hearing about the Department of Defense efforts to strengthen the defense industrial base and mitigate risk posed by China. We're happy to welcome here today Deborah Rosenblum currently performing the duties of the Assistant Secretary of Defense for Industrial Base Policy.

In this role, she serves as the principle advisor to the Secretary, Deputy Secretary, and Under Secretary of Defense for acquisition and sustainment on industrial base policies. Her principle duties, the overall supervision of the Defense Department's efforts to develop and maintain the defense industrial base of the United States to ensure secure materials critical to national security. Appreciate you taking the time to visit with us today. Welcome. Please begin.

OPENING STATEMENT OF DEBORAH ROSENBLUM, PERFORMING THE DUTIES OF ASSISTANT SECRETARY OF DEFENSE FOR INDUSTRIAL BASE POLICY

MS. ROSENBLUM: Thank you very much. I want to begin by thanking all of you for your invitation to testify today regarding the national security implications of supply chain dependencies on China as well as the roles that government and the private sector are playing and can play in the future to secure defense critical supply chains. It is my honor and pleasure to represent the Department of Defense today. I look forward to the discussion as well as an opportunity to address your questions.

Supply chain resiliency is a top of mind issue in a way that it has not been for decades. And efforts are underway across the U.S. government to try and better understand and mitigate some of our more glaring supply chain vulnerabilities. Since the end of World War II, the dominant economic theory has been trade liberalization.

Nations leverage this approach, implementing export led development strategies, for example, the rise of Japan in the '70s and '80s as well as the opening of China in 1979. Meanwhile, suppliers and producers were looking for opportunities to lower their costs, to meet the consumer's demand for the lowest priced goods and investor's demand for high returns. Manufacturers identified increasingly more efficient allocation of capital to drive down costs associated with labor and regulation which included a focus on efficient distribution systems, just on time delivery.

The overall result is the complex global supply chains we see today with concentrated manufacturing in Asia for components such as strategic materials in China, semiconductors in Taiwan and South Korea, and a highly efficient but brittle distribution system. The growth of China's manufacturing prowess is not by accident. Their leadership recognized the opportunities in a business environment seeking the lowest cost supplier and purposely directed its resources to prioritize initiatives while simultaneously generating uncertainty and inefficiencies in areas not prioritized by the Chinese Communist Party.

Priority initiatives like the civil military fusion bypassed the larger economies market inefficiencies as long as the economy continues to grow which helps explain why China is now positioned itself to hold 7 of 15 of the world's leading defense firms. China is making deliberate efforts to secure supply chain inputs necessary to manufacture military capabilities. Eighteen out of 37 defense-related minerals are concentrated in China with 14 more concentrated in countries with whom China has strong diplomatic and economic relationships, such as Russia, Brazil, and the Belt and Road Initiative countries.

Conversely, only 5 defense-related minerals are concentrated in the United States, Australia, and Canada. China's manufacturing accounts for roughly 25 percent of the worlds' manufacturing output. Within this 25 percent, 50 percent of China's manufacturing output can be considered dual use.

Although China is making efforts to develop their own domestic alternatives, they continue to rely on U.S. allies and partners for critical military technology imports such as aircraft and naval engines. Today, China is capable of world leading military technology innovation. Even adjusting for quality, China's military patent output was greater than the United States in 2019 at 544 coming from China compared with 369 from the United States. China demonstrates particular patent leadership in technologies related to munitions.

China's ability to offer low priced -- excuse me -- low prices for goods are a challenge for the U.S. manufacturing, including those in the defense industrial base.
China's competitive

pricing and aggressive market capture strategy has led DoD suppliers to source materials from Chinese producers. Predatory capital from the PRC continues to erode DoD's mission by undermining the foundation of the defense industrial base's manufacturing and technology advantage.

An estimated 500 billion worth of IP is either stolen or coopted each year by the PRC. Especially today in our interconnected and globalized society, it is critical that the United States leverage its available resources and advantages to take proactive measures towards strengthening our industrial base broadly and certainly bringing innovation and commercial technologies to reinforce resilience and security in our defense supply chain and to accelerate our technological superiority over our adversaries alongside of our partners and allies. In my written statement, I have outlined a series of White House and DoD led efforts to strengthen the defense industrial base.

I look forward to discussing them in detail with you during our question and answer period. It is worth noting however that the Department of Defense is focused in particular on addressing challenges in high priority areas critical to our military's operational readiness. These include kinetic capabilities, excuse me, energy storage and batteries, castings and forgings, microelectronics, and strategic and critical materials.

We are also prioritizing strategic enablers that underpin overall mission success and supply chain resilience, such as the workforce, cyberposition, small business, and manufacturing capabilities. Our strategic encompasses efforts that we are undertaking within the Department of Defense itself as well as those that we are doing in collaboration with a number of external stakeholders. The United States government and the administration increasingly recognizes that the supply chain resilience is both a whole-of-government as well as a whole-of-economy requirement, necessitating analysis and solutions emanating from the interagency industry as well as our international partners.

Revitalizing supply chains requires that the United States make cooperative, strategic, and timely decisions to build domestic capacity, collaborate where we can with partners and allies, and safeguard our markets. This approach when balanced across both supply and demand will facilitate the development of a robust market as well as a strengthened defense industrial base. We recognize that we're addressing a problem 70 years in the making, and our current efforts are in many ways a down payment on a very large and complex set of challenges.

Thank you again for the opportunity to testify. Economic security is national security, and our policies reflect that mentality. I hope that this overview of both what's happening in terms of U.S. dependency to a great extent on China and the materials and minerals that it has as well as some of our efforts are helpful to your inquiries. And I'm happy to take your questions. So with that, thank you.

PREPARED STATEMENT OF DEBORAH ROSENBLUM, PERFORMING THE DUTIES OF ASSISTANT SECRETARY OF DEFENSE FOR INDUSTRIAL BASE POLICY

June 9, 2022

Prepared Statement of Deborah Rosenblum, Performing The Duties Of Assistant Secretary Of Defense For Industrial Base Policy, U.S. Department of Defense

Testimony before the U.S.-China Economic and Security Review Commission Hearing On "U.S.-China Competition in Global Supply Chains"

Commissioners Borochoff, Goodwin, and Schriver, I would like to begin by thanking you and your fellow Commissioners for the invitation to testify today regarding the national security implications of supply chain dependencies on China, as well as the roles government and the private sector can play in securing defense-critical supply chains.

It is my honor and pleasure to represent the Department of Defense today. I look forward to hearing from the Commission today and for the opportunity to answer your questions.

Supply chain resiliency is a top-of-mind issue in a way it has not been for decades, and efforts are underway across the U.S. government to understand and mitigate some of our most glaring supply chain vulnerabilities. For more than 50 years, market forces in the United States have prioritized supply chain efficiency over supply chain resiliency; events of the last few years (COVID-19, Ukraine conflict) have crystallized the need to prioritize and build supply chain resilience.

As you are aware, President Biden issued Executive Order (E.O.) 14017, America's Supply Chains, within his first 100 days in office, aimed at revitalizing, fortifying, and in some instances rebuilding our domestic supply chains. The United States government continues to take action to strengthen our supply chains through this E.O., which called for a comprehensive review of supply chains in the form of two directives to assess supply chain health and resilience.

The first directive was a 100-day assessment of four areas – semiconductors (led by the Department of Commerce), pharmaceuticals (led by the Department of Health and Human Services), high-capacity batteries (led by the Department of Energy), and critical minerals and materials (led by the Department of Defense, which also supported the other three reviews). The responses were consolidated and published on June 8, 2021. The E.O. also called for one-year assessments of supply chains in critical sectors, directing the Department of Defense to submit a report on supply chains in the defense industrial base (DIB) that was published in February of this year.

The Department of Defense's report focuses specifically on addressing challenges in high priority areas critical to operational readiness, including: kinetic capabilities; energy storage and batteries; castings and forgings; microelectronics; and strategic and critical materials. We also highlight strategic enablers that underpin overall mission success and supply chain resilience, such as workforce, cyber posture, small business, and manufacturing capabilities. Our strategy encompasses efforts to be undertaken internally within DoD, as well as those in collaboration with external stakeholders.

The United States increasingly recognizes that supply chain resilience is both a whole-of-government and a whole-of-economy requirement, necessitating analysis and solutions emanating from interagency, industry, and international partners. Revitalizing supply chains requires that the United States make cooperative, strategic, timely decisions to build domestic capacity, collaborate with partners and allies, and safeguard our markets. This approach, when balanced across both supply and demand, will facilitate the development of robust markets.

The Department is prioritizing China as our long-term pacing challenge. Beijing has demonstrated increased military confidence and a willingness to take risks. Simultaneously, we face other advanced and persistent threats – as clearly evidenced by Russia's invasion of Ukraine. Russia, Iran, North Korea, and other adversarial transnational and non-state actors are not forgotten in our supply chain resiliency efforts.

Supply Chain Vulnerabilities and Their Impact on U.S. Military Readiness.

We at the Department find that U.S. reliance on sole-source suppliers and foreign sources poses risks to domestic capability and capacity to produce the products we require. Over time, many domestic suppliers have lost business and/or exited the market due to unpredictable DoD procurement practices and competitive pressures from foreign nations, particularly China.

The average American aerospace company relies on roughly 200 first tier suppliers. The second and third tiers have more than 12,000 companies.[1] With globalization of supply chains, these suppliers and their goods come from a wide array of places. Some foundational industrial supply chain sectors, like optical instruments, mechanical gears, welding equipment, and printed circuit boards, source a large part of their components from outside North America.[2]

For instance, in 1990, the U.S share of global semiconductor manufacturing capacity stood at 37 percent. In 2020, the U.S share had declined to 12 percent.[3] 88 percent of the production, and 98 percent of the assembly, packaging, and testing of microelectronics is performed overseas—primarily in Taiwan, South Korea, and China (with China aggressively pursuing a larger market share).[4]

The concentration of global supply chains for strategic and critical materials in China creates risk of disruption and politicized trade practices. For example, China dominates the global advanced battery supply chain, including lithium hydroxide (94 percent), cells (76 percent), electrolyte (76 percent), lithium carbonate (70 percent), anodes (65 percent), and cathodes (53 percent).[5,6] China's lower production costs make importing materials more profitable than producing the same material domestically. It reduces the likelihood of U.S. private capital investment, leading to erosion of the profitability and competitiveness of U.S. manufactured materials and resources.[7]

China's ability to offer low prices for goods are a challenge for U.S. manufacturers including the Defense Industrial Base. China's competitive pricing and aggressive market capture strategy has led DoD's suppliers to source materials from Chinese producers. For instance, China has captured more and more of the global steel market, pushing U.S. suppliers out of the market, making it harder to get steel for things like rocket motor cases, including for some missiles the U.S. is supplying to Ukraine. Low-volume and volatile procurement driven by U.S. Government and DoD practices compound China's price advantage by generating high startup costs and limited profits for U.S. businesses. [8]

U.S. supply chains currently involve significant materials and products from foreign manufacturers. For example, China produces more tonnage of cast products than the next seven highest producing countries, and over four times as much as the U.S. DoD counts on China for very large cast and forged (C&F) products used in the production of some defense systems and many machine tools and manufacturing systems on which the DoD is reliant. [9] DoD's one-year E.O. 14017 report noted that C&F parts are critical to the development, procurement, and sustainment of all major defense systems, including surface ships and submarines. Multiple U.S. sources report that China can often deliver a completed item for the same cost that a U.S. forge will pay for the raw materials needed to produce the parts of an item. The Department plans to make significant investments through the Industrial Base Analysis and Sustainment (IBAS) program and Navy to help de-risk naval vessel production plans. We are also extending existing IBAS and Navy partnerships with Oak Ridge National Lab to refine ways to supplement C&F capabilities, including additive and hybrid manufacturing processes, and advanced digital metrology.

The Office of the Under Secretary of Defense for Acquisition and Sustainment (A&S) is also focused on ensuring that the Department acquires and sustains the country's defense capabilities from trusted sources. A&S also represents the Department within interagency organizations, like the Committee on Foreign Investment in the United States (CFIUS) and Team Telecom, to protect industrial base interests through the national security lens. We have found that predatory capital from the People's Republic of China (PRC) erodes DoD's mission by undermining its foundation - the DIB's manufacturing and technology advantage. An estimated $500 billion worth of intellectual property is either stolen or co-opted by the PRC annually.

How the Department of Defense is Addressing Weaknesses in Defense-Critical Supply Chains.

DoD is committed to strengthening its industrial base and establishing a network of domestic and allied supply chains to meet national security needs. Given the breadth and scale of defense supply chains, DoD is initially prioritizing four areas in which critical vulnerabilities pose the most pressing threat to national security as outlined in the February 2022 E.O. report. These focus areas are:

- **Kinetic capabilities**: current missiles systems and advanced and developing missile capabilities, including hypersonic weapons technology, as well as directed energy weapons
- **Energy storage and batteries**: high-capacity batteries, particularly lithium batteries
- **Castings and forgings**: metals or composites developed into key parts and manufacturing tools through high-intensity processes
- **Microelectronics**: State-of-the-Practice (SOTP), legacy, and State-of-the-Art (SOTA) microelectronics.

This report also provides an update on the implementation of recommendations in DoD's Review of Critical Minerals and Materials, included in the 100-day response to E.O. 14017 published on June 8, 2021,[10] such as the delegation of the authority to release stocks from the National Defense Stockpile to the USD(A&S) from the President in E.O. 14051. To date, DoD's investments in enhancing the U.S. rare earth supply chain resiliency have resulted in over $140 million in commitments to address domestic rare earth element processing capabilities and capacity.

Underpinning all four key focus areas are strategic enablers that are required for mission success. Fragility or gaps in these enablers create operational and strategic risk, and addressing the challenges in each is critical to building overall supply chain resilience. The strategic enablers are:

- **Workforce**: trade skills through doctoral-level engineering skills
- **Cyber posture:** industrial security, counterintelligence, and cybersecurity
- **Manufacturing:** current manufacturing practices, as well as advanced technology like additive manufacturing
- **Small business:** the role of key members of DoD supply chains

Across all focus areas and enablers, the Department identified certain foundational recommendations that enhance and grow its industrial base, and that are critical to the Department's overall ability to make strategic informed acquisition and sustainment decisions. These recommendations are:

- **Build domestic production capacity:** For defense-critical supply chains, the U.S. is committed to ensuring that it has reliable and resilient production access within its domestic and allied DIB.
- **Engage with partners and allies:** The U.S. is collaborating with its international partners and allies to develop policies and arrangements that strengthen our DIBs and improve supply chain resilience.
- **Mitigate Foreign Ownership, Control, or Influence (FOCI) and safeguard markets:** The Department is committed to protecting its supply chains from adversarial FOCI by scaling efforts to identify and mitigate FOCI concerns.
- **Conduct data analysis:** DoD will continue to build on previous efforts to expand its supply chain visibility by collecting and organizing key data, facilitating better risk assessment.
- **Aggregate demand:** The Department will better signal to industry what the likely total demand is across multiple programs, so industry can better anticipate number of orders from year to year.
- **Develop common standards:** To leverage commercial sector innovations, and to embed modernizing technologies in weapon systems, DoD will work, where possible, to limit its use of military-unique requirements when developing performance requirements.
- **Update acquisition policies:** DoD should engage in efforts to develop a whole-of-government strategy and implementation plan to engage with industry and Congress to

determine which policy and regulatory changes would encourage expansion of capabilities.

Efforts Underway to Improve Visibility into Defense Supply Chains.

We recognize that we are addressing a problem 70 years in the making, and our current efforts are a down payment on a very large and complex set of challenges. Continuing to build supply chain resilience requires strategy, commitment, and collaboration. DoD is actively mapping the supply chains linked to the U.S. defense industrial base. This effort will begin with evaluating the data needed to inform real-time supply chain management decisions. Collecting and organizing key data will position the Department to maximize the use of analytic tools and mitigation strategies to proactively identify and address trends, vulnerabilities, and disruptions.

On August 30, 2021, the Under Secretary of Defense for Acquisition and Sustainment established a Supply Chain Resiliency Working Group to address systemic barriers currently limiting supply chain visibility, conduct resiliency assessments, and develop effective mitigation actions. Recognizing the diverse set of challenges facing different supply lines, DoD established five priority areas, aligned to the E.O. 14017 focus areas, to begin developing bespoke supply chain plans: castings and forgings; missiles and munitions; energy storage and batteries; strategic and critical materials; and microelectronics.

The U.S. government has also created a variety of entities designed to help companies coordinate more effectively across the U.S. industrial base, and improve defense supply chains. DoD will continue to support entities like the Defense Innovation Unit and DEFENSEWERX, which establish relationships with commercial suppliers and improves DoD's visibility into small and medium sized firms interested in integrating into DoD supply chains.

The Department is also leveraging and expanding all available investment authorities, to include the Defense Production Act (DPA), to maintain national defense capabilities such as the domestic production of strategic radiation-hardened electronics and the hypersonic weapon industrial base. If those capabilities are not available or viable domestically, the Department – in conjunction with other U.S. Government agencies – is working to encourage investments and funding for ally-sourced or near-shored capabilities.

DoD also works with industry to develop assurance and security standards for critical-defense industries like microelectronics. Aligning these types of standards helps ensure the mutual security and resiliency of commercial and DoD microelectronics supply chains, while also increasing industry's visibility into DoD's future technology needs.

Workers are a critical component of supply chains, and make them possible. In U.S. manufacturing, the gap between open positions and available workers is not expected to close, with an "estimated 2.1 million unfilled jobs by 2030." DoD continues to encourage careers and education in not only STEM fields but critical manufacturing jobs, horizontally and vertically through other Federal Government agencies and through state and local governments, including school districts. Closing the 2.1 million jobs gap will go a long way towards ensuring critical defense industries have the workers necessary to mitigate weaknesses in critical supply chains.

Through our IBAS program, the Department established the National Imperative for Industrial Skills initiative, where we work with industry and academia. Since fiscal year 2019, we have invested over $80 million in industrial workforce development and training projects to help improve or scale workforce pipelines. The intention of this initiative is to support a variety of defense weapon system development, production, and sustainment needs, with a focus on skills such as welding, advanced machining, electronics, precision optics, metrology, digital/additive manufacturing, and other emerging Industry 4.0 skills.

Conclusion.

Thank you again for the opportunity to testify. The examples I have shared today and the sector specific recommendations in our reports highlight the initial set of actions the Department is taking to renew the DIB and maintain its position as the world leader in innovation well into the 21st Century. Economic security is national security, and our policies reflect that mentality. I hope that this overview is beneficial to your efforts, and I am now happy to answer your questions.

[1] McKinsey & Company, "Why Now is the Time to Stress-Test Your Industrial Supply Chain," 27 July 2020

[2] DoD, Security Defense-Critical Supply Chains, pg. 5, February 2022

[3] Boston Consulting Group/Semiconductor Industry Association, "Government Incentives and U.S. Competitiveness in Semiconductor Manufacturing". Presentation. 2020.

[4] DoD at 33

[5] Benchmark Mineral Intelligence. Benchmark Mineral Intelligence Report, Battery Components Manufacturing Asset Map 2019.

[6] National Minerals Information Center, Mineral Commodity-Specific Supply Risk Mitigation Framework, PowerPoint Presentation June 10th 2021 Minerals Resource program, USGS referencing S&P Global Market intelligence, Roskill, Bloomberg NEF, International Energy Outlook and BCC Research data.

[7] DoD at 14

[8] DoD at 27

[9] DoD at 32

[10] United States, White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, And Fostering Broad-Based Growth, 100-Day Reviews Under Executive Order 14017*. June 2021.

ADMINISTRATION PANEL QUESTION AND ANSWER

COMMISSIONER GOODWIN: Thank you very much. Before I turn it over to questions, I will say you have been exceedingly gracious with your time. And we do have a little less than 40 minutes to get through everyone.

If you had a chance to watch any of the hearings this morning, you may have noticed that many of my colleagues like to frame their own testimonies in the form of a question, often exceeding the five-minute threshold.

MS. ROSENBLUM: Rumor has it that that happens here occasionally.

COMMISSIONER GOODWIN: So I would just encourage everyone to be mindful of those time limits as we get started here. Going back to alphabetical order, we'll begin with Commissioner Bartholomew.

COMMISSIONER BARTHOLOMEW: Thank you very much. And thank you, Madam Secretary, for both for your testimony today and for your service over the years. We've all benefitted from it.

I guess it's just a simple question for me. We, of course, on this Commission have been looking at this issue going back into the aughts. How far down the U.S. manufacturing chain do we know where products are being manufactured? It seems to me I remember that we didn't know from Tier 2 or Tier 3 or below.

MS. ROSENBLUM: Yes, thank you, Madam Commissioner. That remains a challenge for us. It is not with high confidence that we have visibility into the second and third and even lower tiers of the supply chain.

It's an area that we recognize as a vulnerability that over time we have lost that level of visibility. And it's one of the areas that we are increasingly trying to focus on, not only at the Department of Defense but also encouraging a number of the primes to make sure that they themselves are keeping track of where those supply chains are. And quite honestly, our current experience with working to replenish the munitions that we are providing to Ukraine along with those of our allies is really demonstrating to us in vivid relief the degree to which we still have a lot of work to do to be able to regain that level of visibility.

And I know one of your questions and we'll come to it. We'll talk about the reviews and in far greater detail. But that is really one of the most recent examples to us that's reminding us of the work that we need to do in this area.

COMMISSIONER BARTHOLOMEW: Great. Thank you. Mr. Chairman, I will go ahead and defer the rest of my time to somebody else.

COMMISSIONER GOODWIN: Thank you. Commissioner Fiedler.

COMMISSIONER FIEDLER: Ma'am, my question goes to whether or not we have increased the number of sole source contractors over the last, say, decade in the defense industry, number one. Are we more dependent on single companies for our weaponry?

MS. ROSENBLUM: So as a general rule, the defense industrial base particularly as it relates you're talking about the contracts has become less competitive. It's an area where we are actively working to try and increase the competition, but not just at the prime level. But also it's an area of focus for us with regards to small business and really trying to have a number of different policies and approaches that were taken to encourage new entrants into the market. I'd have to get back to you on a specific trend line with regards to sole sources. But as a general rule, the decreasing competition is something that we're worried about.

COMMISSIONER FIEDLER: Let me give you an example. Some years ago there was an enforcement action against apparently the only night vision goggle manufacturer in the United States for the Defense Department who had been subcontracting that work to Singapore who in turn had subcontracted it to China. The single source problem in the lack of transparency into the subcontractors seems to be an extremely dangerous situation.

MS. ROSENBLUM: So while I can't talk to the specifics of what you identified here in terms of night vision, I certainly can in terms of the broader comment that you're making here that with the globalization of the markets and the demand for and competition between companies and countries quite frankly for different military technology and supplies is an area that we are continuing to focus on and really looking hard at what are the key areas where we feel that the Department of Defense is overly reliant or greatly reliant on overseas sources for both with regards to critical minerals and critical and strategic materials as well as those that most directly impact our operational readiness. And in one of the reports that we sent forward which was done recently by the Department of Defense released in February that takes a look at Defense's critical supply chains. They're the five areas that I outlined in my remarks that are of particular importance to us.

COMMISSIONER FIEDLER: Thank you very much.

MS. ROSENBLUM: Thank you.

COMMISSIONER GOODWIN: Commissioner Friedberg.

COMMISSIONER FRIEDBERG: Thank you very much. I had a couple of questions. First, just following up on what you said to be clear. Are you saying that we are undertaking efforts to look down into the lower tiers of industry in those five sectors? Is that --

MS. ROSENBLUM: Yes.

COMMISSIONER FRIEDBERG: -- where the focus is?

MS. ROSENBLUM: Yes, yes, we are. We are taking a number of initiatives and have identified this as a key focus area where we need to better understand what is happening in those subtiers. And the situation related to Ukraine gives us exactly a case, and I'll go into it in greater later, of why that is the case.

COMMISSIONER FRIEDBERG: And can you say a little bit more about how exactly that's being done? Who is doing that? Is it industry? Is it government? If so, which agencies of the government and how are they collecting that information?

MS. ROSENBLUM: So yeah, it's being done by both. Certainly, the Department of Defense is encouraging private industry to have better granularity around some of its subcontractors. And we are also doing it at the Department of Defense as a combined effort. Really with the services in terms of working with them to be identifying where some of the subcontractors are, what the state of the health is of those companies. And so it is a Department-wide effort that we're trying to focus on.

COMMISSIONER FRIEDBERG: So it's not just focused on -- you mentioned the prime contractors as having -- or you're trying persuade primes to have more responsibility for looking down into the lower tiers?

MS. ROSENBLUM: Yes, but it's not just limited to the primes.

COMMISSIONER FRIEDBERG: Okay. Do you have any sense of how much this is currently costing the Defense Department or how much it is likely to cost to get to the level of insight and granularity that you think is necessary?

MS. ROSENBLUM: I do not right now. This is an effort that's relatively new in terms of our area of focusing on this. So let me get back to you on that.

COMMISSIONER FRIEDBERG: Okay. This is the last question and maybe something that you can't talk about or it's outside the scope of what we're discussing. But is the Department of Defense to your knowledge making efforts to identify vulnerabilities -- equivalent vulnerabilities in China's supply chains?

MS. ROSENBLUM: I'm sorry. In China's supply chains?

COMMISSIONER FRIEDBERG: Yes.

MS. ROSENBLUM: At a broad level, yes.

COMMISSIONER FRIEDBERG: Okay. Thank you.

COMMISSIONER GOODWIN: Vice Chair Glas.

VICE CHAIR GLAS: Thank you, Assistant Secretary, for your testimony today. Just a couple quick follow-up questions on contracting. I know DoD has done a number of really well-done reports around that there may be only one supplier for certain essential elements, whether it's raw materials.

And you were talking about our military infrastructure here has waned as a result of a variety of different things, right, unfair competition, whatever it is. So I'm trying to think about the fact that the Defense Production Act which a lot of Americans and members of Congress weren't really aware of until we hit COVID-19. How is the Department thinking about deploying the Defense Production Act when you have identified over a number of years there's only one supplier?

Maybe that the one that you have the contract with -- or maybe as we all were talking about here understanding transparency and it's a subcontractor -- about how to prioritize how to use the Defense Production Act. And also I'm sure some of these things keep you up at night. So if you were to give some of your immediate top tier policy recommendations to Congress, what would help you sleep better, better demand signal from appropriations, different contracting vehicles, like, instead of lowest price technically acceptable, having a little more flexibility with manufacturers on contracting practices, understanding subtier suppliers, or anything else.

MS. ROSENBLUM: Yeah, so great, thank you very much. Let me take those questions in turn. With regards to the different Defense Production Act, it is an invaluable tool that we have to make key strategic investments towards developing alternative sources in the United States.

So for instance, the Department used in the past year the Defense Production Act monies to make a critical investment in mining. And it is a capability in California that's not only for the production but also for the processing. So it's the ability to make some of the key strategic areas where as part of our onshoring strategy that we are developing plans for key strategic investments across the five areas that I articulated over the next two to three years.

But I also want to raise that it's not just with regards to making some key investments in that capability. But it's also using tools that we have as part of the Defense Production Act in some key areas around workforce. And in order for us -- and I mentioned this as one of the key strategic enablers.

And this is one of the areas that keeps me up at night because no matter what kind of money we put against some of these key investments which are critical, they will only be as effective if we have a manufacturing workforce here in this country that has the capacity to carry forward with the major military modernization programs, particularly in the area of ship building, that we're trying to get done. And this is something from our perspective that we really need to be doing in partnership with high schools, with community colleges, with technical colleges. And the Department has some pilots that we're doing, particularly in Virginia and the

Mid-Atlantic just because of the heavy concentration there of shipbuilding to really be able to see whether through partnerships with -- excuse me, with community colleges and technical schools, we can begin to develop the kind of manufacturing workforce that we need to do.

The other area that we are very focused on and this relates to the fact that even with these key investments through the Defense Production Act and in other areas, these are capital intensive and they take quite a bit of time. And it's not something that's going to turn on a dime. And as a result of that, we are focused very much with some of key and closest allies and partners such as Canada, Australia, the U.K., New Zealand. What are ways in which we can either do joint things together or where they may have certain key critical materials and minerals and areas where we are focused on that can help in the near term while we are developing further our capabilities with regards to that?

COMMISSIONER GOODWIN: Thank you. Commissioner Mann.

COMMISSIONER MANN: Thanks. I think I want to thank the Assistant -- did that come through? I'm going to pass on questions.

COMMISSIONER GOODWIN: Okay. Commissioner Schriver.

COMMISSIONER SCHRIVER: Thank you, Madam Secretary. Appreciate your appearance and testimony and very much appreciate your long career of public service --

MS. ROSENBLUM: Thank you.

COMMISSIONER SCHRIVER: -- including going back into the breach once again for this position.

MS. ROSENBLUM: Thank you.

COMMISSIONER SCHRIVER: I wanted to ask about the partners and allies piece because I think sometimes there are issues that are sort of conceptually very easy to grasp and understand what the challenges are and what we need to do. But then to operationalize becomes very difficult, how you actually do concrete actionable things. So process-wise, do you feel that the various fora exists for you at your level to plug in and have these substantive discussions and really develop concrete areas of cooperation with some of our key partners in the supply chain? Do you know our counterparts in Asia? Do you have confidence that our leaders when they meet might have this as a talking point but it goes beyond that and gets into the concrete cooperation?

MS. ROSENBLUM: Yeah, no, thank you. And thank you also for your long service and certainly including most recently. So I think the most accurate way to answer that in the way that I think about it is it is a work in progress.

And as I mentioned at the top of my remarks, this is not an area that has been -- and I think this is what, Commissioner Schriver, you're alluding to that this is not typically been top of mind and the highest priority when very senior level people get together amongst allies and partners. But I think COVID and really the pivot to the pacing challenge presented by China and then the acute challenge from Russia has really helped to focus the minds in a much greater way, particularly amongst our allies and partners. I have made it a personal priority to get to know my counterparts that are responsible for their supply chains amongst the allies.

There is a forum that was set up by Congress, the NTIB, that the -- I think it's called National Technical Industrial Base. And it targets Canada, the U.K., U.S., and Australia to be able to work together in a very concrete manner. And the invasion of Ukraine and the need to have replenishment, not just in the United States but amongst these allies that are also providing support to Ukraine is helping to focus that.

And so some of the work that we are going to be doing going forward on the NTIB is not going to just be theoretical around where we can agree on giving minerals or materials but very focused on in Ukraine these are the areas where we see problems with the supply chain. How can we work together to address that? And being an area that is front and center now but hasn't been, we still need that ramp up time to have this become more of the regular cadence. When the Secretary, the Deputy Secretary, the Under Secretaries, not just at Defense but really at Agriculture and Commerce and where this is as a whole-of-government area of work that this is something that we need to be talking with the allies about.

COMMISSIONER SCHRIVER: Thank you. Appreciate that answer. I might just also comment and you can either respond or not. I think Taiwan is a case of particular interest given its role in the supply chain and the area that you identified of microelectronics.

And of course, we don't have a diplomatic relationship with Taiwan. They're not in the IPEF. So it's my view that we would benefit from something at a senior level dedicated between the U.S. and Taiwan on this particular issue. As I said, that's an opinion. You can either respond or not. But again, thanks for your input today.

MS. ROSENBLUM: Thank you very much.

COMMISSIONER GOODWIN: Commissioner Scissors.

COMMISSIONER SCISSORS: I have a naive question. DoD does -- it's related to Aaron's question. But I don't want to tarnish him with my naivete.

DoD does a lot. Many or most products have extensive quality control requirements. Why can't DoD -- with a phase-in period. Obviously there needs to be time, and the phase-in period is going to vary by product.

Why can't DoD require its suppliers to disclose their full supply chain as part of the cost of supplying the Department of Defense? No, I don't know -- no, it doesn't stop after Tier 2 when you don't know what's going on. You don't have to know what's going on if you want to supply us.

Now I'm not suggestion, just to reinforce this, that tomorrow they have to know these things. But with a phase-in period just like every other element of quality control the DoD says if you want to participate, we need to know where everything came from. And if you can't figure that out, you cannot use that supply chain.

You have to use a supply chain that's been verified. Again, there's going to be cost and time involved. I'm not denying that. But I'm wondering if there's something prohibitive that I'm missing.

MS. ROSENBLUM: That's something that I'm not in a position to speak to in terms of what the actual regulations are with regard to that. So, I'd like to get back to you on that one.

COMMISSIONER SCISSORS: I'll ask a follow up because as Carte implied, I just like talking. This is an econ --

(Laughter.)

COMMISSIONER SCISSORS: Everybody just chimed in right there. This is an econ version of this. And so it may be -- it's definitely partial and you may not be able to address it.

I completely understand your focus on labor and how important it is. No disagreement. We have pretty good information about the labor market. So where would you place your biggest -- I guess this echoes Kim's question. Where would you place your biggest concern? I understood your answer to her saying labor is a big deal and I agree. But it's a known problem.

When you talked about minerals and I read the DoD supply chain report and I've read other supply chain work from DoD. It doesn't really matter the 32 of the 37 are concentrated in a country. What matters is this exact real demand-supply relationship, right, not who has the reserves because that's endogenous to exploration and all that.

So it doesn't seem to me that DoD has a very good grasp of the materials side. It may not have a good grasp of the equipment side going down the supply chain how the equipment is made. Given the information problem, would you still put labor first?

Or would you feel like, I feel like there's something unknown out there that's really scary for us? And this is basically a follow-up to Kim's question, and your answer was fine. But I thought, but we know the labor market situation. And I'm not sure we know about some elements of the supply chain.

MS. ROSENBLUM: So, I look at it as a continuum. So, in the sense of as we better understand where our vulnerabilities are, we try and address them as quickly as possible. And so, I apologize if I led to the mistaken impression that the only thing we care about is labor. That is absolutely not the case.

But we do know that as a country, we are not manufacturing in a way in which we were decades ago. And as a result of that -- and I say that as a value neutral statement. So as a result of that, we do not have people that get out of high school or college and say, wow, I want to go into manufacturing.

So, we need to regenerate that, and that's going to take a while to be able to do that. There is in two-year point end terms of where we have visibility on different pieces and different areas of it, what I would say is we have a good idea with regards to where minerals and materials are that we rely on for be it equipment and other things that we are doing. The question becomes one of having to make assessments with regards to when those supplies are going to become vulnerable to industry to be able to use them.

And in some cases, it's a result of unexpected events. I mean, we all sat around and didn't know definitively whether Putin was going to launch and unprovoked invasion in Ukraine. There are direct ramifications to the markets for some of the minerals that we rely on.

So, I think it's -- so that's where when we are having to make decisions around limited investment dollars even though the amount that's gone into the Defense Production Act is certainly gone up, it's still a finite amount of resources that it is not just making sure that we have the visibility. But it's also the calculus of which ones of these are more vulnerable necessarily than others so that we can address them and find ourselves in a position either to be onshoring it or working with our allies to address where the concerns are.

COMMISSIONER SCISSORS: Thank you.

COMMISSIONER GOODWIN: Commissioner Wessel.

COMMISSIONER WESSEL: Thank you. Thank you for your service. Thank you for being here today. Two questions, first, as part of your overall examination of this issue, wondering where a scrub of the DFAR comes in. We in this Commission have identified vulnerabilities in the past.

For example, for some period of time, DoD could only look at foreign sources of supplies related to items of the munitions list. C4ISR is not on the munitions list. So, it was the procurement specialists appropriately.

We're looking wherever they could get the least cost products. So number one, how does DFAR fit into this? How do we try and promote the development of our supply chains here and reduce vulnerabilities? That's number one.

Number two, broken record since I've raised it on each panel, Congress has before it an outbound investment screening review mechanism that is bipartisan and bicameral that looks at critical supply chains and whether capabilities are being outsourced to China and other potential adversaries. And if that would undermine U.S. interests, either seek to mitigate those or in worst case prohibit them. Is that an authority you think would be valuable to the Department of Defense?

MS. ROSENBLUM: Great. Thank you. So first off, thank you very much for raising the issue around just updating acquisition policies broadly and more than certainly the DFARS. That is an area that we are focused on for a wide variety of reasons. And the resiliency of the supply chain and strengthening the defense industrial base will be a benefit of that without a doubt.

So that absolutely is an area that we are indeed very focused on. And within my organization is working very closely with the parts of the Under Secretary of Acquisition and Sustainment where there's relevancy with regards to that. And that will help us broadly also in terms of bringing new entrants into the defense industrial base.

It'll help with other areas in terms of transparence, in terms of being able to use more flexible acquisition authorities that we have. And so, it's less around needing new or different authorities than it is really using the ones that we have. So, thank you for giving me an opportunity to be able to kind of foot-stomp that.

So thank you. Appreciate that. With regards to your comment on the outbound investment, I would like to -- if you'll respect me on this -- not comment on that particular piece but to talk kind of more broadly on an area that we are focused on. And that is with regards to CFIUS and the role that being able to stop or prevent the further degradation of some key capabilities within our defense industrial base is very important.

And we see it as kind of a balancing that we cannot just do that with that so that it's not just that we're saying no to certain things. But it is that we are balancing that with proactively using the investment tools that we have to be able to invest in developing of the capabilities here in the United States and then certainly those of our allies and our partners. But it is very much an active lever that we do use and do take very seriously as a way to strengthen the defense industrial base.

COMMISSIONER WESSEL: Thank you. Just as for your last point, I would urge you -- and I know there's some work going on about the intersection of CFIUS with bankruptcy courts --

MS. ROSENBLUM: Yes, yes.

COMMISSIONER WESSEL: -- where that is a vulnerability that is not subject to full review. And we've seen some problems there. So, I would welcome any actions in that venue.

MS. ROSENBLUM: Thank you. Thank you for that recommendation. It is absolutely not lost on us that that is an area where companies who have capabilities can get bought.

COMMISSIONER GOODWIN: Chairman Wong?

CHAIRMAN WONG: Thank you. Secretary Rosenblum, thank you for being here again today. I just want to focus a little bit on the workforce human capital piece of your testimony. You talk about some of the initiatives that DoD has pursued to develop industrial skills. And just a question, in the main, are these industrial skills that you're focusing on, do they require or arise out of four-year college degrees? Or are they not out of the four-year track?

MS. ROSENBLUM: We do not believe that the skills that we are looking for require. And we, of course, have some skills that require a four-year degree and engineering degrees and things like that. But that there are other skills where that is absolutely not required. And so that's why we are keenly focused in and aware of trying to have there be an attractive and economically competitive path for people who may elect not to go to four-year college but rather are interested in welding, interested in really project management, the whole range of the skills that are ultimately going to be need to be done to have a robust manufacturing base here in the United States.

CHAIRMAN WONG: Yeah, I ask that because you list in your written testimony certain numbers since FY 2019, DoD has invested back 80 million dollars in the development of this program. Now I'm not one to sneeze at 80 million dollars. It's a large amount for an individual, but it's a relatively small amount for this type of program.

And I'm sure there are other kind of vocational non-four-year college subsidy programs throughout the federal government. I don't know how much we are overall spending on that. I do know that we're spending upwards of 200 billion a year on college education subsidies through loans and grants and contracts.

Just it's a question to ask, and maybe we'll take a look at this to maybe total up those subsidies coming from the federal government for non-four-year and four-year college and seeing if there needs to be a rebalance there. So I imagine there's distortions to the workforce market if we are subsidizing four-year college and creating shortages, if there is a shortage, in manufacturing skills. So just something that in your testimony that raises issues for me, and maybe we'll take a look at that.

MS. ROSENBLUM: Thank you very much. I would certainly encourage and appreciate if this is an area that is of interest to you as Commissioners to take a look at. Some of -- while 80 million, I agree with you, is a lot in and of itself, is a big number. But it is also not the whole amount.

I mean, there's some cost sharing and things going on. But your point, Commissioner Wong, certainly stands in terms of when you look at it relative to investments that are being made kind of across the board on education. But it is an area that we think deserves more attention and is something that in the president's budget we have said we would like and are requesting additional money. So that's out there on that. Thanks.

COMMISSIONER GOODWIN: Commissioner Borochoff.

COMMISSIONER BOROCHOFF: Out of respect for your time, I'm going to be just very quick. But there was one thing that I want to ask you about which I'll do in just a moment. I want to just follow on something that Chairman Wong said.

That is very close to my heart because of the industry that I've worked in my whole life in the restaurant business. There are some really fabulous programs around the country that are doing just what you're discussing doing and spending meaningful money and working with very, very large firms that need welders, that need other things. And so separately I would suggest -- I was just going to say you might want to look into that or ask. We can help with that.

I wanted to ask this question. I saw with great happiness update acquisition policies as one of your points. And the reason is that having twice gone through the process on doing DoD contract work as a small business, the first time over two decades ago, with a small business that was small by your standards. It was, like, 18 million a year.

And it was very complicated, very, very daunting to try to work our way through it. And I heard your comment in the opening statement about trying to get more small businesses to step up and perhaps help with sole sourcing. So, I love that idea.

I hope that you are planning -- and forgive me for this for just making my speech. I'm going to ask the question. I'm hoping that you are planning to signal some future demand to those companies.

I think just because I have done that, I personally have had numerous small companies call me just in the last year with great ideas for the defense department and say, how did you do it? And I said, well, it was a long time ago. I don't even remember.

But my question is are you going to try to streamline? It's almost in direct contravention what you were talking about, Commissioner Scissors, with lining out every single supply chain supplier. Some of the small businesses won't be able to do that, particularly if they're startups or if they're in their second or third generation of getting going.

So my question is are you planning to create perhaps a category to make it a little easier for folks to deal, for instance, with the Defense Logistics Agency. Even CAGE is somewhat challenging for folks to work their way through. It's necessary. But is there a plan to try to make that a little easier as you reach out and say, bring us your people?

MS. ROSENBLUM: Yeah, absolutely. And thank you very much, sir, for the comment. Bringing in more small business is a very high priority of the administration as well as certainly at the Department of Defense.

And it's in recognition that we are not going to be able to successfully strengthen the defense industrial base without small business. They are absolutely at the heart of innovation, flexibility, and everything that you spent you whole life doing. And for that, thank you very much.

We have a number of different efforts that are underway at the Department related to small business with the idea of fundamentally driven by the objective of bringing more entrants in as I mentioned. And really that will involve reducing the barriers to doing business with DoD. It's not really transparent.

It is difficult. It is acronym heavy. And so, we are trying to have a number of different programs and ways in which we are doing that outreach to include mentor protégé programs.

We also have moved the procurement technical assistance program out from DLA -- actually to the Office of the Secretary of Defense -- so that it can get the attention that we feel that it's needed. We are also committed very much to a strong partnership within the Office of the Secretary Defense between acquisition and sustainment and research and R&E and engineering so that you've got that way to help with the horrible valley of death so the good ideas don't die there. And so that is an area that we are very keenly focused on.

COMMISSIONER BOROCHOFF: So, I want to say thanks, that makes me very happy, and ask the same question that a few others did. Relevant to just that, is there anything if we were making a recommendation to Congress that you would want us to say you would like to see them do for you in that area? Or can you do that without any kind of authority?

MS. ROSENBLUM: No, I think that -- again, I think it's an issue around not needing new authorities. But stability of funding is a critical area and issue. It becomes very difficult when you're trying to start new ideas and programs not just for small business but for other areas when it's under continuing resolutions which has really been the way it is for quite a while. And it's also having a degree of more permanency in the funding, for instance, for programs like the mentor protégé so that it's not a feast or famine situation. And small businesses that are in the middle of it, then funding is dropped and it creates the disruptions.

COMMISSIONER BOROCHOFF: Also applies to the person who's building you a ship.

MS. ROSENBLUM: Yes. Oh, without a doubt. I mean that's across the board, yes.

COMMISSIONER BOROCHOFF: Thank you very much.

MS. ROSENBLUM: Thank you.

COMMISSIONER GOODWIN: Madam Secretary, thank you so much for your time and your candor today. We're going to take a ten-minute break and start up our last panel at 2:35.

MS. ROSENBLUM: Great. Thank you. And I'll get back to you on the few areas that I took for questions. So, appreciate that very much, and thank you very much for all your hard work.

COMMISSIONER GOODWIN: Thank you.

(Whereupon, the above-entitled matter went off the record at 2:30 p.m. and resumed at 2:41 p.m.)

PANEL III INTRODUCTION BY COMMISSIONER BOB BOROCHOFF

COMMISSIONER BOROCHOFF: Our third panel is starting now. It will examine challenges and vulnerabilities in defense critical supply chains and determine solutions for maintaining U.S. military readiness. We will start with Mr. James Brown, CEO of BCI Solutions.

Next, we'll hear from Mr. Jeff Stoff, founder of Redcliff Enterprises. And finally, we'll hear from Ms. Jennifer Bisceglie, CEO of Interos, Inc. Thank you all very much for your testimony.

The Commission is looking forward to your remarks. I ask all of our witnesses to please keep their remarks to seven minutes. Mr. Brown, we will begin with you.

OPENING STATEMENT OF JAMES BROWN, CEO, BCI SOLUTIONS

MR. BROWN: Thank you. Good afternoon, Commissioner Borochoff, Goodwin, and other members of the Commission. Thank you for the invitation and the opportunity to speak with you today. I apologize for not being able to testify in person on such an important matter.

I'm JB Brown, CEO of BCI Solutions in Bremen, Indiana. I'm proud to be a fourth generation Indiana metal caster and small business owner. Our foundry founded by my great-grandfather in 1939 has been in continuous operation for over 80 years. My daughter, Jordan Brown, and my son, Ryan Topper, are part of the team and represent the fifth generation of our industry.

BCI represents one of 1,725 metal casting facilities in the U.S. We are a ferrous foundry producing gray and ductile iron castings with our own machine shop and assembly division. Our team of over 250 associate manufacturers, array of castings from heavy duty trucks, agricultural equipment, valves, pipe fittings, pump components, compressors, lawn and garden equipment as well as a variety of critical parts for the U.S. Department of Defense found in military equipment.

The U.S. metal casting industry remains critical to the U.S. economy as 90 percent of all manufacturing goods incorporated engineered casting into their makeup. All major metals can be casted. The most common are iron, steel, aluminum, magnesium, zinc, titanium, and copper-based alloys. Castings have thousands of applications.

They are found in cars, trucks, planes, rail, transit, ships, and all types of machinery, air conditioners, refrigerators, lawn mowers, power generation equipment, medical devices, water infrastructure, kitchen appliances, wind turbines, tanks, bombs, mine equipment, and tractors just to name a few areas. In short, castings represent a vitally basic aspect of our everyday lives. Our industry employs over 490,000 workers and generates 110 billion in economic output when considering the direct and indirect induced impacts that provide 10.59 billion of federal, state, and local taxes annually.

The metal casting industry is comprised primarily of small businesses with nearly 80 percent of domestic metal casters employing fewer than 100 workers. Many foundries are still family owned. The foundry industry which is key supplier of various metal castings to the DoD and other government agencies along with public and private OEMs. For our company, BCI Solutions, we supply over 23 different types of machine complete ductile iron castings to AM General for the military Humvee brand vehicles as a Tier 2 supplier.

I'm here today to discuss the supply chain challenges that we have experienced and note that there is no real contingency plan for the foundry industry to deal with the China competition in our global supply chain. The foundry industry uses recycled metal, pig iron, rare earths, minerals to produce castings for the above groups. Foundries use massive amounts of electricity to melt these materials to a molten state to be poured into a mold to become a casting.

The casting is then finished, machined, and assembled and goes into a product. If we are unable to obtain the correct material in the quantities needed, BCI would not be able to meet those demands, especially if an increase were to be requested at this moment. Some of the challenges as a Tier 2 supplier for the defense sector is common among most casting suppliers.

Most are small businesses reading government requirements for the manufacturing of castings or components is more extensive than any other customer relationship that we have. The extra requirements to meet government contracts takes additional staff time, more documentation, and more effort to fulfill. This is not something suppliers want to do, especially for low volume.

We are more dependent than ever in our industry in getting raw materials or components from China today primarily because our government restrictions to operate mining facilities in the U.S. along with labor rates compared to some other countries. One of the questions that was asked is about dependency of China for materials and chemicals that go into a casting manufacturing process. To me, this could be one of the most critical questions everyone needs to know the answer to.

Currently, magnesium silicon prices are at an all-time high and the world supply is very tight. A sole source U.S. supplier, US Magnesium, put into place force majeure since October due to equipment failures which is still in effect. Prior to the Russian invasion of Ukraine, we are using Ukraine as our silicon supplier.

We have had excellent material with good pricing from India, but the logistics have been the issue. We used to get the products to ship within five to six weeks. Now it takes five months with a number of foundries of purchasing the magnesium silicon from China now.

Pig iron continues to be a major sourcing issue for us due to the Russian invasion of Ukraine. Effectively, 50 percent of the global supply of pig iron, both basic and nodular, has been affected. China remains the largest producer of pig iron.

They are domestic consumers and not exporting pig iron. U.S. foundries needing pig iron was sourcing it from Ukraine until the Russian invasion. Suppliers are now coming from Brazil, Turkey, and Canada.

I don't believe there are any domestic sources of nodular grade pig iron. If iron ore was mined domestically and was desulfurized further, the U.S. would have a potential for domestic supply. Cost increases across the border are staggering right now.

Pig iron that was 400 dollars a ton is now 1,200 dollars a ton. Nickel that was 7 dollars a pound is now 15 dollars a pound. Silicon carbide that was 800 dollars a ton is now 1,500 dollars a ton. There are other critical rare earths that are almost exclusively mined in China, predominately used for making ductile iron.

I would like to address recommendations to this Commission with suggestions from myself and some of my peers. Increased production and processing of critical minerals and materials in the U.S., the U.S. faces a shortage of minerals, materials, and processing capacity to support key sectors of the economy and the clean energy transition. It can take at least a decade to get new American mine operations permitted.

Materials such as copper, cobalt, nickel, lithium, graphite, and zinc are essentially for renewable technologies. However, the mining and the process are dominated by China and other nations. In 2021, the United States produced just 6 percent of the global copper supply, 0.4 percent of the cobalt supply, and 0.67 percent of the world's nickel, zero percent of the global graphite supply, and about 5.7 percent of the world's zinc.

Anything that incentivizes automation and energy efficiency would be helpful. That can be in grants, tax policy, or tax credits. Our industry is actually simpler than credits for installing solar panels.

We have significant opportunities to be more energy efficient such as increasing yield on reducing machine idle time. It takes extra staff and time and possibly new equipment for those gains. But they may pay back faster than solar would actually be analyzed. Thank you for this opportunity to express the foundry industry and small business concerns. I welcome your questions.

PREPARED STATEMENT OF JAMES BROWN, CEO, BCI SOLUTIONS

Testimony

U.S.-China Competition in Global Supply Chains, Panel IV:

Safeguarding U.S. Defense-Critical Supply Chains

James (JB) Brown

CEO

BCI Solutions - Bremen, Indiana

Testimony before the U.S.-China Economic and Security Review Commission

June 9, 2022

Good afternoon, Commissioners Borochoff and Goodwin, other members of the Commission, and staff. Thank you for the invitation and opportunity to speak with you today. I apologize for not being able to testify in person. My testimony will focus on the importance of the U.S. metalcasting industry in providing key castings for our nation's national defense, and the challenges, vulnerabilities, and implications of our continued reliance on China as part of our critical supply chain.

I am JB Brown, CEO of BCI Solutions, Inc. in Bremen, Indiana. I am proud to be a fourth-generation Indiana metalcaster and small business owner. Our foundry was founded by my great-grandfather in 1939 and has been in continuous operation for over 80 years. My daughter, Jordan Brown, and my son, Ryan Topper, are part of our team and represent the 5th generation.

BCI is a ferrous foundry producing gray and ductile iron castings. We also operate our own machine shop and assembly division. Our team of over 200 associates manufactures an array of castings for heavy duty trucks, agricultural and healthcare equipment, valves and pipe fittings, pump components, compressors, lawn and garden equipment, as well as a variety of key parts for the U.S. Department of Defense found in military equipment.

U.S. Metalcasting Industry

The U.S. metalcasting industry remains critical to the U.S. economy, as 90 percent of all manufactured goods incorporate engineered castings. All major metals can be cast. The most common are iron, steel, aluminum, magnesium, zinc, titanium, and copper-based alloys. There are currently 1,725 metalcasting facilities operating in 49 states,[1] down from 2,620 plants in 2003.[2]

Castings have thousands of applications. They are found in cars, trucks, planes, rail, transit, ships, all types of machinery, air conditioners, refrigerators, lawn mowers, power generation, medical devices, water infrastructure, home appliances, wind turbines, military equipment, oil and gas, mining equipment, and tractors – just to name a few. In short, castings represent a vital, yet basic, aspect of our everyday lives.

According to the American Foundry Society, our industry's trade association, the U.S. metalcasting industry contributes over 490,000 jobs and generates $110.52 billion in economic output when considering the direct and indirect induced impacts, and provides $10.59 billion in federal, state, and local taxes annually. It is comprised primarily of

[1] Industry Outlook: Strong Sales Expected, Casting Source, Jan/Feb 2022, pg. 35.
[2] Steady Growth in Global Output, Metal Casting Design & Purchasing, Jan. 2015, pg. 26.

small businesses, with nearly 80% of domestic metalcasters employing fewer than 100 workers. Many foundries are still family owned, such as my own.

Growth of Chinese Manufacturing and Chinese Foundries

Over 90,000 American manufacturing facilities have closed their doors since the late 1990s, according to the Economic Policy Institute[3], eliminating millions of good-paying, middle-class jobs. China surpassed the United States as the world's largest manufacturing nation in 2010, and in 2019 held nearly 29 percent of global factory output, while the U.S. share had shrunk to 17 percent.[4] Imports have replaced domestic production throughout our supply chains, often from adversarial countries like China and Russia.

Since 2000, China has become the largest producer of metal castings. There are over 25,000 metalcasting facilities in China.[5] The China Foundry Association maintains that there are 14,000 iron foundries, 4,000 steel foundries, and 8,000 nonferrous foundries operating in China.

The world volume of casting production has fallen steadily by 6.4 percent since 2018, with a recorded production volume of 105.5 million metric tons in 2020. Despite this global decline, China's production has increased, maintaining the lead in 2020 with 51.95 million metric tons – nearly 49.2 percent of the world's production. India and the United States followed with a casting production of 11.31 and 9.75 million metric tons, respectively, that same year, with the U.S. showing a year-on-year decrease of 13.8 percent.[6]

The Chinese government continues to heavily subsidize its metals-related sectors through cash grants, preferential loans and directed credit, land use subsidies, subsidies for utilities, raw material price controls, and tax policies.

Chinese castings have continued to be priced 30 percent lower than U.S.-produced castings, despite the Section 301 tariffs being put in place on dozens and dozens of ferrous castings for past several years, and the increase in overall operating costs due to the pandemic. For years, U.S.-based companies have purchased from low-cost producers, primarily castings from China and broader Asia.

The pandemic has exposed a dangerous reliance on global suppliers for many consumer

[3] "Free Trade is Killing American Manufacturing," Michael Collins. Industry Week, Nov. 23, 2020. See Appendix A - Volume of global casting production from 2018 to 2020.
[4] "China Is the World's Manufacturing Superpower," Felix Richter. Statista. May 4, 2021. Link: https://www.statista.com/chart/20858/top-10-countries-by-share-of-global-manufacturing-output/
[5] China Foundry Association, Nov. 2021 – provided to the American Foundry Society.
[6] Published by Statista, April 26, 2022 - https://www.statista.com/statistics/237526/casting-production-worldwide-by-country/.

and commercial products – revealing that the United States is ill-equipped to produce enough medicine, medical equipment, personal protective equipment, semiconductors, automobiles and parts, building materials, and consumer goods, let alone the quantities needed to address a future emergency. Decades of offshoring have contributed to the ongoing supply chain shortages and risks that continue to hinder the U.S. economy, especially for manufacturers and metalcasters.

Defense & National Security

Metal castings play an integral role in our national defense. All branches of the U.S. military are reliant on castings found in jet fighters, helicopters, ships, tanks, trucks, submarines, laser-guided missile systems, weapon systems, as well as other vital systems and equipment. Many of the castings we supply are contained in weapons being sent to Ukraine, including Javelin antitank weapons. Our company, BCI Solutions, supplies over 23 different types of machined complete ductile iron castings to AM General for the military Humvee brand vehicles as a Tier 2 supplier.

In February 2022, the U.S. Department of Defense (DoD) issued its report in response to last year's Executive Order 14017, Securing America's Supply Chains, which called for a comprehensive review of supply chains in critical sectors, including the defense industrial base (DIB). The DoD report, titled "Securing Defense-Critical Supply Chains," assesses supply chains in the DIB and sets out DoD's plan to align its priorities and capabilities to strengthen the industrial base and to establish a network of domestic and allied supply chains to meet national security needs.[7]

The DOD identified four types of technology and goods about which it is particularly concerned, including castings and forgings; kinetic capabilities such as missiles, hypersonic and directed-energy weapons; high-capacity batteries, especially those using lithium; and microelectronics.

Regarding castings and forgings, the Report attributes capability challenges in part "to the impacts of offshoring and waves of industry consolidation since the mid-20th century."

It highlights concerns about how there is only one foundry that can produce the large titanium castings required for certain key defense systems, while China produces four times as much as the United States in terms of casting tonnage. The resulting erosion of the domestic market share and increased reliance on foreign sources could introduce national security vulnerabilities in addition to the general diminishment of U.S. technological innovation.

[7] "State of Competition within the Defense Industrial Base," Office of the Under Secretary of Defense for Acquisition and Sustainment (Feb. 2022), available here.

DoD recommendations to address these offshoring and consolidation issues include:

- Development of a cast and forged (C&F) strategy to "inform policy and investment decisions over the coming years," which would include, in part, expanding use of additive manufacturing and digital production capabilities.
- Investment in the C&F industrial base. This investment will leverage DoD's overall C&F strategy to revitalize sub-tier supplier and workforce development and address procurements that optimize DIB synergies.
- Identifying and developing allied and partner C&F capabilities. Through international coordination, DoD aims "to scope, develop, and implement plans to develop and coordinate C&F capabilities."

Our industry looks forward to working with the DoD and other key federal agencies on these recommendations to strengthen the U.S. metalcasting industry.

Disconcerting is the fact that that the number of small businesses in the U.S. defense industrial base shrank by more than 40% over the past decade. In fact, the DoD warned that if the trend continues, the country could lose an additional 15,000 suppliers over the next 10 years.[8]

One of the challenges as a Tier 2 supplier for the defense sector is that most foundries are small businesses. Reading through government procurement requirements for the manufacture of castings or components is more extensive than other customer relationships. These extra requirements to meet government contracts takes additional staff time, more documentation, and more effort to fulfill. Foundries that sell to the U.S. military also need to comply with a cybersecurity certification process. Some foundries are overwhelmed with the risk management expertise required and financial resources to achieve the levels of the cybersecurity compliance. These stringent requirements are not something that some small foundries would be willing to undertake.

Critical Materials and Rare Earth Elements

One of the questions that was asked is about dependency on China for materials and chemicals that go into the casting process. To me, this is one of the most critical questions that manufacturers need to know the answer.

Unfortunately, we remain more dependent than ever in the manufacturing sector in securing strategic and critical materials and components from China. In 2019, China was responsible for 80 percent of rare earths imports into the U.S., according to the U.S.

[8] "Hicks says DOD will take 'meaningful action' to remove barriers for small contractors," John Hewitt Jones. FedScoop, Sept 21, 2021.

Geological Survey. The U.S. went from a position of global dominance in rare earth element (REE) supplies in the 1990s to a heavy dependency on China within 10 years. They are essential for electric motors, military hardware, smartphones, and many other products and industrial processes — and demand for them is expected to increase dramatically in the next 20 years.

Extracting, processing, and refining the rare earths elements pose a range of technical and environmental issues. Domestic efforts to extract rare earths are taking place in states including Wyoming, Texas and California, but the recent past provides cautionary tales. In 2002, after the only major U.S. REE supplier, California's Mountain Pass mining company, went bankrupt, the federal government and U.S. manufacturers began sourcing REEs from foreign countries. Molycorp, which reopened the Mountain Pass mine in the early 2000s, only to go bankrupt in 2015. MP Materials bought the mine and restarted production in 2017. It is our understanding that the company is expanding its facilities, including a restoration of domestic refining capability at Mountain Pass by next year.

On March 31, President Biden ordered the U.S. secretary of defense to "create, maintain, protect, expand, or restore" domestic production of critical minerals such as lithium, nickel, cobalt, graphite, and manganese. The IEA recently estimated that demand for these five minerals and rare earth elements will grow ten times by 2040 in a baseline scenario based on current government policies — and by 30 times in a scenario with more aggressive policies.

Ferrous foundries require REEs in the metalcasting process. The foundry industry uses rare earths and minerals, scrap metal, and pig iron to produce castings. **If we are unable to obtain these materials in the quantities needed, BCI would not be able to meet that demand, especially if an increase were to be requested at this moment.** For certain materials, we are limited to the amounts that we ordered last year due to ongoing supply chain issues which I describe below.

Currently, magnesium silicon prices are at an all-time high and world supplies are very tight. The sole-source U.S. supplier, US Magnesium, put in place a force majeure since October due to equipment failure, which is still in effect. Prior to the Russian invasion of Ukraine, we were using Ukraine as our silicon supplier. We have had excellent material with good pricing from India, but the logistics have been the issue. We used to get magnesium silicon shipped within 5-6 weeks. Now it is taking five months at a minimum for delivery. A number of foundries are purchasing their magnesium silicon from China and Brazil.

Pig iron continues to be a major sourcing issue for gray and ductile iron foundries since Russia and Ukraine were top suppliers of pig iron. Most American gray and ductile iron foundries utilizing pig iron were sourcing it from Ukraine. Effectively 50% of the global supply of pig iron, both basic and nodular, has been affected.

Supplies are now coming from Brazil, Turkey, and Canada. Mills in China, Japan, and the United Arab Emirates have started offering pig iron. China remains the largest producer of pig iron – until recently they were domestic consumers and were not exporting pig iron in large quantities.

Meanwhile, prices for pig iron have increased from $400 net ton (NT) to now $1,200/NT. I don't believe there are any domestic sources of nodular grade pig iron. If iron ore were mined domestically and desulphurized further, the U.S. would have a potential for domestic supply. American steel companies using blast furnaces typically use their molten iron to make finished steel, rather than sell pig iron to their competitors or U.S. foundries.

Cost increases across the board are staggering for other materials as well. Nickel that was $7.00/lb is now $15/lb. Silicon carbide that was $800/NT is now $1,500/NT.

Additionally, here is an overview of additional metals and minerals used by ferrous foundries, as well as their sourcing (China is a critical source of several of these commodities):

Commodity	Major Import Sources
▪ **Chromium**	**Russia is the primary source**, along with South Africa, Mexico, Kazakhstan
▪ **Fluorspar**	Mexico, Vietnam, South Africa, Canada
▪ **Graphite**	**China is the primary source of the material**. Also, Mexico, Canada, and India.
▪ **Magnesium (metal compounds)**	**China is the primary source of the material**. Other countries include **Russia**, Israel, Kazakhstan, **Ukraine,** Brazil, Turkey.
▪ **Manganese**	Gabon, South Africa, Australia, and Georgia.
▪ **Rare earth elements group**	**China is the primary source of the material**. Other countries include Estonia, Malaysia, and Japan.
▪ **Strontium**	Mexico, Germany, and **China**.
▪ **Tin**	Indonesia, Peru, Malaysia, and Bolivia.

Energy Security

Three months into the war in Ukraine, the outlook for oil supply and demand remains uncertain. The timing of the resolution of the conflict is unclear and both consumers and investors are being buffeted by price volatility. Metalcasting is among the most energy-intensive industries in the United States. The heating and melting of metals consume large amounts of energy, accounting for about 55% of the total energy used. Mold-making, core-making, heat treatment and post-cast operations use significant energy as well.

Compared to other foundry sectors, energy costs are typically higher for iron foundries such as BCI. Most iron casting work is done at temperatures up to 2850° F, with subsequent heat treating done at up to 1900°F. The melt temperature is much higher for gray and ductile iron compared to non-ferrous metals.

Today, energy costs are again at the forefront of U.S. metalcasters' concerns, with oil prices at a record high, dwindling domestic natural gas supplies pushing up the cost of a major energy component for many plants, and the once-reliable electricity network in increasing jeopardy.

The IEA warned in its latest monthly oil market report released June 15 that the market may loosen up later this year, but producers could face fresh challenges to keep up with rising consumer use in 2023 as sanctions squeeze Russian supply, Chinese demand returns from pandemic restrictions, and oil-producing nations face limits on output increases.[9]

Furthermore, there is less U.S. and Canadian refining capacity today than there was before the pandemic, as some refineries have closed permanently, and others are being converted to refine renewable fuels rather than crude oil.

As temperatures rise ahead of what forecasters say will be a hotter-than-normal summer, electricity experts and officials are warning that states may not have enough power to meet demand in the coming months. This is problematic for foundries given furnaces require a constant power supply to maintain the standard temperatures necessary to melt iron in large quantities. A power failure would result in production being stalled, materials wasted, and equipment damaged.

Metalcasters risk losing their global energy advantage if prices continue to rise and exacerbate supply chain constraints. Increasing energy production and mining critical minerals here at home is the way we can drive down energy costs, lower inflation, support our allies, and make manufacturers in America more competitive in the global marketplace.

Recommendations

Our reliance on China as a supplier remains high. The time to address the supply chain threat and risk to our nation's national security and military readiness is now, not after a major incident. I would now like to address recommendations to this Commission with suggestions from myself and some of my peers.

[9] The International Energy Agency, Oil Market Report – June 15, 2022 - https://www.iea.org/reports/oil-market-report-june-2022

- **Production and Processing of Critical Minerals and Materials in the U.S.** – The U.S. faces a shortage of minerals, materials, and processing capacity to support key sectors of the economy and the clean energy transition. It can take at least a decade to get a new American mine operation permitted. Materials such as copper, cobalt, nickel, lithium, graphite and zinc are essential for renewable technologies and metalcasters. However, the mining and processing are dominated by China and other nations. In 2021, the United States produced just 6 percent of the global copper supply, 0.4 percent of global cobalt supplies, 0.67 percent of the world's nickel, 0 percent of global graphite supply, and about 5.7 percent of the world's zinc.

- **Institute More Efficient Permitting Processes** – Project delays related to both infrastructure and the energy transition hurt our nation. America's system for permitting the development of projects is broken. Projects of all kinds — renewables, electricity transmission, critical mineral mining, oil and natural gas, and pipelines — face extensive delays and can even be halted due to unnecessarily lengthy reviews and associated litigation. There is no reason that permitting a mine in the United States should take five times longer than it does in Canada or Australia.

- **Implement Tax Credits & Changes to Tax Code to Promote Automation and Energy Efficiency** – Urge Congress to provide additional incentives to bolster the integration of additive manufacturing technologies in metalcasting, automation, and energy efficiency. That could be in the form of grants or tax credits. Our industry has significant opportunities to be more energy efficient, such as increasing yield or reducing machine idle time. It takes extra staff time and possibly new equipment to make those gains, but the payback will be fast.

- **Promote Reliable Domestic Energy Production and Infrastructure Development to Enhance Energy Security** – Urge Congress and the Administration to reverse obstacles to domestic oil and natural gas leasing and work to build a reliable power grid. That starts with approving responsible exploration and production, supporting sustainable permitting, and quickly building out more energy infrastructure, including electric vehicle charging and pipelines. Foundries produce crucial castings for the oil, gas and renewable energy sectors, as well as for the electric grid and hydroelectric dams.

- **Trade Enforcement** – Strengthen and aggressively enforce U.S. antidumping and countervailing duty laws, ensure adequate resources for the agencies responsible for enforcing these trade laws, and work to address transshipment, circumvention, and evasion of trade remedy orders. BCI Solutions supports strengthening trade enforcement tools to ensure that our efforts to secure critical supply chains are not undermined by unfair trade practices from China, Russia, and other countries. Specifically, we urge Congress to pass the Eliminating Global Market Distortions to Protect American Jobs Act (H.R. 6121/S. 1187) which would update and modernize

U.S. trade laws to ensure that domestic industries are able to pursue and rely upon remedies to address new and evolving unfair trade practice.

- **Maintain Section 301 Tariffs** – For decades, the Chinese government has led an effort to dominate global industries through predatory trade practices, from using subsidies, intellectual property theft and forced technology transfers, to lax environmental and labor practices. The tariffs aimed to level the playing field for American manufacturers and workers. I urge the Administration to maintain the Section 301 tariffs on metal castings.

  It was disappointed to see the Administration's recent decision to allow solar components from Cambodia, Malaysia, Thailand, and Vietnam to be imported into the U.S. duty-free for two years, regardless of whether they contain Chinese-produced parts that are subject to U.S. tariffs. This sends a clear message to our foreign adversaries that our trade enforcement laws will not be upheld.

- **Strengthening U.S. Investments in Critical Industries** – Congress should prioritize funding to strengthen domestic semiconductor manufacturing and other federal assistance as outlined in the CHIPS Act. Metalcasters supply key castings to a wide range of sectors where semiconductor chips play a central role including in their products, including military equipment, cars, buses, trains, planes, appliances, tractors, motorcycles, and machinery. Forecasts for North American automotive production dropped in June as semiconductor shortages continue to drag on the industry, meaning fewer casting orders for foundries in 2022.

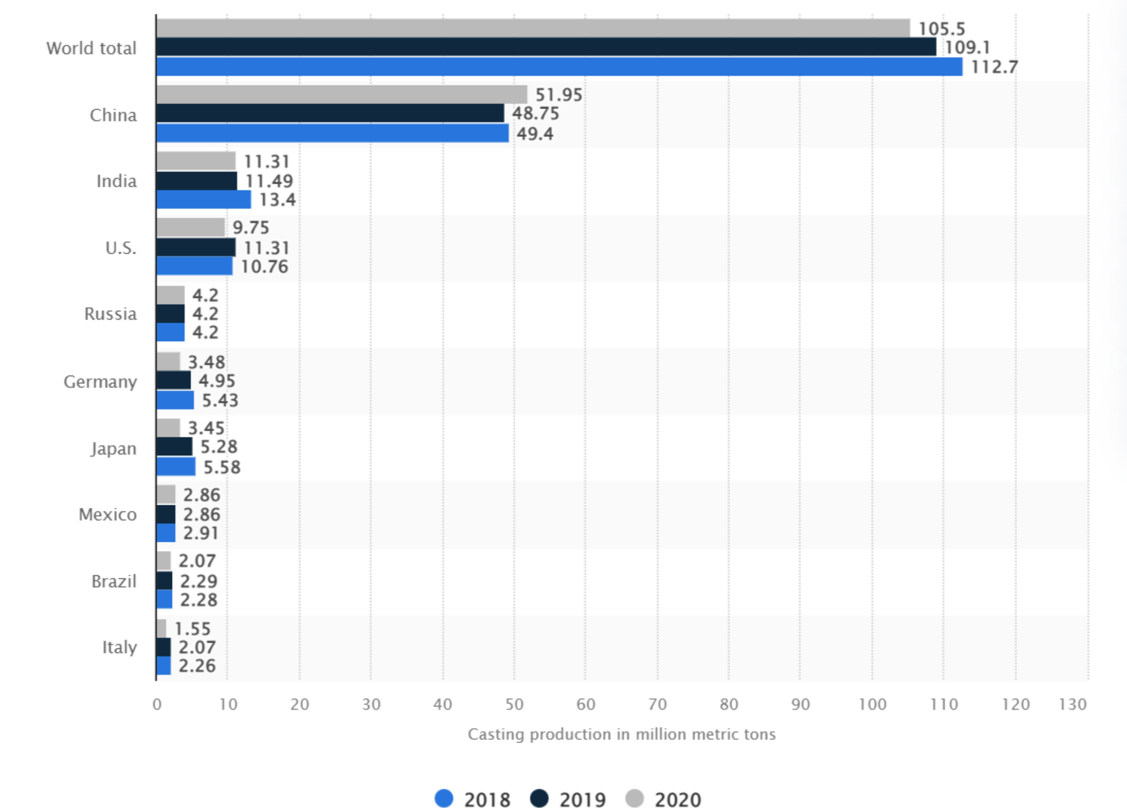
Conclusion

Thank you for the opportunity to express the concerns of U.S. foundries and small businesses regarding the threat that China continues to pose to our industry and the U.S. supply chain. I welcome your questions.

Appendix A

Global Casting Production Worldwide, 2018 to 2020

Volume of global casting production from 2018 to 2020, by country (in million metric tons)



Published by [Statista Research Department](), Apr 26, 2022

OPENING STATEMENT OF JEFF STOFF, REDCLIFF ENTERPRISES

COMMISSIONER BOROCHOFF: Thank you, sir. Mr. Stoff.

MR. STOFF: Hearing Co-Chairs Borochoff and Goodwin, distinguished Commissioners and staff, thank you for the opportunity to participate in today's hearing. Much of what I discuss in this testimony comes from my knowledge and experience working in the U.S. government on China issues for nearly two decades. That said, all statements of fact, opinion, or analysis are my own and do not reflect the official position of the Department of Defense or other federal agencies.

My testimony focuses on the methods China uses to acquire technology and know-how from the U.S. and our knowledge gaps and vulnerabilities with respect to future supply chains. Specifically, I'm referring to the R&D and human capital pipelines that make up our innovation ecosystem. As this hearing discusses how to secure critical supply chains, we need to view R&D and innovation as key supply chain inputs and national assets.

U.S. government attention and responses to PRC threats have primarily focused on illicit acquisition of intellectual property and economic and cyber espionage. But this belies the scale and scope of China's technology know how transfer apparatus, much of which is not illicit in nature. To oversimplify complex issues, the U.S. government's deficiencies in neutralizing these threats are rooted in several interrelated areas.

First, a lack of understanding of the magnitude and complexity of China's state driven tech transfer apparatus and an over-reliance on law enforcement as a means of threat mitigation. Second, underutilized tools such as export controls, Treasury sanctions, CFIUS and counterintelligence operations. These levers are inherently tactical or transactional, and limited resources leave little room to assess the strategic aspects or interconnectedness of China's predations.

And third, the minimal use of publicly available information, particularly within the intelligence community, due to structural impediments and a dearth of Mandarin language and subject matter expertise. China's strategy to tap into talent and know how in the U.S. increasingly relies on methods to exploit U.S. innovation without having individuals relocate to China. In 2018, President Xi Jinping urged China to, quote, mobilize talents to engage in offshore innovation in foreign countries or attract talent to engage in part-time innovation in China while employed overseas.

It's important to understand the implications of the strategy. It weakens the argument, claiming that high rates of PRC nationals who stay in the U.S. after receiving advanced degrees means American, not China, is benefitting from this talent pool. PRC talent programs, for example, target individuals after they have gained expertise and access to technologies and R&D in the U.S.

This also means that running faster strategies such as investing more in domestic R&D and reshoring critical supply chains such as semiconductors will make little differences if there aren't corresponding efforts to identify and mitigate the various ways China siphons, acquires, influences, or diverts U.S. innovation for its benefit. While I worked for the Department of Defense, I led several pilot projects that while small in scope nevertheless demonstrated vulnerabilities that may affect future defense supply chains. Some findings include U.S. academics crediting DoD funding published articles with co-authors affiliated with PLA organs such as a hypersonics facility, China's nuclear weapons complex, and national defense laboratories.

Over 300 individuals were identified that were recruited through our PRC talent program and claimed to have supported DoD funded research either as principle investigators, PIs, or Ph.D. students and postdocs. Some of the PIs or co-PIs on DoD grants have trained generations of graduate students and postdocs who subsequently contributed to China's defense R&D and industrial base. U.S. firms receiving DoD contracts through the Small Business Innovation Research program, or SBIR, established PRC-based subsidiaries and in some cases later dissolved U.S. operations and received PRC government investments.

And in one case, a U.S. firm receiving multiple DoD SBIR contracts established a company in China based on its U.S. developed technologies and reportedly developed combat vehicles for a subsidiary of Norinco, one of China's largest arms manufacturers. China also exploits the duel use nature of fundamental research. An example is a U.S. professor working on National Institutes of Health funded research to develop hearing aids by using AI to improve signal processing and speech segregation.

Through China's Thousand Talents program, the professor held a concurrent appointment at Northwest Polytech University, one of China's Seven Sons of National Defense schools that focus on defense R&D. The department the professor worked in focuses on underwater weaponry, hydroacoustic engineering, and underwater vehicle research. In other words, China hired the U.S. professor to help develop naval warfare applications probably involving submarines from the NIH funded signal processing technology.

NIH is not equipped to assess national security risks associated with potential future applications of the research it funds. And DoD has no oversight or control over what other federal agencies fund. A lack of scholarship on this issue also means we don't know how pervasive this type of exploitation is.

There are other knowledge gaps that have implications with respect to defense supply chains. For example, the China Electronics Technology Group Corporation, or CETC, is a large state owned defense conglomerate with reportedly more than 700 subordinate companies and public institutions. Yet the BIS entity list names only about two dozen CETC subsidiaries and research institutes.

My testimony lists five semiconductor firms, majority owned by CETC. None of those are on the entity list, and I'm not aware of any systematic efforts to survey state owned defense enterprises, subordinate entities, and determine whether they are involved in U.S. supply chains. My recommendations focus on using open sources to bolster the supporting collection and analysis that would make the existing arsenal of government tools more effective.

However, I believe the structural limitations prevent any government agencies from exploiting open sources are insurmountable, short of a radical change in mission priorities. But that could create zero sum effects where other descope missions have unintended consequences. I recommend Congress and federal agencies support the build out of an independent non-government entity known as the Center for Research Security & Integrity, or CRSI. This will be a nonprofit 501(c) corporation whose mission is to protect U.S. research and innovation by identifying ethical national security and research integrity risks facing public and private sectors.

CRSI will assist academic, government, and private sector institutions in mitigating risks posed by adversarial nations starting with China. CRSI will create partnerships via consortium of select private sector firms that conduct industry leading open source and due diligence research, think tanks, NGOs, and academic institutions that have capabilities to support research security efforts. This consortium will combine unique capabilities and resources of each of its members that allow for agility, cost savings, and unique advantages that surpass existing structures. Thank you for your time, and I look forward to your questions.

PREPARED STATEMENT OF JEFF STOFF, REDCLIFF ENTERPRISES

“Reassessing Threats to US Innovation Posed by China and Implications for Safeguarding Future Supply Chains”

Testimony Before the U.S.- China Economic and Security Review Commission

Hearing on “U.S.-China Competition in Global Supply Chains”

June 9, 2022

Jeffrey Stoff
Founder, Redcliff Enterprises

Table of Contents

Hearing Co-Chairs Borochoff and Goodwin, distinguished Commissioners and staff, thank you for the opportunity to participate in today's hearing. Much of what I will discuss in this testimony comes from my knowledge and experience working in the US government on China issues for nearly two decades, and in particular the last 10 years that was dedicated to examining China's technology transfer apparatus. That said, all statements of fact, opinion, or analysis provided in this testimony are my own and do not reflect the official policy or position of the Department of Defense or other federal agencies.

Introduction

My testimony will focus on US vulnerabilities, challenges and the long-term implications with respect to China regarding future supply chains. Specifically, I am referring to the R&D and human capital inputs that make up our innovation ecosystem. As this hearing discusses how to secure defense-critical supply chains, it is important that we frame our R&D and innovation ecosystem as a critical supply chain input and a national asset. *Yet this is an area that is the least protected and the most vulnerable to China's predations.*

Protecting the earlier stages of our innovation ecosystem will become even more important in the near future as the pace of technology development accelerates; in many areas timelines will likely shorten between fundamental research and the development of commercially viable or weaponizable applications.

It is also important that we have candid conversations on the challenges and shortcomings that affect our ability to protect our research and innovation. We must objectively examine our deficiencies to overcome them. To oversimplify complex issues, these deficiencies are rooted in several inter-related areas, which include:

- Underutilized US government policies and tools to address supply chain risks and related threats posed by China, such as export controls, Treasury sanctions, other trade restrictions, CFIUS, and law enforcement and counterintelligence operations. These levers are inherently tactical or transactional; they are whack-a-mole efforts by their nature and their lack of sufficient resources leaves little room to examine the strategic aspects or interconnectedness of China's predations.
- A fundamental lack of understanding of the magnitude and complexity of China's state-supported technology acquisition and transfer apparatus. This has led to misconceptions over the nature and scope of the threats China poses to our innovation ecosystem, especially at earlier stages of R&D.
- An over-reliance on law enforcement as a means of threat mitigation.
- The minimal use of publicly available information within the government, and in particular the Intelligence Community, due to structural impediments and a dearth of Mandarin language and subject matter expertise.

This testimony will describe key entities, methods, and programs the PRC party-state deploys to acquire technology and knowhow from the United States and the corresponding vulnerabilities, knowledge gaps, and impediments to mitigating threats to our R&D and innovation ecosystem. This survey is not exhaustive; rather, the examples I provide are used to dispel misconceptions of China's predations and inform the recommended solutions.

Other China and international trade experts have called for revisions to existing policies and new legislation for good reason. As such, my recommendations will focus on capacity building - bolstering the supporting infrastructure needed to allow the existing arsenal of tools, policies, and enforcement mechanisms to realize their full potential. However, this capacity building requires new paradigms that specifically address structural impediments that have prevented the government from adequately exploiting publicly available information.

Rethinking Prevailing Concepts

The lack of understanding of the magnitude and complexity of China's technology transfer apparatus has resulted in misperceptions, some of which downplay or understate the threats posed by China and/or overestimate the United States' ability to maintain technological and military superiority. For instance, our views of risks and threats posed by China are too often placed in simplistic, binary terms. The most common of these binary constructs are legal vs. illicit activity, international research collaboration vs. shutting ourselves off, and openly shared (and published) vs. classified research.

The White House Office of Science & Technology Policy (OSTP) recently stated that "the research security challenges we face are real and serious: some foreign governments, including China's government, are working hard to illicitly acquire our most advanced technologies. This is unacceptable."[1] While OSTP rightly draws attention to research security challenges posed by China, it also typifies the US government's myopic focus on "illicit" acquisition of US technology. Indeed, US government attention and responses are often limited to fighting lawbreakers. To be fair, this is partly by design, as democracies place constraints on government power and policing. A consequence of this limitation, though noble in intent, is that *the scale and scope of national and economic security threats posed by the PRC's technology transfer apparatus have outpaced the government's abilities or priorities to detect, deter, or neutralize the PRC's efforts.* Most of the threats I describe in this testimony are neither criminal in nature nor involve espionage, at least not how our legal system defines it.

The US government's focus on pursuing criminal prosecutions through efforts like the China Initiative led by the Department of Justice (DOJ) does little to resolve or neutralize research security threats. A series of dropped cases and unsuccessful prosecutions are perhaps a reason the DOJ decided to end the China Initiative (at least in its current form). But dropping criminal charges due to difficulties in proving criminal intent does not necessarily equate to an absence of concerning activity. These cases often involved individuals employed and tasked by the PRC government and Communist Party (CPC) to facilitate knowhow transfers that can undermine the security and integrity of federally sponsored research.

The other oft-used binary arguments relate to research collaboration and partnerships (particularly in STEM fields) with PRC institutions. For example, many within the academic community reject or downplay collaboration concerns by emphasizing that the pursuit of knowledge and advancement of science are critically dependent on global scientific collaboration and the US has benefitted tremendously from it. But the importance and value of international collaboration is not in dispute. The reality is there are certain risks when dealing with authoritarian nations, especially China, which require more robust scrutiny and nuanced approaches, and this fact cannot be overlooked through zero sum or all or nothing arguments with respect to international collaboration.

In a similar vein, some within academia frequently argue that fundamental research is meant to be openly shared through publication. This was also codified in the still-in-effect National

[1] Statement by Dr. Eric Lander, "Guidance for U.S. Scientific Research Security That Preserves International Collaboration," January 4, 2022, https://www.whitehouse.gov/ostp/news-updates/2022/01/04/guidance-for-u-s-scientific-research-security-that-preserves-international-collaboration/.

Security Decision Directive 189 (NSDD-189), a policy stipulating that there should be no restrictions on the sharing of fundamental research, except in special circumstances where national security concerns necessitate making such information classified. The argument is that given that the research is openly published, there is nothing to steal or cause national security concerns.

Here too, we need to lay to rest this argument. It overlooks the issue of who or what is using the research and for what specific purpose, and bypasses the fact that the hands-on, unpublished input, knowledge, and experience that goes into conducting research in collaborative environments is not easily replicable through passive reviews of published literature. Raw data and knowhow exist and may be transferred in ways that lie outside of the published result. Why would China devote so much effort and resources -- such as through its hundreds of talent programs that recruit individuals who had placement and access to US research -- if they can just read the published literature at home and "use" it themselves?

These knowledge transfers within the research enterprise often do not involve criminal acts or espionage, but just like the intent of our export control regime, end-users matter. An obvious example is fundamental research (such as materials science and metallurgical fields) that can enhance a nation's capabilities in designing and manufacturing nuclear weapons. Would it be wise to invite PRC, North Korean, and Iranian nuclear weapons scientists to the U.S. to study advanced methods in these fields, even if some of that research is fundamental and published? "End-user" entities within China's research enterprise matter, and real national security concerns can arise from the open collaboration they enjoy with US institutions.

Lastly, many have argued that the US government's response is an overreaction or overreach. Academia has justifiably asked the US government what the scale and scope of the research security threats posed by China looks like, as the government has shared only limited information on a small number of cases that are typically the results of completed investigations. There is a great deal of unknowns and a lack of empirical evidence that have important, unaddressed, or unrecognized implications. Consequently, we need to empirically examine the issues, such as viewing research security as a research discipline itself and develop systematic ways to understand the scale and scope of what is taking place. A key challenge is that no single agency owns this problem. This requires an unprecedented level of collective action, which gets to the heart of my recommendations I will describe at the end of this testimony.

PRC Exploitation of US R&D

This section offers four case studies that show how the PRC is exploiting the open nature of our research ecosystem that have serious national security implications and may affect future defense supply chains. Specifically, these examples show how China's defense and mass surveillance R&D and industrial bases are benefiting from largely unrestricted research collaboration with the U.S.

Example 1: US Research Collaboration with China's 'Seven Sons of National Defense'

In 2020, I coauthored a study that examined collaboration between US research institutions and a group of civilian universities in China that serve its defense R&D and industrial base, known as the "Seven Sons of National Defense" (国防七子). The report surveyed published scientific and engineering literature and examined coauthor networks and funding sources and discussed findings from supplemental due diligence performed on the PRC entities involved. These seven universities have a primary mission to support defense R&D and industry development and promote state-directed military-civil fusion efforts. Most partner with defense state-owned conglomerates and serve as a training ground for future military leaders and technicians working on weapons systems and defense programs.[2] The seven PRC universities examined are:

1. Beijing Institute of Technology (北京理工大学)
2. Beihang University (a.k.a. Beijing University of Aeronautics & Astronautics, 北京航空航天大学)
3. Harbin Institute of Technology (哈尔滨工业大学)
4. Harbin Engineering University (哈尔滨工程大学)
5. Northwestern Polytechnical University (西北工业大学)
6. Nanjing University of Aeronautics & Astronautics (南京航空航天大学)
7. Nanjing University of Science and Technology (南京理工大学)

The report surveyed six years of scientific publications (2013-2019) that name coauthors from US academic institutions or government-funded laboratories[3] and the 'Seven Sons' schools. The survey identified 254 articles naming coauthors from 115 US research institutions. It is important to note that our findings understate the level of collaboration as the collected corpus of S&T literature was limited to exploitation of a domestic PRC publication aggregator; it did not examine English-language publications from international sources. Nevertheless, our research showed that many of the PRC partners directly supported People's Liberation Army (PLA) programs, classified weapons R&D projects, and PRC state-owned defense conglomerates.

In addition to the 'Seven Sons' schools, some of the surveyed publications named other China-based collaborators who work at nuclear weapons R&D facilities, missile design and fabrication centers, and/or conduct classified weapons research projects. For instance, the Harbin Institute of Technology (HIT) partners with two state-owned defense conglomerates - China Aerospace Science & Technology Corporation and China Aerospace Science and Industry Corporation. HIT also collaborates with the PLA Equipment Development Department (formerly known as the General Armament Department) and the PLA Rocket Force, which manages the PRC's strategic and nuclear missile arsenal.[4]

We presumed in this study that all collaboration involved fundamental research and no illicit activity had occurred. None of this research was subject to regulatory oversight (such as export controls), and some US academic institutions were unaware that such collaboration was taking place. Consequently, we judged that:

- A binary test of (il)legality is not a sufficient basis for assessing risks to national and economic security regarding research collaboration with foreign entities.
- Neither the US government nor the universities and national laboratories in the US research enterprise are adequately managing the risks posed by research engagements with China.
- Fundamental scientific research should not default to meaning that research institutions and federal funding agencies have no control over, and thus no responsibility over research partnerships and the collaborators.

[2] Tiffert, Stoff, Gamache, "Global Engagement: Rethinking Risk in the Research Enterprise," *Hoover Institution Press*, 2020, https://www.hoover.org/global-engagement-rethinking-risk-research-enterprise.
[3] Examples of US government-funded facilities included Department of Energy national laboratories, Department of Defense laboratories, and National Institutes of Health research facilities.
[4] See pages 30-31 of the Hoover report for details.

Example 2: DoD-Commissioned Studies on Research Collaboration

While I worked at the Department of Defense (DoD), I oversaw several projects that also surveyed published scientific literature - in this case to catalog research collaboration of potential concern between entities receiving DoD research funding and PRC institutions or programs. This effort was methodologically similar to the Hoover Institution study on US collaboration with China's "Seven Sons" universities. The DoD studies were also limited in scope in terms of collected data. Most of the data were derived from domestic PRC publication aggregators, supplemented with limited exploitation of international publication sources and due diligence research. These studies served as initial proofs of concept; not as exhaustive risk assessments associated with US-China research collaboration.

The collected corpus of bibliographic data of scientific publications all credited DoD funding sources (though they varied in level of detail[5]) and named coauthors affiliated with PRC institutions and/or credited a PRC funding source. Key findings from these studies include:

- Some publications list coauthors affiliated with entities subordinate to the PLA (including a key hypersonics research and testing facility), China's nuclear weapons R&D complex, national defense laboratories, and civilian research institutes with extensive ties to defense research and industry.
- In one study, 97 out of 188 identified articles credited PRC government funding sources in addition to DoD grant(s).
- Multiple studies found that some coauthors maintained concurrent positions at both US and PRC institutions. Supplemental due diligence on a few cases revealed that the US-based coauthor did not disclose his/her dual affiliation with a PRC entity on CVs or faculty pages of their US employing institutions. In other cases, some coauthors claiming dual affiliations were PhD students and/or visiting scholars that spent a portion of their time in both nations.

Further investigation is needed to identify individuals who have (or had) full or part-time employment in both countries, and whether such joint appointments were reported to their US employers, created conflicts of interest or commitment, or ran afoul of other grant compliance issues.

Challenges remain, partly because the published literature surveyed in these studies were assumed to be designated fundamental in nature, which in accordance with NSDD-189, do not require restrictions on the publication of research findings or are subject to export controls. While the level of national security risks associated with collaboration with PRC entities vary depending on the mission of the PRC organization or specific research area, there is nevertheless a real risk that China's defense R&D and industrial base is benefitting from DoD-funded research programs.

Example 3: PRC Gifts or Contracts to US Institutions

In the previous two examples, it is unclear whether the collaborations involved direct resource sharing, personnel exchanges, or other formal agreements. This raises similar questions regarding the scope of PRC funding support to US research institutions writ large in the form of grants, gifts, or contracts. Being transparent and accountable on foreign monies coming in and reported to the government and made available to the public is important, particularly for higher

[5] For instance, some publications listed full details such as the DoD component and grant number/codes while other sources just stated that the research was supported by a particular DoD component. Additionally, not all publications identify which author received the DoD funding.

education institutions that receive federal funding. Public disclosures are not just important for national security reasons and to identify potential foreign influence, but also for ethical reasons. Human Rights Watch proposed a code of conduct encouraging universities to publicly disclose annually all direct and indirect PRC government funding and a list of projects and exchanges with PRC government counterparts.[6]

There is a formal process for such disclosures. Section 117 of the Higher Education Act of 1965 (20 U.S.C. 1011f) requires US colleges and universities to report the foreign gifts and contracts they receive to the Department of Education twice each year. This requirement is for all foreign gifts and contracts valued at $250,000 or more (alone or in combination with other gifts or contracts with a foreign source). I examined this disclosure data, which is accessible on the Department of Education's website,[7] and discussed below are two areas of concern.

Between 2014 and 2019, two U.S. universities reported 16 contracts totaling roughly $4.2 million from an entity listed as "Beijing Inst of Aeronautical Materia." This is a truncated or incomplete title, referring to the Beijing Institute of Aeronautical Materials (also known as the Beijing Aeronautical Materials Technology Research Institute, or BAMTRI), a subdivision of the PRC state-owned defense conglomerate Aviation Industry Corporation of China (AVIC). BAMTRI and its parent firm AVIC develop engines, cruise missiles, and defense aircraft for the PLA and is named on the Department of Commerce / Bureau of Industry and Security (BIS) Entity List for export control purposes. Thus, a major PRC defense aerospace firm was contracting with US universities to perform research on their behalf. If that research was designated fundamental, such contracts likely did not violate US export control rules.[8] Even if such arrangements are legal, is it really in the national interest to have US institutions perform contracted research for China's defense industrial base?

In late 2020, the Department of Education issued a report that showed significant non-compliance by US colleges and universities with respect to disclosing foreign gifts and contracts mandated by the Section 117 law.[9] This trend continues unabated: an examination of newer disclosures of foreign gifts or contracts from mid-2020 (when the department revamped its reporting system) to October 2021 show a trend of failure to name specific sources. There were 4,479 records that name China as a funding source; yet only 129 of those records list the specific entity. Additionally, 4,202 records state "N/A or No" on the question of whether the source is from a foreign government. Yet nearly all universities and research institutes in China are state-run; there is a real risk that many US universities may be falsely reporting (intentional or not) information to the Department of Education.

This lack of transparency by universities on foreign revenue sources also means the government cannot assess risks or advise universities on such risks when partnering with organizations that may threaten national security or undermine US interests. Consequently, it is impossible to

[6] "Resisting Chinese Government Efforts to Undermine Academic Freedom Abroad – A Code of Conduct for Colleges, Universities, and Academic Institutions Worldwide," Human Rights Watch, March 21, 2019, https://www.hrw.org/sites/default/files/media_2020/09/190321_china_academic_freedom_coc.pdf.

[7] Both current and historical data on foreign gifts and contracts can be found here: https://sites.ed.gov/foreigngifts/.

[8] Firms listed on the BIS Entity List does not equate to a ban; it simply indicates a license is required to export certain items to that entity.

[9] "Report on Institutional Compliance with Section 117 of the Higher Education Act of 1965," US Department of Education Office of the General Counsel, October 2020, https://www2.ed.gov/policy/highered/leg/institutional-compliance-section-117.pdf.

determine to what extent PRC defense-affiliated research entities or enterprises are funding US academic research.

Example 4: US Research Collaboration with China's Mass Surveillance Apparatus

US-China research collaborations of national security concern are not limited to China's defense R&D and industrial base. Equally troubling is academic and private sector cooperation with PRC entities that are part of or support China's mass surveillance and public security apparatuses that engage in human rights abuses. This is another area that receives insufficient scrutiny. Within academia, ethical risks to research collaboration with the PRC and other authoritarian nations are rarely considered if the research does not directly involve human subjects.

I coauthored a second study with the Hoover Institution that serves as a case study on ethical risks to research collaboration and demonstrates the critical importance of conducting robust due diligence on PRC partners. The report examined the domestic and international activities and partnerships of a major AI research institution in China: the Chinese Academy of Sciences Institute of Automation (CASIA).[10] CASIA exemplifies the challenges and complexities of collaboration with PRC institutions. CASIA has a dual identity: it conducts cutting edge research in AI and neuroscience fields and collaborates extensively with institutions throughout the developed world. Domestically, CASIA partners with public security organs and develops and commercializes mass surveillance technologies that enable the PRC's documented human rights abuses.[11] Figure 1 (in the Appendix) shows CASIA's diversion of nominally benign or beneficial research areas it conducts to ethically troubling applications.

The report found that CASIA collaborates extensively with US research institutions as well as major technology firms that sponsor research. And US entities are not just supporting or enhancing CASIA's fundamental research. CASIA is already commercializing and weaponizing its R&D. There are five companies CASIA owns major stakes in whose mass surveillance products and services -- including video surveillance and gait, iris, and facial recognition -- were born directly out of CASIA laboratories and research centers. These five companies contract with PRC public security organs, and at least two of them explicitly state they deploy their capabilities in the Xinjiang region where the party-state has engaged in genocide, mass incarceration, and other documented human rights abuses against the ethnic Uyghur and other Muslim minorities. These firms also partner with defense conglomerates and other companies known to support China's mass surveillance apparatus, such as Huawei and Hikvision.[12] Several of these commercial spinoffs claim to partner with or procure equipment from major US semiconductor firms. CASIA also owns equity stakes in at least 30 other companies, though further research is needed to determine the types of technologies those companies develop.

At the time of this testimony, neither CASIA nor its commercial operations are on the BIS Entity List. However, Tan Tieniu, one of CASIA's senior leaders and an expert in computer vision and surveillance technologies, concurrently serves as Deputy Director of the PRC government's Hong Kong office. He was placed on the US Treasury Department's "specially designated nationals list" as part of the US government's sanctions on Hong Kong officials for their

[10] Stoff, Tiffert, "Eyes Wide Open: Ethical Risks in Research Collaboration with China," *Hoover Institution Press*, 2021, https://www.hoover.org/sites/default/files/research/docs/stoff-tiffert_eyeswideopen_web_revised.pdf.
[11] Ibid.
[12] Ibid.

responsibility for a human rights crackdown in the city.[13] Yet Tan has played a central role in facilitating international cooperation agreements with both academic institutions and private companies from the U.S. and its allies.

Knowledge Gaps with Respect to China's Defense R&D and Industrial Base

China's exploitation of our research enterprise that may affect future supply chains described in the previous section is a complex problem. Securing or restricting existing US supply chains, both inbound and outbound, is at least conceptually a more straightforward problem. Much of the focus has been on identifying our vulnerabilities and choke points, such as over-reliance on China and/or a small number of suppliers of a particular input (e.g., pharmaceutical ingredients, rare earth metals, etc.). Equally important, however, is that the U.S. must have a clear picture of what China's defense research and industrial base looks like that may be in our critical technology supply chains. The previous example on CASIA identified unknown elements to China's mass surveillance R&D and supply chains. Similar efforts must be made to address the yawning knowledge gaps in this area.

Our knowledge gaps can substantially be attributed to a) the US government's inadequate use of and arguably its devaluation of publicly available information as a source of intelligence; and b) China's lack of transparency over corporate structures and ownership, minimal use of English (Chinese language serves as a form of encryption), and deliberate obfuscation of the nature or missions of key entities. I offer two examples that are illustrative of this problem.

Case Study: China Electronics Technology Group Corporation

Many of China's centrally managed state-owned enterprises (SOEs) are large conglomerates that can have hundreds or even thousands of subsidiaries or investments. Their ownership stakes can include other SOEs, publicly traded companies, privately held firms, and joint ventures with foreign businesses. China's state-owned defense conglomerates are no exception, and the China Electronics Technology Group Corporation (CETC) is an illustrative example.

CETC specializes in all aspects of electronics, microelectronics, and electronic information for the PLA as well as for civilian purposes such as public security, intelligent transportation, and new energy. It reportedly conducts business internationally in more than 110 countries and regions.[14] According to a 2021 securities filing, CETC had more than 200,000 employees, and encompassed more than 700 subordinate companies and public institutions. The latter includes 47 research institutes, 16 publicly traded companies, and 35 state key laboratories, research centers, and innovation centers.[15]

However, the BIS Entity List only names about two dozen CETC subsidiaries and research institutes. I am not aware of any efforts by the US government to survey all of CETC's subordinate entities and determine whether they are involved in US supply chains (import products to the U.S.), whether US firms have partnerships (such as joint ventures) or export

[13] "Publication of Hong Kong Business Advisory; Hong Kong-related Designations," US Department of the Treasury, July 16, 2021, https://home.treasury.gov/system/files/126/20210716hongkongadvisory.pdf.
[14] "China Electronics Technology Group Corporation," website of China Services Info, April 19, 2019, http://govt.chinadaily.com.cn/a/201904/19/WS5cb99627498e079e6801e9bc.html.
[15] "Issuance of Public Securities for CETC - Prospectus, November 17, 2021, file.finance.sina.com.cn/211.154.219.97:9494/MRGG/BOND/2021/2021-11/2021-11-17/16545564.PDF

hardware components or software to CETC entities, or whether there are US outbound investments in CETC affiliates.

This issue is particularly relevant within the context of semiconductors and microelectronics, given the criticality of the industry to our defense supply chains and increased calls to reduce our reliance on China via the CHIPS for America Act[16] and related legislation. A nascent survey of CETC-owned firms demonstrates the need for bolstering our due diligence efforts in this space. Table 1 (in the Appendix) lists five semiconductor or microelectronics firms in which CETC holds majority stakes in. It is notable that "CETC" or its name variants are excluded from these firms' names and none of them appear on the BIS Entity List. Table 1 is a mere sampling and should not be construed as a comprehensive inventory of CETC affiliates involved in semiconductor or related industries.

University-Industry Partnerships

China has a well-developed system of university and industry partnerships, such as dedicated S&T and industrial parks attached to or co-managed by major universities and innovation and technology transfer centers that seek to commercialize R&D conducted in academia. Some universities, including the "Seven Sons of National Defense" schools and other major scientific and engineering institutions like Tsinghua University, have commercial spinoffs and holding companies that make commercial investments both domestically and internationally. Jason Arterburn has conducted research in this area and shared some of his findings in previous testimony to this Commission. For example, Arterburn examined corporate records on the Harbin Institute of Technology (HIT, one of the 'Seven Sons' schools) and found that HIT has direct or indirect ownership interests in approximately 1,000 China-based companies and owns a 50-percent or greater ownership interest in approximately 50 entities.[17]

This offers a glimpse into the scale and scope of what may comprise China's defense industrial base outside the major SOEs. Needless to say, far more research needs to be done in this area to understand the supply chain implications.

Knowledge Gaps on PRC Universities Supporting Defense R&D

China's State Administration for Science & Technology Industry for National Defense (SASTIND) was established in March 2008 as the successor to the Commission for Science, Technology, and Industry for National Defense (COSTIND, 国防科学技术工业委员会) after a State Council reorganization that also created the Ministry of Industry and Information Technology, which oversees SASTIND.[18] SASTIND has joint development agreements with the Ministry of Education and provincial governments to promote defense-related research and education programs at over 50 PRC universities. These agreements have focused on recognizing and developing defense-related academic disciplines, key laboratories, and research groups at the universities, incentivizing researchers to apply for defense research funding, and promoting collaboration between university labs and defense industry firms and research institutes.[19]

[16] https://www.congress.gov/bill/116th-congress/house-bill/7178
[17] Jason Arterburn, "The Party-State in China's Military-Industrial Complex: Implications for U.S. National Security," Testimony to the US China Economic Security Review Commission, March 19, 2021.
[18] http://www.gov.cn/2008lh/content_921411.htm.
[19] https://www.sohu.com/a/255615361_396354

These universities that partner with SASTIND receive less scrutiny than the "Seven Sons of National Defense" in part because they do not have the same degree of involvement in defense-related research. SASTIND's support is typically limited to select departments, divisions, and labs within these universities. Thus, more robust due diligence research is needed to assess national security risks associated with collaborations with these PRC universities.

Compounding this challenge are deliberate efforts by the PRC to obfuscate information on entities supporting defense programs. An illustrative example is the University of Electronic Science and Technology of China (UESTC), one of the civilian universities co-managed by SASTIND. The English-language version of its website describing its organizational structure has a page entitled "Labs & Centers." This page lists only one entity it calls the "National Key Laboratory of Science and Technology on Communications."[20] Figure 2 (in Appendix) provides a screenshot of that English webpage.

In contrast, UESTC's Chinese-language website that corresponds to the English version lists nine entities, including one of the official names of the "communications laboratory" mentioned on the English page. Figure 3 (see Appendix) shows a screenshot of that Chinese webpage. A translation of the corresponding Chinese name is the National Technology Key Laboratory on Anti-Interference Communications, also referred to as the National Defense Technology Key Laboratory on Anti-Interference for Tactical Communications.[21] The pronounced difference between the English and Chinese versions suggests deliberate obfuscation to avoid international scrutiny. In addition, at least two of the other centers listed only on the Chinese page likely involve defense research, including a laboratory for "electromagnetic radiation control materials" and a laboratory for "extremely high frequency complex systems."[22]

Tapping into US Innovation

A key element of China's technology transfer apparatus are the tethers it has built to tap into the R&D and innovation occurring inside the U.S. In addition to benefitting from informal research collaboration and partnerships with US academic institutions described in the previous section, China's party-state deploys official and unofficial proxies; investment structures such as venture capital funds, incubators and innovation centers; start-up contests; talent programs and supporting recruitment networks; and partnerships with diaspora organizations, at least some of which are part of China's United Front apparatus commonly and myopically viewed in terms of political influence operations. A comprehensive examination of these areas exceeds the scope of this testimony and the topic of today's hearing. Instead, I offer a few examples of how this works and their implications.

A glimpse of China's evolving strategy to exploit US innovation can be gleaned from CPC policy documents and leadership speeches. In the book *China's Quest for Foreign Technology: Beyond Espionage,* contributing author Andrew Spear compiled excerpts of these policy

[20] https://en.uestc.edu.cn/Academics/Labs_Centers.htm
[21] The Chinese names are "战术通信抗干扰技术国防科技重点实验室," also known as "通信抗干扰技术国家级重点实验室." UESTC uses both of these Chinese name variants.
[22] The Chinese webpage listing these centers can be found here: https://www.uestc.edu.cn/211202a06493bf4a2a046d2b638cf5dd.html?n=8e7z368tn51.

documents.[23] A sampling of these statements along with the year in which they appeared include:

> "Fully exploit overseas talent resources and encourage overseas scholars to serve the motherland through various methods while that are studying or working overseas." (2009)

> "China must deepen international exchange and cooperation, fully use global innovation resources, [and thereby] advance indigenous innovation from a higher starting point, actively deploy and proactively use international innovation resources." (2013)

> "Adopt flexible and diverse methods to strengthen connections and communications with overseas-based Chinese student, scholar, and professional groups in order to provide them information, consultation, and 'matchmaking' services." (2014)

> China should "mobilize talents to engage in offshore innovation in foreign countries" or "attract 'migratory bird talent to engage in part-time innovation in China, while employed overseas." (2018)

Case Study: ZDG Group

A state-owned investment firm and technology incubator known as Zhongguancun Development Group Co., Ltd. (ZDG) and its US operations is a good example of how these policies have been put into practice.

In early 2017, at the "Beijing Silicon Valley High-level Talents Summit," eight American scientists were hired by the ZDG as the first batch of a newly created "Zhongguancun Overseas Strategic Scientists Program." The PRC Consul General San Francisco and the head of the Organization Department of the Beijing Municipal Party Committee unveiled the program, which seeks to recruit top scientists from prestigious US universities.[24] ZDG is a state-owned investment enterprise with operations in the US that seeks to invest in and/or acquire technologies and incentivize firms to set up operations in Beijing's technology district Zhongguancun.[25]

In a press interview, ZDG's Chief Operating Offer explained the reasoning behind the Zhongguancun Overseas Strategic Scientists program. He stated, "it is not always necessary for talents to return to their country. Rather, with the establishment of [this program], top scientists with outstanding achievements abroad can not only contribute to China's scientific research while in the United States, but also cultivate talent and continuously connect overseas talents with Chinese entrepreneurs and capital…This is a new option for those scientists who want to serve their country."[26]

In other words, a PRC state-owned entity, a PRC Consulate General, and a Communist Party official in charge of talent recruitment were involved in or supported establishing a program to hire US scientists to help the party-state with critical technology offshoring to China and talent recruitment efforts while remaining in the U.S. Supplemental research indicates that most of the

[23] See chapter 2 written by Andrew Spear of William Hannas and Didi Kirsten Tatlow, editors, *China's Quest for Foreign Technology: Beyond Espionage,* (Routledge, 2021). Note I authored three chapters of this volume.
[24] "中关村硅谷创新中心招才引智新方式: 引 '才'留 '人'", *People's Daily Online (Renminwang),* March 7, 2017, http://world.people.com.cn/n1/2017/0307/c1002-29129869.html.
[25] A discussion of Zhongguancun Development Group and its US strategy appeared in: "Findings of the Investigation Into China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation Under Section 301 of the Trade Act of 1974, Office of the US Trade Representative, March 22, 2018, pages 145-147, https://ustr.gov/sites/default/files/Section%20301%20FINAL.PDF.
[26] "中关村硅谷创新中心招才引智新方式: 引 '才'留 '人'", *People's Daily Online (Renminwang),* March 7, 2017, http://world.people.com.cn/n1/2017/0307/c1002-29129869.html.

recruited scientists have worked on federally sponsored research throughout their academic careers, including from DoD.

PRC State-Sponsored Startup Contests

The PRC government sponsors many start-up or entrepreneurial contests that incentivize individuals to establish businesses in China. These start-up contests are often organized and controlled out of PRC diplomatic posts across the U.S. Overseas-based scholars, graduate students, and employees of technology companies pitch ideas for a start-up based on the research or technology they worked on in the U.S. These contests have grown in number over the last decade, and they now number at least several dozen that hold initial contest rounds in the U.S. (and other nations) to select finalists. Overseas finalists receive PRC government stipends to travel to China for the final rounds. Winners receive incentives to found businesses, such as low-cost financing, venture capital investment, housing, and free space in designated S&T and returnee parks.

PRC diplomatic missions and CPC organs have co-opted US-based professional associations to help host, organize, and serve as judges of the start-up contests. Many of these partnering entities are US nonprofit organizations that do not have to disclose donors and sources of revenue. Some of the co-opted diaspora groups also partner with China's United Front system. The United Front has traditionally been viewed as leading China's global political influence operations that co-opts organizations around the world to promote and project the CPC's interests. Less understood is that United Front operations include co-opting US-based entities to carry out technology transfer activities.[27] The start-up contests these organizations support also evade regulatory scrutiny such as export controls or the Committee on Foreign Investment in the United States (CFIUS) as no transactions occur on US soil.

Venture Capital Investments

Entities that enable PRC state-supported technology and knowhow transfers also support efforts to invest in or acquire technology firms and startups in the United States. Venture capital (VC) firms with close ties to or directly owned by PRC national or municipal government entities are active in major US technology hubs. The aforementioned ZDG is one example. Another is the PRC's flagship recruitment program, the Thousand Talents Program. This program has its own state-owned venture capital (VC) fund with a branch in Silicon Valley that provides "angel" or early round investments in technology startups and recruits talent from these firms to transfer the technology to China.[28]

According to an insider in the VC community I spoke with, some VC firms have shared sensitive startup company information obtained under the auspices of participating in an investment round, but subsequently provided that information to competitor firms (including PRC-based companies). It is unclear if VC firms with managing partners and staff from China conduct sufficient security vetting of those individuals (or are even incentivized to do so). There are risks that PRC nationals may be tasked, funded, or directed by PRC state entities to access business

[27] Alex Joske and Jeffey Stoff, "The United Front and Technology Transfer," Chapter 15, Hannas, Tatlow, eds., *China's Quest for Foreign Technology: Beyond Espionage*, Routledge, 2020.
[28] Additional examples of the investment activities and forums held in the U.S. by PRC-affiliated entities appear in Appendix 9 of: Michael Brown and Pavneet Singh, "China's Technology Transfer Strategy: How Chinese Investments in Emerging Technology Enable a Strategic Competitor to Access the Crown Jewels of US Innovation," *Defense Innovation Unit Experimental,* January 2018.

plans, deal flow, and influence seed investment decisions that may be diverted to China's benefit. Additionally, PRC state-backed investment entities are active in the US and partner with VC firms on investment rounds, some which obfuscate their PRC government backing which complicates risk assessment efforts by partnering VC firms or startups seeking capital. This can be particularly problematic for US startups that hope to contract with DoD in the future, as the PRC investors may create unacceptable foreign ownership, control, or influence risks to the DoD.

Tapping Into Talent Pipelines

China's state-sponsored talent recruitment programs are an important part of the overall technology acquisition strategy. They are run at national, provincial, municipal, and individual institution levels, and are woven into government and party organs, SOEs, research institutions, national laboratories, nominally private industry, domestic and overseas "NGOs," and global diaspora organizations. These programs have a singular purpose: to recruit experts of any nationality to transfer to China intellectual capital and property from overseas (agnostic to the legality of such activity) to bolster the PRC's economic, technological, and military competitiveness. Some of the national talent programs have been around long enough (some over two decades) such that many key leaders in critical technology fields in China were recruited from overseas through these programs. This is especially the case in areas where China is near-peer or perhaps overtaking the U.S., such as AI, hypersonics, and quantum communications.[29]

The US government has increased scrutiny over these talent programs given the national security implications and the fact that some selectees were tasked or incentivized to commit economic espionage or trade secret theft, and policymakers and members of this Commission are likely familiar with them given the significant media coverage and government messaging. My focus here is to highlight the persistent vulnerabilities and challenges to mitigating threats posed by these programs, and address misconceptions due to knowledge gaps.

The Australian Strategic Policy Institute, a government-funded think tank, has identified about 200 PRC state-sponsored talent programs.[30] However, US government efforts to date to identify and mitigate threats posed by these talent programs have focused primarily on the illegal activities of selectees of just a few of the nationally run programs. Consequently, the scale and scope of China's talent programs targeting US innovation (legally or not) are largely unknown.

Vulnerabilities to DoD-Funded R&D

While I worked for the Department of Defense (DoD), I led several projects that sought to identify and assess vulnerabilities to DoD investments in unclassified arenas. Both the Intelligence and Security and Research and Engineering divisions of the Office of the Secretary of Defense recognized the need to better understand the threats and challenges posed by the PRC in unclassified R&D domains. The studies identified potential instances where China was exploiting DoD investments for its benefit.

There has been a lack of oversight in this area largely because many of the identified threats posed by China are not illicit in nature. Nevertheless, the projects highlighted national security

[29] Jeffrey Stoff, "China's Talent Programs," Chapter 3 of *Beyond Espionage: China's Quest for Foreign Technology*.
[30] Alex Joske, "Hunting the Phoenix: The Chinese Communist Party's Global Search for Technology and Talent," *Australian Strategic Policy Institute,* 2020, https://www.aspi.org.au/index.php/report/hunting-phoenix.

concerns that can have serious implications with regards to future defense supply chains and warfighting capabilities. The projects sought to address these questions:

- What is the scale and scope of China's technology acquisition and transfer activities affecting unclassified DoD programs or investments?
- What does this threat landscape look like regarding research designated as fundamental that are not subject to export controls or other regulatory oversight?

The previous section of this testimony discussed research collaboration of national security concern that involved both DoD funding and PRC research institutions or programs. DoD-commissioned studies also examined PRC talent programs that recruited individuals involved in DoD-funded research.

In aggregate, these studies identified over 300 individuals who were recruited through a talent program that claimed to have supported DoD-funded research either as the Principal Investigators (PIs) or co-PIs (i.e., individuals that received DoD funding and oversaw the research projects), or the PhD students, postdoctoral researchers, or visiting scholars that helped conduct the research. Numerous programs run at national, provincial, and local levels had recruited these US-based individuals, although the nationally run programs such as the Thousand Talents and Changjiang Scholars Award Programs represented about half of all identified selectees.

It is important to note that further investigation would be required to determine if any individual engaged in illicit activity. However, based on engagement with the responsible DoD program and policy offices, we concluded that very few of the concerns raised in these studies likely involved criminal violations. Other key findings include:

- Some selectees were full-time US faculty members and PIs of DoD grants who are experts in their field with years of experience working on US government funded research. Many of those individuals did not disclose their China commitments or positions on DoD grant applications,[31] nor did they detail their (often extensive) China-based commitments, positions, or activities on their CVs or faculty pages on US institution websites.
- Roughly half of the identified PIs also supported other federal agency sponsored research, especially the National Science Foundation, Department of Energy, and National Aeronautics and Space Administration (NASA).
- Most of the US-based experts that served as PIs or co-PIs have trained PRC graduate students and postdoctoral researchers who subsequently return to China and engage in defense research programs.
- Roughly two-thirds of identified talent program selectees were graduate students, postdoctoral fellows, and visiting scholars - not the PIs themselves.
- Nearly all selectees have held appointments or affiliations with PRC entities that support defense research, or they collaborate with scientists associated with China's defense R&D and industrial base. These entities include China's nuclear weapons complex, PLA hypersonics facilities, state-owned defense conglomerates, and major civilian research institutions that conduct defense research.

In nominal terms, the affected DoD grants and PIs recruited by a PRC talent program represent a small fraction of the thousands of research grants and dollars awarded annually. Some may argue

[31] Some of these disclosures may not have been required at the time these studies were conducted. Changes in disclosure policies have been implemented since then, and National Security Presidential Memorandum-33 is establishing a set of government-wide standards on types of information required to be disclosed on federal grants.

that this indicates the risks to DoD are small and manageable. There are several problems with that argument. First, these studies were limited in scope and surveyed only a few of the DoD components that fund academic research. The number of identified talent program selectees (about 300) also constrained our ability to examine every individual to assess security or integrity risks. These projects represented an initial effort to identify areas of concern that warrant more systematic scrutiny across all DoD elements; they were not designed to be exhaustive threat assessments.

Secondly, some of the identified individuals who were PIs on DoD grants have overseen federally funded research for a decade or more and have trained multiple generations of graduate students and postdoctoral researchers who were subsequently recruited into talent programs and contribute to the PRC's defense R&D and industrial base. Some of the graduate students and postdoctoral researchers trained by PIs have no known association with talent programs, but now work on PRC defense research programs. Thus, the small number of identified PIs have influenced a much larger number of individuals of national security concern not reflected in the number of identified talent program selectees. Complicating this problem is that most DoD program offices do not have sufficient mechanisms to track and perform due diligence on key performers of research grants in academia other than the PIs.

Vulnerabilities to DoD's SBIR Programs

Another DoD commissioned study I oversaw sought to identify specific risks and vulnerabilities posed by China's tech transfer apparatus that affect DoD-funded Small Business Innovation Research (SBIR) programs. This was a small, pilot effort to document the nature of the identified risks and recommend solutions to address SBIR program vulnerabilities. That effort narrowly focused on case studies involving entities that directly or indirectly support China's defense R&D and industrial base. Limited resources constrained the number of cases and due diligence research performed. Nevertheless, the study found that China has benefited from DoD's SBIR programs and reveal vulnerabilities to potential future DoD supply chains. Some key findings include:

- DoD's SBIR program lacks standard, DoD-wide capabilities and resources to conduct adequate due diligence on funding recipients *pre- and post-award* of a contract to assess national security risks or monitor for compliance. The program primarily relies on self-certifications by offerors.
- Some key employees of US firms receiving SBIR funding were recruited via a PRC talent program and relocated to China, but they continued research collaboration with officers of the US companies where they were previously employed.
- US firms established PRC-based subsidiaries, and in some cases, later dissolved US operations and received PRC government investments.
- In one observed case, a recipient of multiple DoD SBIR contracts established another firm in China based on the same technologies and has reportedly worked on wheeled combat vehicles in partnership with a subsidiary of state-owned defense conglomerate China North Industries Group Corporation (中国兵器工业集团公司, NORINCO). NORINCO is one China's largest weapons and defense systems manufacturer.
- US firms received VC funding from PRC sources, including state-owned enterprises that create potential foreign ownership, control, or influence risks.

- PRC researchers have conducted (and published) detailed analyses of US Navy SBIR programs over time to deduce DOD technology development priorities and catalogue firms that receive the most SBIR funding.

The case studies examined in the SBIR study represented a very small sample of SBIR awardees, but nevertheless demonstrate the need for more robust due diligence for national security risks both pre- and post-award of a contract.

Implications of Other Federal Agency-Funded Research

Another challenge is the dual-use nature of STEM and biomedical research conducted in academia that is exploited by China. An illustrative example is a US university professor who received funding from the National Institutes of Health (NIH) to develop hearing aids using AI applications applied to audio signal processing and speech segregation. While working on this NIH-funded research, that professor was recruited through the Thousand Talents Program, holding a concurrent appointment at Northwestern Polytechnical University's School of Marine Science & Technology.[32]

Northwestern Polytechnical University (NWPU) is one of China's "Seven Sons of National Defense" universities and extensively supports PLA Navy programs. Its School of Marine Science & Technology conducts "scientific research and personnel training in the fields of underwater weaponry, hydroacoustic engineering, underwater vehicles, and marine engineering."[33] In other words, NWPU hired this US professor to help develop underwater warfare applications (probably involving submarines) from the NIH-funded signal processing technology.[34]

NIH is not equipped nor mandated to assess national security risks associated with potential future applications of the type of research it funds, and DoD has no oversight or control over what other federal agencies fund. The PRC has a history of diverting research to military use applications and although such research is not overseen by DoD, the research runs the risk of affecting or undermining the US military's future warfighting capabilities. The lack of oversight or scholarship over such exploitation of STEM and biomedical research makes it impossible to determine how pervasive or successful China's efforts in this area have been.

Conclusion and Recommendations

The examples discussed here provide a glimpse into the complexity of China's apparatus to target and exploit US research, expertise, and training pipelines that will be part of our future critical technology supply chains. This is not a comprehensive survey of all aspects to China's system. Nevertheless, an important implication is that concepts of "running faster," such as investing more in domestic R&D and reshoring critical supply chains will make little difference if there are insufficient efforts to identify and mitigate the various means China deploys to siphon, invest in, influence, or divert US innovation for its benefit.

[32] https://web.archive.org/web/20160624032139/http://www.nwpu.edu.cn/info/1279/12650.htm; and "Brief biography," http://www.freekaoyan.com/guide/daoshi/2019/05-27/1558903628393839.shtml.

[33] "西北工业大学 航海学院 (Northwestern Polytechnical University School of Marine Science & Technology), https://hanghai.nwpu.edu.cn/xygk/xyjj.htm.

[34] It is worth noting that the professor's Thousand Talents appointment and formal position at NWPU do not appear on his CV or faculty page (or were perhaps removed), raising integrity concerns as well.

China's extensive mechanisms to tap into US talent and R&D to "serve China while overseas," weakens the argument that high rates of PRC nationals who stay in the U.S. after receiving advanced degrees means America, not China is benefitting from this talent pool and thus the threats posed by PRC talent programs are overblown. PRC talent programs and related strategies are designed to transfer knowhow, technology, and research to China often without having individuals relocate there, and these programs target individuals *after* they have gained expertise and/or access to cutting edge technologies and research. Note these risks are not unique to the United States. China deploys the same methods, organizations, and supporting infrastructures throughout the developed world to exploit innovation wherever it occurs.

Another problem is the lack of systematic efforts to identify and assess China's defense R&D and industrial base and mass surveillance apparatus and their supporting entities and infrastructure, hampering the effectiveness of existing trade restrictions, export enforcement, supply chain risk management, and related measures.

Challenges and Limitations to Protecting Our Innovation

Effective recommendations require addressing our knowledge and regulatory gaps and their root causes. Here I will highlight some of the key challenges within the government, academia, and the private sector that limit our ability to protect earlier stages of our innovation ecosystem.

The examples provided in this testimony involve activities that are typically not illicit in nature and/or circumvent regulatory oversight. This limits both the scope and effectiveness of law enforcement tools in combating China's predations. The US Intelligence Community (IC) also has its own mission constraints. In 2020, the House Permanent Select Committee for Intelligence (HPSCI) issued a report that examined the Intelligence Community's (IC) competencies with respect to China. The report concluded that the IC "has not sufficiently adapted to a changing geopolitical and technological environment increasingly shaped by a rising China." The report noted the IC lacks sufficient language, cultural, and subject matter expertise on China.[35]

China's domestic S&T development relies heavily (at least for now) on tapping into international resources and expertise. Consequently, assessments of China's critical technology development and its defense R&D and industrial base require *both* an examination of China's domestic capabilities and infrastructure *and* its corresponding technology transfer apparatus. In my opinion, the IC and the government writ large are doing little in either space. As the HPSCI report states, "foreign science and technology (S&T) capabilities, plans, and intentions have been less of a priority for US collection and analysis than other traditional foreign intelligence topics, such as leadership, military, political, and economic intelligence."

Another cause of our knowledge gaps relates to the IC's over-reliance on classified information sources and the minimal use of or resources applied to publicly available information or open-source intelligence (OSINT).[36] A recent study by the Center for Strategic & International Studies, pointed out that the availability of publicly available information, commercially-acquired data, and AI or machine learning solutions developed outside of the IC, combined with

[35] House Permanent Select Committee on Intelligence, "The China Deep Dive: A Report on the Intelligence Community's Capabilities and Competencies with Respect to the People's Republic of China," 2020, https://intelligence.house.gov/uploadedfiles/hpsci_china_deep_dive_redacted_summary_9.29.20.pdf.
[36] OSINT is differentiated from publicly available information in how the information is acquired, used, and analyzed within the IC, not by the sources of information themselves.

the IC's unwillingness to exploit such information has resulted in the "IC's diminishing primacy as the source of intelligence analysis for policymakers."[37]

For instance, while I served in the government, I supported offices responsible for conducting CFIUS threat assessments. I observed that except for the Office of the US Trade Representative, federal agencies rarely used domestic PRC sources of information in the vernacular. At interagency meetings, I advised that CFIUS threat assessments could be substantially improved if the process utilized publicly available data sources in China that include information on corporate registries, securities filings, business and industry sector descriptions, and shareholder ownership stakes. To my knowledge, no such efforts have been made to use these Mandarin-language sources. This is unfortunate, as there can be significant differences in content between English and Mandarin sources related to company information. A government colleague described this discrepancy as "reverse marketing," i.e., companies downplay or minimize information in English discussions of their mission, customers, and types of products or services they provide to avoid international scrutiny.

Challenges, Risks Facing Academia, Private Sector

Table 2 (in Appendix) lists some key impediments that limit the US government's effectiveness at countering the PRC's technology transfer apparatus. In addition to the government, academic and private sector institutions face their own challenges that make them vulnerable to China's predations. These include (but are not limited to):

- Academia lacks resources, subject matter knowledge, or incentives to conduct due diligence on foreign research partners and foreign sources of revenue
- Ethical risks to research collaboration with the PRC and other authoritarian nations are rarely evaluated if the research does not involve human subjects; research institutions may be enabling human rights abuses and development of mass surveillance capabilities of adversarial nations
- Universities' lack of transparency on foreign revenue sources means there is little scrutiny over ethical, integrity, national security, or malign foreign influence risks
- Universities that employ faculty who have concurrent appointments in China (typically through talent programs) may create conflicts of commitment / interest or related compliance risks on federal grants
- University administrators are generally unaware of activities that violate the integrity of research by faculty who are under contract with PRC institutions and tasked with undermining merit-based hiring, filing patents in China based on US-funded research, exploiting US facilities to support "shadow labs" in China, etc.
- Research conducted at technology firms or corporate-sponsored research in academia receive little scrutiny, and risks to the security or integrity of that research are rarely assessed
- PRC state-sponsored talent programs and start-up contests recruit individuals working at US technology firms and startups that encourage unauthorized transfers of knowhow to PRC competitors, yet the private sector generally lacks capabilities to identify such risks
- The US VC community does not adequately vet investment partners or portfolio companies that represent substantial foreign ownership or control risk; PRC entities can exploit private deal flow and business plan information without US investors' awareness

[37] "Maintaining the Intelligence Edge: Reimagining and Reinventing Intelligence through Innovation," *Center for Strategic & International Studies*, January 2021.

Recommendations

In a recent study, Jon Bateman provided a comprehensive catalog of the authorities, tools, and trade policies the US government has in its arsenal, many of which can be brought to bear with regards to safeguarding our critical supply chains.[38] When combined with IC and law enforcement authorities and operations, the government has a dizzying array of levers it can utilize. Yet many of the agencies that can deploy these tools lack sufficient resources to fully realize their potential. This is particularly true with respect to the inputs needed to conduct research and assessments on China.

As such, my recommendations focus on bolstering the supporting infrastructure that can make the existing arsenal of government tools more effective, rather than proposing new authorities, policies, or legislation. Much of the collection and analysis can come from publicly available information. Past hearings of this Commission have discussed the value and criticality of using OSINT and publicly available information; for example, previous testimony and a related report by Jason Arterburn offers an excellent framework for conducting due diligence on China entities of national security import.[39] However, this capacity building requires new paradigms that can address the structural impediments that have prevented federal agencies from adequately exploiting publicly available information and can also provide support to academic and private sector institutions.

A New Paradigm for Collective Action

Based on my experience working with many federal agencies and overseeing open-source collection and analysis programs, it is my view that no government agency or program can overcome their structural limitations without a radical transformation of their missions, priorities, and resources. That would be a difficult task and could create zero-sum game effects; other missions would need to be descoped that could have unintended or dangerous consequences. Additionally, constitutional and regulatory limits constrain certain missions of federal agencies (particularly the IC and law enforcement), for reasons that may not make sense to change.

Consequently, I recommend Congress and federal agencies support the buildout of an independent, non-governmental entity known as the Center for Research Security & Integrity (CRSI).

CRSI will be a non-profit organization whose mission is to protect the US research and innovation ecosystem from harmful foreign influence and interference. CRSI will assist academic, government, and private sector institutions in mitigating risks to the security and integrity of research from adversarial or authoritarian nations, starting with China. A key element can include data collection, analytic, and research support to our trade and export control regimes, such as nominating organizations to be added to the BIS Entity List and/or Treasury sanctions.

[38] Jon Bateman, "U.S. – China Technological 'Decoupling': A Strategy and Policy Framework," *Carnegie Endowment for International Peace,* 2022.
[39] Jason Arterburn, "Party Capital: A Blueprint for National Security Due Diligence on China," *C4ADS*, 2021.

I have initiated the process to incorporate CRSI as a nonprofit organization and an application for 501(c)(3) designation with the IRS is forthcoming. CRSI intends to operate on the following principles:

- CRSI serves the public interest by maintaining the highest standards of expertise and analytic rigor and offers unbiased, empirically driven products and services tailored to the needs of the research enterprise.
- CRSI will be built on public-private partnerships via a consortium of *select* private sector firms that conduct industry-leading open source and due diligence research, think tanks, NGOs, and academic institutions that have capabilities to support research security efforts. This consortium will combine unique capabilities and resources of each of its members which would surpass existing structures.
- CRSI will produce products and services tailored for stakeholders of all sizes and shared in a trusted manner that do not compromise privacy protections or sensitive matters. A core mission will also include projects designed for public sharing and awareness.

CRSI's will undertake three lines of effort: R&D, operations, and information sharing and outreach, all of which are centered on identifying ethical, national security, research integrity, and regulatory (compliance) risks for public and private sectors focusing on "left of theft" areas. Each of these efforts may overlap, and the R&D will be foundational to all activities as it builds the required technical and analytic infrastructure.

- **R&D efforts:** Build due diligence and data collection methods; develop risk assessment and risk rating schema; conduct studies on PRC state-directed knowhow transfers and malign influence on research; map China's defense and surveillance R&D and industrial bases; conduct critical technology vulnerability assessments
- **Operational efforts**: Provide risk advisory and due diligence services to academia, government, and private sector clients; support grant compliance monitoring and risk assessments for federal agencies; build training programs for government and academia
- **Information sharing/outreach efforts**: Publish studies, trends, and analyses; convene public and private workshops and seminars

CRSI's consortium structure allows for agility, cost savings, and unique advantages that other entities lack, such as:

- **Resource sharing:** CRSI's mission aligns with select NGOs and think tanks that are part of the consortium; some projects need not be funded or staffed entirely by the center; consortium member institutions can host and organize public/private events minimizing the need for large (and costly) physical office spaces
- **Unparalleled expertise:** in-house staff and consortium members are leading experts in technology protection, research security, and risk assessments relating to China
- **Cost savings to taxpayer:** grant compliance and monitoring support to both government and academic clients can result in cost savings in terms of avoiding litigation or return of federal grant dollars to federal agencies; as a non-profit, CRSI can also contract with the government to perform select research and analytic services at a lower cost than most private firms
- **Innovator of open-source intelligence:** the R&D projects, data exploitation and analysis, and published materials will be foundational to supporting new initiatives on building open-source capabilities the US government lacks

CRSI will seek revenues through federal grants and/or Congressional appropriation, philanthropic sources, as well as contracts with academia, government agencies, and the private sector. Diversifying sources of revenue will be important to maintain long-term sustainability, independence, and to engage with numerous stakeholders across public and private sectors. CRSI's mission areas could also be expanded to support allied nations as well, particularly nations that are integral to our defense supply chains.

It is worth noting that the final report issued by the National Security Commission on Artificial Intelligence (AI) made a similar recommendation. It urged Congress to authorize the sponsorship of a university affiliated research center (UARC) that would act as a center of excellence on research integrity and provide information and advice on research security. It stated this center should "bridge the gap between the government and academic and private-sector research institutions and lower the barriers for research organizations to independently conduct compliance and informed risk assessments." The recommended lines of effort of that proposed entity align with CRSI's.[40]

However, I believe CRSI is a better model than sponsoring a UARC. While UARCs have capabilities that can contribute to these efforts, they are run by individual universities. Other universities would be reluctant to share potentially sensitive information affecting their organization with an outside UARC. An independent entity is better suited to engender trust among different stakeholders. Additionally, no single UARC has all the necessary capabilities to be fully effective, hence CRSI's consortium model would offer a more comprehensive approach.

[40] "Final Report," *National Security Commission on Artificial Intelligence*, 2021, https://www .nscai .gov /wp -content /uploads /2021 /03 /Full -Report -Digital -1 .pdf.

Appendix: Tables and Figures

Table 1: Sampling of CETC-Owned Semiconductor or Microelectronics Firms

Company Name	Description, Affiliation with CETC
Nanjing Zhongdian Xingu High-frequency Device Industrial Technology Research Institute Co. Ltd. (南京中电芯谷高频器件产业技术研究院有限公司)	CETC's 55th Research Institute holds a 55% ownership stake. The firm engages in R&D of semiconductor high-frequency components; consulting, technology transfer, and technical services in the semiconductor domain; design of semiconductor materials, integrated circuits, electronic devices, modules and components.[41]
Guoqi Optoelectric Science and Technology (Tianjin) Co. Ltd (国麒光电科技(天津)有限公司)	CETC's 53rd Research Institute holds an 80% ownership stake. The company conducts R&D in and sells opto-electronic countermeasures and passive radar jamming equipment. The firm also develops AI products such as facial recognition systems, Internet of Things services, information systems integration, equipment communication systems and automatic controls, security monitoring systems, electronic components, and semiconductor materials[42]
Shanxi Shuoke New Materials Co. Ltd. (山西烁科新材料有限公司)	CETC's 2nd Research Institute owns 63.75%, CETC Investment Holding Co. Ltd. owns 13.36%, and CETC's 55th Research Institute owns 9.54% of the company's shares. The firm engages in R&D and production of semiconductor materials, electronics components, jewelry products, software development and sales, and import and export of goods and technologies.[43]
Hebei Poshing Electronics Technology Co. Ltd (河北普兴电子科技股份有限公司)	CETC's 13th Research Institute owns 72.3% of the company's shares. The firm specializes in R&D and production of high-performance semiconductor materials, including silicon-based epitaxial wafers, gallium nitride epitaxial wafers, and silicon carbide single crystals and epitaxial wafers. Industries it serves include clean energy, new energy vehicles, aerospace, computers, tablets, and smart phones.[44]
Shanghai Nanpre Mechanical Engineering Co. Ltd (上海微高精密机械工程有限公司)	A CETC subsidiary, CETC Electronics Equipment Group Co. Ltd., owns 70% of the company's shares. The firm was originally established by CETC 45th Research Institute's First Research Laboratory, which specialized in lithography and reportedly contributed to the development of equipment for military-use integrated circuits.[45] The firm develops core subsystems for lithography machines and also engages in used semiconductor equipment refurbishment, remanufacturing, technical services, and parts sales.[46]

[41] https://www.qcc.com/firm/763b04d5d6328aaaa7a54c3c07e572c9.html
[42] https://www.qcc.com/firm/6bce9a27be356b82b1fc96d575920dea.html
[43] https://www.qcc.com/firm/351373d70d41f57aa7c04ff9fe95eabe.html
[44] https://www.qcc.com/firm/0389ab78278aa1f4338e9f381a54c5d8.html; and https://web.archive.org/web/20181220023844/http://www.poshing.cn/.
[45] https://www.qcc.com/firm/ed2eb764eea00d19da38fca7b738efdc.html
[46] http://www.nanpre.com/a/guanyuwomen/

Figure 1: Chinese Academy of Sciences / Institute of Automation Research Areas

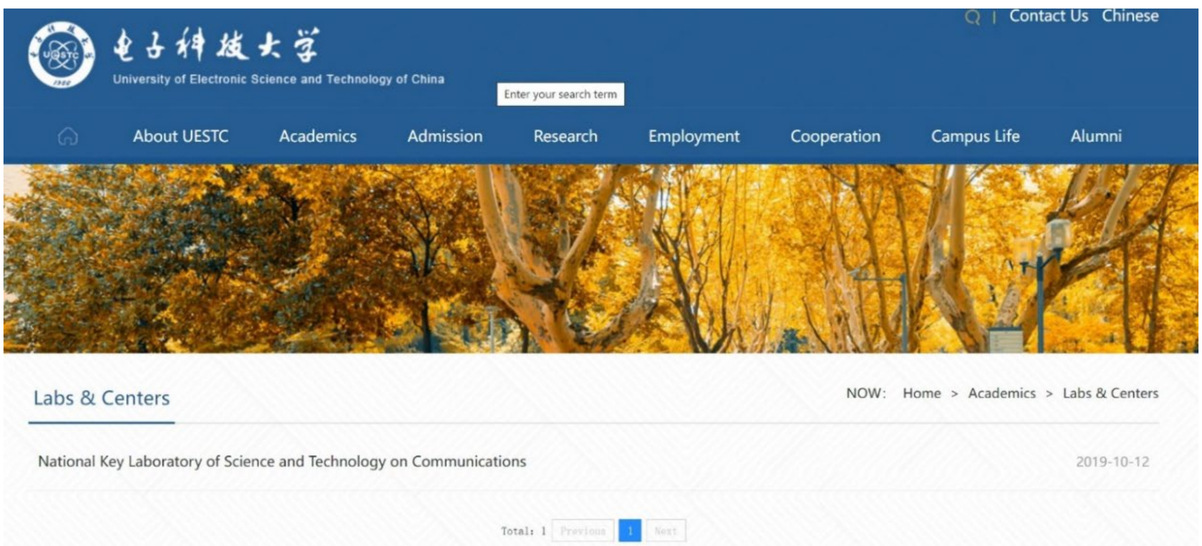
Beneficial or Benign Research Areas

- pattern recognition
- image processing
- speech and natural language processing
- neural computation
- cognitive brain modeling
- neuromorphic computing systems
- brain-inspired information processing
- brain mapping and function
- psychiatric disorders

Mass Surveillance Research Areas

- gait, iris, and facial recognition
- suspect targeting and tracking
- video / visual surveillance
- object recognition
- “abnormal behavior detection” for public security
- pedestrian monitoring

Figure 2: Screenshot of a University of Electronic Science and Technology of China (UESTC) English-Language Webpage



Screenshot of English-language webpage listing a single laboratory associated with UESTC

Figure 3: Screenshot of the Corresponding Chinese-Language Webpage of UESTC

Screenshot of the Chinese language webpage listing laboratories and centers at UESTC. The red arrow points to the official Chinese name of the one laboratory listed on the English webpage.

Table 2: Select Challenges and Impediments of the US Government

Government Element	***Impediments***
Intelligence Community	• A lack of sufficient language and subject matter expertise on China, particularly as it relates to the PRC's technology transfer apparatus • Restrictions on the collection and use of US Persons information limits access to data and impedes knowledge building and information sharing on threats to US research • The minimal use of and lack of reliance on publicly available information severely restrains the ability to collect, analyze, or share threat information related to research security
Law Enforcement	• Most threats to research security and integrity posed by China fall outside criminal activity and regulatory oversight, rendering most law enforcement efforts ineffective • Narratives of "IP theft, economic espionage, or academic espionage" used by federal agencies in public messaging fails in academic contexts • Inadequate resources in Offices of Inspectors General severely constrain their ability to investigate and mitigate abuse, undue foreign influence or interference in federally sponsored research
Other Agencies	• Program offices at federal agencies funding academic research lack capabilities to evaluate grant applicants for national security concerns • Few mechanisms are in place to monitor for national or economic security risks *post award* of an unclassified grant or contract

OPENING STATEMENT OF JENNIFER BISCEGLIE, CEO, INTEROS INC.

COMMISSIONER BOROCHOFF: Thank you. It's now Commissioner Wessel's turn. I'm sorry. Jennifer Bisceglie from Interos.

MS. BISCEGLIE: Thank you.

COMMISSIONER BOROCHOFF: Thank you. My apologies.

MS. BISCEGLIE: That's okay. Commissioners Borochoff, Goodwin, and other members of the Commission, thank you for the invitation and the opportunity to speak with you today on safeguarding the U.S. defense critical supply chains as it relates to military readiness. I founded Interos 17 years ago to map, monitor, and model risks in the global economy and the business partnerships, alliances, and distribution networks that make up our supply chains.

This company is built on over 30 years in the global supply chain industry, having helped multiple U.S.-based companies create maximum advantage from different skill sets, labor pools, and competitive business arrangements with partners around the world. During those years, I've watched risk concerns in the supply chain move from quality to physical security to resiliency and now to product integrity and the role of the digital connection or cyber which I just heard this week, year over year, there are 400 percent growth of cyber-attacks through the supply chain. Over the last few years, we've seen supply chain crisis increase exponentially from COVID to solar winds to the Suez Canal blockage and most recently with baby formula.

As Interos noted in our 2018 report for this Commission, the federal supply chain is reactive, meaning until we as a country adopt a centralized government role for supply chain risk management, we will continue to suffer consequences of supply chain disruptions, whether it be in our federal IT networks or in the discussion of military readiness. Before addressing specific areas of today's hearings, I would like to stress that the principles of the 2018 report we provided remain true today and whether it's 5G, blockchain, the internet of things, or any other emerging technology, an underlying foundation for national security, both physical and digital, is an understanding of who the stakeholders are, where the vulnerabilities lie, and having a strategy for managing the associated risk.

The solution cannot solely be focused on the latest tools and the technologies. Cultures need to change, and money needs to be spent to educate people on their role in traditional risk management. Given our position in the market, Interos has had the opportunity to work with public and private sector organizations spanning multiple industry verticals, and the situation is always the same.

If the organization doesn't take a focused and comprehensive approach to risk management prioritized by senior leadership, there will be unnecessary exposure and invariably negative impact. I'm also very pleased to see a recent attempt by the House Armed Services Committee to draft legislation in an effort to address the rare earth elements and minerals shortage. Currently, the U.S. is heavily reliant on China and Russia for its ammunition supply chain.

To further illustrate and outline the current federal posture for supply chain risk management, federal government laws and policies do not currently address risk management comprehensively. Rather, supply chain risk has been addressed in a somewhat disjointed manner across the various types of federal information systems, across initiatives designed to protect critical infrastructure or high value assets, and across national security systems as a further subset of federal IT networks. The other thing that we keep in mind is that supply chain is always thought to be separate from cyber, and the two topics in reality are inseparable.

In the current supply chain risk management ecosystem, responsibility for risk management is held at different levels within agencies, resulting in supply chain risk management offices that function largely under resourced stove pipes, often lacking executive sponsorship or oversight, and only catering to the needs and the procurement policies of the individual programs. Policy needs to be instituted to support effective, unclassified information sharing to end the redundant efforts within agencies and to maximum the investment in supply chain risk management programs. In that, Interos recommends the following four steps.

Embrace an adaptive process. Military readiness and national security have increased reliance on the private sector and commercial off-the-shelf products. These products have increasingly complex and globalized supply chains, many of which include commercial suppliers from sources from China and Russia as we know today. These supply chains morph over time as companies develop new technologies and partner with new suppliers.

Thus effective risk management policies must be able to adapt as well. It's not the supplier we know. It's the embedded and other unknown industry partnerships that potentially could cause us harm.

The second recommendation is to promote supply chain mapping and transparency. This increases our national security posture by enabling the federal government to source responsibility and securely and by improving the government's ability to act with ready military at the moment needed as well as the ability to proactively de-escalate when the opportunity presents itself. The government should partner with industry to push for transparency and mapping on the part of all tiers of the suppliers according to the level of risk management rigor required. Not all programs and suppliers present the same level of risk.

Third recommendation is to centralize the federal risk management efforts with the supply chain. The U.S. government lacks a consistent holistic supply chain risk management approach and does not realize the forever connection of the physical and cyber supply chain as seen in the separate authorities of the Department of Defense, DHS CISA, and the SEC. The conflicting and confusing laws and regulations result in loopholes, duplication of effort, and inconsistently applied policies.

Congress and the Executive Branch should encourage information sharing and the consolidation of common federal supply chain risk management efforts. Last, craft and implement forward looking policy. Future risks will involve software, cloud-based infrastructures, and hyper-converged products, not just hardware and physical weapons.

A supplier's business alliances investment sources and joint research and development efforts are also sources of risk that are not routinely evaluated in traditional supply chain risk. Identifying these risks and addressing them creatively will be important to the success of federal policy efforts. In summary, the threat that China poses to the U.S. federal supply chains is real. It's significant, and it's growing.

A reliance on China as a supplier will remain high. The time to address the supply change threat and risk to our nation's national security and military readiness is now, not after a major incident, the scale of which we may not have yet envisioned or realized. I thank you again for inviting me here today, and I'll be pleased to take your questions during the remaining time and look forward to future dialogue with the Commission. Thank you.

PREPARED STATEMENT OF JENNIFER BISCEGLIE, CEO, INTEROS INC.

U.S. – China Economic and Security Review Commission
Written Testimony
"U.S.-China Competition in Global Supply Chains"

June 9, 2021

Jennifer Bisceglie
CEO, Interos Inc.

Commissioners Borchoff, Goodwin, and other members of the Commission, thank you for the invitation and opportunity to speak with you today on safeguarding U.S. defense-critical supply chains as it relates to military readiness.

Interos is a company I founded 17- years ago to evaluate risks in the global economy and the business partnerships, alliances and distribution networks that make up our supply chains. This company is built on my 30 years in the global supply chain industry, having helped multiple US-based companies create maximum advantage from different skillsets, labor pools and competitive business arrangements with partners around the world.

During those years, I've watched risk concerns in the supply chain move from quality to physical security, to resiliency and now to product integrity and the role of the digital connection, i.e., cyber. Over the last few years, we have seen supply chain crises increase exponentially with COVID, SolarWinds, the Suez Canal blockage, and most recently with Baby Formula. As Interos noted in its 2018 report for the Commission, the federal supply chain is reactive. Meaning, until we as a country adopt a centralized government role for supply chain risk management (SCRM), we will continue to suffer consequences of supply chain disruptions whether it be in our Federal IT networks, which was my testimony in 2018, or the discussion of military readiness.

Before addressing specific areas of today's hearing, I would like to stress that the principles of the 2018 report remain true today, and whether it is 5G, blockchain, the Internet of Things, or any other emerging technology, an underlying foundation for national security – both physical and digital - is an understanding of who the stakeholders are, where vulnerabilities lie, and having a strategy for managing the associated risk. The solution cannot be solely focused on the latest tools and technologies – cultures need to change, and money needs to be spent to educate people on their role in traditional risk management.

Given our position in the market, Interos has had the opportunity to work with public and private sector organizations spanning multiple industry verticals and the situation is always the same – if the organization doesn't take a focused and comprehensive approach to risk management, prioritized by senior leadership - there will be unnecessary exposure and invariably negative impact.

To further illustrate and outline the current federal posture for supply chain risk management:

1) Federal government laws and policies do not currently address risk management comprehensively. Rather, SCRM has been addressed in a somewhat disjointed manner across the various types of federal information systems, across initiatives designed to protect critical infrastructure or high-value assets and across national security systems as a further subset of federal information systems. Additionally, SCRM is held separate from cyber – and the 2 topics are in reality inseparable.
2) In the current SCRM ecosystem, responsibility for risk management is held at different levels within agencies, resulting in SCRM offices that function largely as under-resourced stovepipes,

often lacking executive sponsorship or oversight, and only catering to the needs and procurement policies of individual programs.

3) Policy needs to be instituted to support effective unclassified information sharing to end the redundant efforts within agencies and to maximize the investment in SCRM programs.

Moving to address the topic areas for today's hearing, I will further outline the current state of our global supply chains, out interconnectedness with China, and the landscape of federal supply chain risk and resiliency.

1. How reliant are U.S. defense contractors on second and third tier suppliers from China? For what sorts of components is reliance or exposure greatest? Where is our dependence greatest? For areas where it is impossible to answer these questions, what obstacles prevent use from understanding the answer?

In a single word, very. Interos recently took a look at just how reliant the US and the UK are on the Shenzhen region:

- 8,900+ US distinct entities buy directly from suppliers in the Shenzhen region.
- This number grows to over 76,000 entities when indirect suppliers at the second tier are included, and 195,700 at the third-tier level.
- 130+ distinct UK entities buy directly from suppliers in the Shenzhen region.
- The number grows to over 11,900 entities when indirect suppliers at the second tier are included, and 29,400 at the third-tier levels.

2. What is the role of industry in mapping supply chains for critical materials and components used in U.S. defense systems? How should the U.S. government engage with industry in this area, and what does industry need (or not need) from the government to implement more robust solutions for achieving supply chain visibility? Where is private-public coordination most needed in securing supply chains critical to national security?

Industry is fully capable of mapping and monitoring supply chains for critical materials and components used in U.S. defense systems – anymore this is the cost of doing good business. Specifically, after the experiences of the past 2.5 years – from a pandemic to cyber breaches to a ship going sideways in a canal, not knowing is not good enough for business anymore. If the US government would request supply chain mapping and monitoring, as a part of normal business for industry, the flow down of this transparency would be included in the cost of the program and the shift would occur in delivery of the service. To be honest, as the world's largest buyer, as long as the US government asks for securing the supplier chains critical to national security – and is willing to pay for it – it will occur.

3. What are countries like Canada, Germany, and the United Kingdom doing to build more resilient and transparent supply chains? What types of requirements are in place in those countries to try and give their governments more visibility into companies' supply chains? In your work with executives, how do they view concentration in their supply chains? What challenges do they face in diversifying their supply chains?

All of these countries have the same or similar challenges to securing and diversifying their supply chains as the US does – so size and scale may change but the problem remains the same.

Unfortunately, when we all started offshoring manufacturing back in the 1990s, we all simply got lazy and left supply chains very global, single threaded and fragile. The good news is, via the education of the past almost 3 years, we all realize that sometimes a global and unknown supply chain is not necessarily resilient - nor does it support National Security and military readiness. We now have the option to change. The challenge is going to be a strong enough desire, the right leadership and the available funding as security comes at a cost. But so does not being secure.

4. What challenges do companies face in mapping and monitoring their supply chains? What solutions or technologies, like artificial intelligence, can companies utilize to better map their supply chains?

While businesses are experiencing an average cost of $184M per instance of supply chain disruption, Interos' recent study showed: (1) Only 11% of organizations monitor supplier risk on a continuous basis and (2) Only 19% have technology (automated/intelligent solutions) in place to gain visibility into interdependencies within their supply chain.

The good news is that there are technologies, including such offered by Interos, that offer continuous mapping and monitoring of supply chains using artificial intelligence. Specifically, the Interos platform ingests real-time data from a wide array or sources both public and commercial. New data is continuously ingested to provide supply chain awareness and our platform utilizes cutting edge technologies, including artificial intelligence, to sift through these large quantities of data. This technology allows us to not only map with accuracy, but also provide expert guidance across multiple risk factors including financial risk and geopolitical risk.

It's worth noting, on average, using Interos' technology results in a reduction of over 8000 hours – almost a full man year – that used to be used for manual supplier assessments. This cannot – nor should it be - replicated by humans. National security and military readiness requires the adoption of the latest technologies and capabilities to get ahead of the negative impact vs always being in response and clean up mode.

5. Can you discuss how different tiers of suppliers may present different threats to U.S. national security? How far down the supply line should companies map?

This is a great question and a hard one, knowing that the malicious actors are 100% augmented by the normal dynamic business process, creating a constantly changing and uncontrollable extended supply chain network. In this, there really isn't a limit of tiers that we should be talking about, we should be mandating that the cost of doing business with the US Government is the requirement for supply chain mapping of your next tier supplier, and flow that down for ongoing illumination, as well as the continually monitoring of the network. Once this expectation is set, the US Government can begin to expect – and to receive – a more secure and operational resilient supply chain.

6. In its work with the Department of Defense, what types of vulnerabilities has Interos identified in supply chains providing critical goods for the military? How might China take advantage of these vulnerabilities, and what would that mean for military readiness?

The vulnerabilities identified are extensive and continuously changing based on what's happening in the world; everything from financial instability to cybersecurity, geopolitical and restricted entities, and now the rise of Environmental, Social, Governance (ESG) and sustainability.

7. The Commission is mandated to make recommendations to Congress. Do you have other policy recommendations would you make based on the topic of your testimony? Specifically, what are several first steps the government should be taking to improve supply chain security?

Interos recommends 4 steps:

Embrace an Adaptive SCRM Process – Military readiness and national security have increased reliance on the private sector and commercial off-the-shelf products. These products have increasingly complex and globalized supply chains, many of which include commercial suppliers which source from China. These supply chains morph over time as companies develop new technologies and partner with new suppliers, thus effective SCRM policies must be able to adapt as well. It's not the supplier we know, it's the embedded and other unknown industry partnerships that potentially cause us harm.

Promote Supply Chain Transparency - Supply chain transparency increases our national security posture by enabling the federal government to source responsibly and securely, and by improving the government's ability act with a ready military at the moment needed – as well as the ability to proactively de-escalate when the opportunity presents itself. The government should partner with industry to push for transparency on the part of all tiers of suppliers according to the level of risk management rigor required (not all programs and suppliers present the same level of risk).

Centralize Federal SCRM Efforts - The U.S. government lacks a consistent, holistic SCRM approach – and does not realize the forever connection of the physical and cyber supply chain as seen in the separate authorities of the DoD, DHS CISA and the SEC. The conflicting and confusing laws and regulations result in loopholes, duplication of effort, and inconsistently applied policies. Congress and the Executive Branch should encourage information sharing and the consolidation of common federal supply chain risk management efforts.

Craft and Implement Forward-Looking Policy - Future risks will involve software, cloud-based infrastructures, and hyper-converged products, not just hardware and physical weapons. A supplier's business alliances, investment sources, and joint research and development (R&D) efforts are also sources of risk that are not routinely evaluated in traditional SCRM. Identifying these risks and addressing them creatively will be important to the success of federal policy efforts.

In summary, the threat that China poses to U.S. federal supply chains is real, is significant and is growing. Our reliance on China as a supplier will remain high. The time to address the supply chain threat and risk to our Nation's national security ad military readiness is now, not after a major incident, the scale of which we may not yet have envisioned, is realized. I thank you, again, for inviting me here today and will be pleased to take your questions during the remaining time and look forward to future dialog with the Commission.

PANEL III QUESTION AND ANSWER

COMMISSIONER BOROCHOFF: Thank you. I want you to know that I read your testimony several times to the point to the I think you had already said it, and I apologize again. Commissioner Wessel.

COMMISSIONER WESSEL: Thank you all for being here. Jeff, thank you for your service. It's been a little while since we last talked. I'm a big fan of your work and research, although deeply troubled by its conclusion.

And Jennifer, similarly, thank you for the work you've done for us on supply chains over the years. It's really both advanced our knowledge and work as well as Congress'. Jeff, let me go back first and then, Jennifer, for you to chime in as well.

We've been dealing with this issue for a long time. Jeff, when we last talked, you had been pounding your head against the wall for a while, getting good support I thought from some offices but were having trouble dispersing the knowledge and having people but their energy into the task which is voluminous. There's no question about it.

We face threat vectors across every area of government. You're now on the outside. You are suggesting an entity that uses public resources. Appreciate that we're all -- that's what our staff does. That's a growing area.

But do you think that's actually going to get attention of the right people in government to close the holes in the dyke, whatever it is? Our last panelist who we appreciate her being here, over the years, we've faced enormous cracks in the DFAR regs that have allowed bad things to happen, your work with the -- as I recall, with the National Defense Seven Sons to address their activities. Can this be addressed?

MR. STOFF: Well, thank you for your question. And it's nice to see you in person.

COMMISSIONER WESSEL: Yes.

MR. STOFF: The idea behind this center is not to replace or duplicate what the government is doing. It's really designed to get at and address the critical gaps basically, mission priority resource gaps that the government has. And in my written testimony, I laundry list a whole number of impediments, structural changes that the U.S. government and the national security community has in this space.

The idea that I'm proposing is really to think of getting rather the top-down approach where the government has a particular set of policies or mandates really work from the bottom up. And by working directly with the academic institutions, private sector entities, way, way left of theft, so to speak, where you're really looking at on the ground kind of stuff that's happening where those institutions do not have the capacity really. They're not mandated to either to have the capacity to really understand and assess risk in a nuanced way.

And the federal government and the national security community just doesn't have the capacity to provide that level of granularity to an individual institution level. So it's trying to meet in the middle starting from kind of a ground up approach. And by having trusted stakeholders where we partner with academic institutions in the private sector to try to solve these problems in a collective way, I think that can go a long way into getting to what you're describing at the government level and then feeding into what the government needs or can't acquire on their own to affect policy.

COMMISSIONER WESSEL: But let me pull on that because to me it's partially a desire. So take Uyghur forced labor. The two seminal studies on supply chains were done by Horizon Advisory, one on polysilicon and the other on aluminum.

That was all public source material. Why should we have to rely on the private sector for what government should be doing? And again, this is not news. We've been talking about Xinjiang for years. But a private sector entity has to come in where government should be doing its job?

MR. STOFF: Well, again, this is my personal opinion, so just to be clear. I really do think working in the national security community -- and there's been other discussions about this, I know, at previous hearings as well as other documents. The challenge in my view is most of this can be done through open source information, publicly available sources.

The problem is the government has not really mandated or resourced or prioritized to exploit that in an effective way. And there are also structural impediments partially by constitutional design, limitations on what we collect on activities in the United States. Although just to be clear, publicly available information, they really are not those same level of restrictions if it's opening acquired.

Yet there are still cultural and institutional biases that prevent that. And so, I think the fact that private institutions are having to come out and do this work as well as think tanks just shows that the government is not really equipped to handle this. I have personally

COMMISSIONER WESSEL: Equipped or interested?

MR. STOFF: I think it's a resource and a priority issue. And speaking from working in the national security community, as you all know, this isn't news. Other sources of intelligence are just a higher priority.

They're a higher resource priority. They're a higher priority in terms of usage and assessments and analysis. The open source mission has been, in my opinion, descoped to our detriment.

And so, there are holes that others are trying to fill. And what I'm trying to do is say we can kind of combine forces here. And we can create a consortium of organizations that have a lot of unique interesting capabilities and data, some of which the U.S. and national security community is unable to acquire. And use that to bring additional resources to bear.

So, I don't really have a solution for what the interagency should be doing or specific agencies in terms of whether they fund something or not. And I do have concerns over -- based on my experience, if there's some new initiative, that usually involves descoping something else. And what are the consequences of that? So, my approach is really from kind of a bottom up, and then it could feed into the government structure, for what it's worth.

COMMISSIONER WESSEL: I'm over my time. If there's a second round because I also want to give Jennifer the chance to respond. Thank you.

COMMISSIONER BOROCHOFF: Thank you. Commissioner Scissors.

COMMISSIONER SCISSORS: Quick comment for Mr. Stoff, questions for the other two witnesses. This is obviously my opinion. The entity list is a joke. And having subsidiaries not listed or listed on the entity list just means, like, oh, we're going to pretend we're doing something about this firm when we're not going to.

So obviously, we can add. We can take other actions, limit investment, foreign direct product rule. But just a quick comment, something not being on the entity list doesn't disturb me because if it's on the entity list, it doesn't make any difference.

Ms. Bisceglie, I completely agree that firms can provide the information we're looking for in nearly all cases. Where we decide this is a critical technology or critical product or critical sector of whatever language we're using, they should be required to do so. The U.S. government can compensate them as necessary which is going to vary by product, and it's far better than the government trying to do it as was just discussed within blind policymaking.

I've been saying this for years. You probably -- I don't want to put words in your mouth. You may have said a variant of this too. What is the barrier -- and we're not doing it obviously. Are you aware of a barrier for when we're talking about firms supplying the government, doing business with the government, the barrier to forcing them to know their own supply chain? Like, why isn't that happening?

MS. BISCEGLIE: Thank you for the question. And I think it's a little bit of the same conversation we were just having. And I've never been government, respectfully. Thank you for your service.

But I think it comes down to kind of three things for me, authorities, leadership, and funding. And I will be very, very clear to say that the only place in the world that my company has ever lost a contract where the entity has left you from using world class technology that we've provided and gone back to using humans and manual processes is the U.S. federal government. Every other customer we have, I'm getting phone calls on Saturday mornings from CEOs of large aerospace defense primes because they are aware trying to figure out how to fill orders around national security, profitability, brand reputation.

The supply chain has become a competitive and strategic one or two priority. And here in the federal government and back to the question you asked as well, it's who has the authority to do it, who's got the leadership to do it, and are they funded to do it. And the fact that we think it's okay to go back to manual processes or just to stick our head in the sand because we don't want to know if China or Russia is in there is the wrong approach.

So, to answer your question, those are the limitations. I don't know that there's anything factual. And there's a lot of I don't know and I don't want to take it on because nobody told me to do so.

COMMISSIONER SCISSORS: Thank you. It's not a wonderfully reassuring response.

MS. BISCEGLIE: But it's honest.

COMMISSIONER SCISSORS: Appreciate that. Mr. Brown, I'm going to do this to you. It seems fair. I do it to public policy people all the time. Might as well do the private sector.

You get one thing the federal government can help you with, one. And it can't be, like, a billion dollars. What's the thing that you most need, because I already have that request in. Get in line.

What's the thing that would be most helpful to you in your business, and you can think of closely related businesses that you know a lot about. But I really want to hear from you because I agree with you about the importance of your business. What's the thing that the government could do that would be most helpful?

MR. BROWN: Ease off on regulations. Let's just take the new OSHA standard on employees over 80 degrees. We're facing employee shortages, and we're having to do the best things that we can do. And there's other regulations coming down the pipelines that hinder us from doing our day-to-day duties and being the best performers that we can in our industry.

And it's just a lot of regulations all the time. We spend a lot of money coming to D.C. We spend a lot of time with members of Congress and talking about how these can impact our industry or other industries or whoever else that can. And it's time away from our businesses where that's really needed to be.

COMMISSIONER SCISSORS: Thank you. I appreciate that. Thanks to all the witnesses.

COMMISSIONER BOROCHOFF: Commissioner Schriver?

COMMISSIONER SCHRIVER: Let me add my thanks to all the witnesses. Appreciate your testimony, and really appreciate what the three of you have respectively built out. Really impressive work.

Mr. Stoff, I appreciate your focus on talent recruitment, something I've had a long-term interest in myself. And full disclosure, I do a little work, my private life on this. So, I don't want to ask a question that's too leading to get myself in trouble.

But you made the comment that so much is available in open source. But there's still the problem of harvesting that data, processing it, and understanding it. Could you talk about sort of the state of the field, technology enabled ways of doing that, various platforms that might exist? If you create your center or not, there's still the problem of massive data and how you sort of make sense of that and make it useable.

MR. STOFF: Thank you for your question. This is kind of the existential question, right, that I know everybody in the open source world is facing. I think that it's a combination of the evolving sophistication of various tools and automation and machine learning that can get you pretty far.

But it's also increasing sophistication is required in extracting and exploiting the data that's out there and the information as China increasingly obfuscates and denies access. And I have umpteen examples where I wrote a chapter in a book or we profiled some entities, organizations, and then they disappear, right? So, the sophistication is in the sense of figuring out ways to get to the material in sometimes not so open ways.

But it's openly available, at least in some places. So, you have to -- so in my view, the technology is a combination of the data collection and acquisition aspect which is its own really industry. And there are capabilities out there, both in the government and the private sector that are able to do some of that.

But you have to also remember -- well, at least in my experience no AI or machine learn tool is going to be able to get you some of the answers that you're describing. You mentioned talent programs. All the work that I have done, both in and outside the government related to talent programs, was mostly very manually labor intensive.

Because of the way that it's distributed and decentralized in terms of the information out there, there's no real solution where you can just somehow aggregate it in a central place. There used to be one place where the Chinese government provided it. They took that down.

So that's just simply brute force analytic and collection capabilities of knowing where to poke around and then put it into something. And then you could apply the analytics and the various tools to get at some of the trends and patterns, et cetera, which we have done. And that can be done.

In my opinion, there is -- and what I propose in the center is there is a -- I'm talking about a consortium because there are pockets, silos of excellence which you probably have all heard from the government, right? Well, outside the government too within think tanks and NGOs, they have interesting data collection tools and methodologies that they've done for their own projects. But there's no interdisciplinary aspect to this.

So, imagine if you were able to tap into certain data and tools that this particular think tank or NGO was able to put together and you combine it with some other tools and capabilities, then you really do have the sum is greater than its parts. And so that's the idea. And because it's decentralized and the government doesn't own or control a lot of this capability, to me, it doesn't make sense for the government to own or control this capability.

COMMISSIONER SCHRIVER: Thank you. I cede the rest of my time.

COMMISSIONER BOROCHOFF: Commissioner Mann, are you with us?

COMMISSIONER MANN: I am.

COMMISSIONER BOROCHOFF: You're up. I'm afraid you're frozen. Can you hear me?

COMMISSIONER MANN: Yes, I can hear you. Can you hear me now?

COMMISSIONER BOROCHOFF: Yeah, I think turn the video off and let's see if that's frozen. We can hear you, however.

COMMISSIONER MANN: Okay. Well, let's do that. I wanted to ask each of the panelists how the war in Ukraine in the last five months have affected supply chains and for the future, whether it's had any impact on the larger considerations you're talking about. Or maybe it's had none. But I'd like to hear from each of you, including how it affects a specific company for James Brown but also from the other panelists on the larger considerations. Maybe it's had none, but let's hear it.

COMMISSIONER BOROCHOFF: Mr. Brown, would you like to go first?

MR. BROWN: Sure. (Audio interference) the invasion in Ukraine. I know that they took out the largest pig iron facility in the world. And with that being that said, we're going to have to either bring something on domestically or we're going to have to do that through buying other materials or pig iron through other countries.

That being said, that's going to take a few years. So, we're looking at a few more years down the road that we're going to have to rely on, India, Turkey, China, Brazil, even in Canada some. So, I think definitely the invasion is going to cripple. You still have the mines. You still have the other facilities that produced and briquetted and did things for the U.S. foundry industry.

COMMISSIONER BOROCHOFF: Ms. Bisceglie, would you like to answer?

MS. BISCEGLIE: Sure. Thank you. So, when the crisis started within the first five days including that weekend, we had almost 300 companies reach out to us to be able to map out their global supply chain to see what the impact was going to be because the concern of sanctions. Really, this is why we're getting phone calls from CEOs, the concern of sanctions. We are cutting off -- there's 2,000 sanctions against Russia right now globally.

We're cutting off whole parts of the developed economy. And the ripple effect is not going to be known for a very long time. So, you hear about agriculture. And most of the wheat in the agriculture had already been harvested.

That was all in the news, but what about next season, right? So, the ripple effect will continue. I think that you had Airbus that went on and said 40 percent of their titanium was coming out of Russia because they weren't dealing with the government. So, what are they going to do now?

And so, you have major economic shifts that are occurring. I think as we were talking about before we started, the need for transparency and mapping has never hit the CEO and the Board like it has right now and it's not going to stop. And so, three weeks after the crisis occurred when we started getting Saturday phone calls, it was, as you mentioned, Shanghai, Beijing, the rolling shutdowns from the pandemic.

Everybody is realizing how hyper-connected they are. And so, the war made a very acute cut and alert. But the ripple effect is going to be felt for a long time.

I think you see it in the energy sector, right? So, Shell went very public and said, we still have to procure from Russia. We're sorry. We'll donate our profits. But that's real. Germany having to unhook and go back to old fuels in effort to go forward.

So, I think it's hitting every industry. It's hitting every company. And every companies'

CEO is realizing this is not going to be the last shock to their system. And so, we're seeing across industries just the advent of the requirement, back to the question that the Commissioner just asked. You just have to ask for this transparency because the impact of things like Russia and Ukraine will continue to happen.

COMMISSIONER BOROCHOFF: Mr. Stoff?

MR. STOFF: So, I can't address the immediate issue. But let me give you some ideas on intermediate and long-term applications. And that is assuming that China increasingly supplies Russia with advanced weaponry and other capabilities to circumvent sanctions, there are serious implications. So, if you go back to the innovation side and the R&D side, the level of collaboration that's occurring, that's basically enabling China's defense industrial base and their mass surveillance capabilities.

I just recently did a study I hope to publish soon. I looked at not just U.S. but German research collaboration with all these Seven Sons schools and hypersonic facilities and it's extensive. And so, the implications are, are we allied nations providing a lot of that know-how and future technology that then China can then bolster Russia and reduce the effects that we are trying to have in constraining them? So, there are very serious implications, and this is consistent across the developed world that I think needs a lot more attention. Thank you.

COMMISSIONER BOROCHOFF: Commissioner -- I'm sorry.

COMMISSIONER GOODWIN: Thank you. And my appreciation to the panel for their great testimony. Ms. Bisceglie, I want to get some additional clarity into your recommendation that we centralize our supply chain risk management efforts.

Obviously, I appreciate the notion that we should enhance information sharing and collaboration. But should it be centralized in a central single office? You would certainly know better than I.

My sense is that chain specific, industry specific, sector, product specific knowledge and know how is critical to truly understand these supply chains in assessing risk in the individual supply chain. So how do we square that circle? How do you draw on that sort of sector-specific knowledge and know how while also avoiding a lot of the duplication and loopholes that you alluded to in your testimony?

MS. BISCEGLIE: So, it's a really great question, and thank you for that. I think the interesting thing about the global supply chain is that the redundancy and the reuse of individual suppliers and companies is somewhere about 60 to 70 percent. And so, for example, we looked at the aerospace and defense industry, excuse me, and oil and gas.

And if you look at the primes, the Tier 1s, there's, like, 10 percent overlap. When you got to the Tier 2s, the next tier supplier, there was 75 percent overlap. So, there's only a certain amount of companies that make a certain amount of things.

And I'll give you another great example from a government standpoint. We're been in the Navy and the information warfare systems for years. And they gave us 74 of their weapon systems to the primes, so Lockheed Martin, Northrop, whoever.

We mapped down just two tiers. There are 60,000 companies, and the whole idea was to map and monitor. So, if Northrop Grumman gets hit, not only is it a Tier 1 to this of the 74, but it's also a Tier 2 and a Tier 3. It's a very incestuous relationship in the global economy. And so, from a governmental standpoint, from a taxpayer standpoint, from a why does everybody have to be impacted individually standpoint, the opportunity to collect once and share that information. The impact is very great just because honestly how the economy works.

COMMISSIONER GOODWIN: Thank you.

COMMISSIONER BOROCHOFF: Vice Chairman Glas.

VICE CHAIR GLAS: Thank you all so much for your testimony. Mr. Stoff, I really appreciated the thought that went into your testimony and the recommendations and sort of the whole-of-government approach to these really complicated issues. And I'm going to try to simplify this a little bit.

I completely -- obviously, our innovation and R&D is critical as anything that we are investing in. It's what gives us a competitive advantage. And we just heard from the previous panelists and heard from our fellow Commissioners about government contracting processes and whether we need more transparency and how best to do that and different concerns related to the Federal Acquisition Regulation process or industrial expansion processes.

So, can you elaborate if the U.S. government is evaluating proposals for the next generation whatever that is really stocked with innovation? What are some things that they should be looking for to ensure that that intellectual property that we're investing in, right, and the next generation manufacturing tool that's going to be an essential element is not stolen by the Chinese or replicated by the Chinese or others who are adversaries? And thinking through -- I think our Federal Acquisition Regulation and our industrial expansion processes need to be improved.

So, I would love to hear any recommendations that you have. And Ms. Bisceglie, I saw and I appreciated hearing this in your testimony that we should be -- we can find out who our suppliers are. I hear from folks in Washington, I don't know. I can't find out. That's just too expensive.

I mean, this is a globalized world. But you're saying, yes, we can do that. And how much cost would it cost a prime to go figure out? Like, is there a cost equation to figure out, gosh, to track my suppliers, that cost me 200,000 dollars a year? I don't know. Does it cost anything actually? So, I'll start with you, Mr. Stoff.

MR. STOFF: Thank you, Vice Chairman, for your question. I believe that I have -- when I was in government and what I'm trying to do now is there definitely can be an improved process in terms of due diligence and threat vetting procedures. Some of this is already in place in some places.

But it's not in the most critical and vulnerable aspects to our innovation ecosystem. And that's really all of the critical areas or technologies -- our future technologies that are not under any sort of export control regime or even in the industrial security program, for example. And in those areas, such as I point out in my written testimony, the DoD's SBIR program, there's really even not even a mechanism to vet for due diligence or national security risk pre- or post-award of any contract.

Basically, it's self-reliance on the offerors to say, yeah, we're legitimate and we're doing business in the United States. So, what can be done is you can develop a framework, a risk assessment framework. It's been done in other areas.

It can be applied here where you look at various risk factors. You look at the principals involved that would be conducting the research or developing the technology, looking at what ties, foreign ownership control, influence risk type of vetting processes. You can do this both for academic research as well as for business.

That's difficult. It takes a lot of work. I don't know of easy automated solutions to do this. Maybe there will be. But if you -- what I'm trying to do is if you develop a framework where you have a bunch of different factors that can assess risk and then you basically standardize that as a process.

And then federal agencies can incorporate that into any type of acquisition or even a federal grant. Given the scale and the scope we're talking about, though, that's not a trivial task given the amount of research dollars, for example, just NIH funds per year, the tens of thousands of grants. So there has to be a process.

In the case of the SBIR program, what I had proposed in a report -- a DoD report was as there are different phases, you have different levels of vetting and due diligence. And the initial phases, simply feasibilities do not require that same level because nothing has actually been created yet. So, you would have a phased process that would become more robust as you get to deployed, for example.

And so, you can apply this both to the private sector and public sector. The risk factors would look a little bit differently. But it's very important to understand in order to do this type of risk framework, you have to understand the adversary's tactics and methods.

You can't look at this in a vacuum. And you also have to understand and do extensive due diligence which I talk about in my written testimony of the organs and institutions involved over there that are seeking to acquire it. And understanding what does that look like so that you can assess risk and say, okay, well, that institute is directly underneath a PLA versus this institute here is three layers removed, that sort of thing. So, you would apply both sides in this vetting and this risk assessment that can be systematized. Thank you.

MS. BISCEGLIE: I'd like to invite you over to our office because that's what we built in Interos, the technology. I think to answer the question that you asked me on security costs, it just does. And I think that I kind of look at it as the cost of doing business with who you want to do business with as well, right?

If we're all janitorial suppliers, it's not as mission critical in national security as if I want to provide a product or a service to the Department of Defense. And so, I think some of these need to be the cost of doing business. I think it needs to be taken very seriously, and I think it needs to be asked for as part of procurement.

And I think once you do that, then the costs actually get spread because it gets flowed down through the supply chain. I think that gone are the days of not knowing who your suppliers are. And again, it's not just because we're trying to do it from a governmental standpoint but you're doing it from a business continuity in the private sector.

So again, whether it's a ship going sideways in a canal or a cyber breach, you have to know who your suppliers are. And a really easy way, as my colleague just said, is to create a framework within the FAR and the DFAR that says these are the things we look at. And then make it repeatable and scalable and right sized based on the product or service you're providing.

And so, it gets you away from the argument that small and medium sized businesses can't do it. Yes, they can. And oh, by the way, if they want to provide this type of product or service to this type of a customer, they should.

And again, I look at this as the cost of doing business. It's not outrageous. What is outrageous is kind of, again, sticking your head in the sand not asking for it when things do go bump in the night because it's a very scary and interconnected world out there.

COMMISSIONER GOODWIN: Commissioner Friedberg.

COMMISSIONER FRIEDBERG: Can I ask a quick follow-up on that, and then I have a question for Mr. Stoff. Wouldn't it be the case that if you mandated this, required it for suppliers to the U.S. government that eventually the costs would get passed back to the government? Wouldn't they just make that a part of their bill?

MS. BISCEGLIE: So, the answer is yes. And I think that the alternative is that they don't bake security into their processes and you keep being vulnerable. And I think there's been a lot of -- so the good news if I could. The good news is there actually have been examples of situations that we have locked things down.

I'll give you a couple specific. So, to the extreme if you look at -- if you want to go into safety mission assurance at NASA where we've been at eight years, their risk tolerance is zero, right? Or if you look at the National Nuclear Stockpile where you have to document and own and understand your supply chain.

That costs a lot. That's really not scalable or maintainable, right? Do I think that if you ask -- pick a prime that they're going to say, well, that's going to cost you a million dollars, that's because they're being lazy and not thinking about it.

I think this is a bit more of if you put it into acquisition policy and say, if you want to deliver an ACAT I system, you must map and monitor your supply chain. It becomes the cost of doing business. They will spread it through their supply chain.

And yes, the cost may go up. But the positive of that, if you do put it into normal acquisition policy is that it becomes a competitive situation. What's happening right now is that the aerospace defense contractors don't want to invest in it because you're not asking for it. So therefore, somebody else is not providing it and they're going to beat them on cost. So, you're actually enabling the vulnerability. I think just coming back and say, this is going to cost you 10 million dollars is a bit lazy.

COMMISSIONER FRIEDBERG: Okay. Thank you very much. Mr. Stoff, in my day job, I'm a professor. So, I wanted to ask you a question about the academic part of this problem that you've identified. And I want to make sure that I understand correctly what you're saying.

I understand it as follows. In addition to theft and forced transfer of technology by China, there is also research cooperation by institutions and/or by individuals with Chinese counterparts who at some remove or other, it maybe not much of a remove at all, are supporting the Chinese military or the Chinese Party state. Some of that activity might be illegal if it violates, for example, export control regulations. But a large portion of it is not.

So, then the question becomes what do you do about that. And one answer might be you need new laws or new regulations, for example -- and I don't know whether there is such a regulation now. But it sounds like there was in the past. The U.S. government might say, you, university or individual, cannot accept federal funds if you are also accepting money from one of these Chinese entities. So that might be one part of it.

Then the other piece seems to have to do with, as you describe it, providing information that influences the decisions of people because they are concerned about what, about their reputations because they don't want to appear -- they don't want to be unwitting. Maybe it's patriotism. What is it exactly that that information does for people who are not concerned about whether they're violating the law or not?

MR. STOFF: Well, I think -- first of all, I agree that the vast majority of the concerns related to academia that have national economy security implications do not involve any illegal or illicit activity because it's really the informal knowledge transfer and the nature of global research that's open by design. The issue is based on my work experience, a lot of university administrators and federal agencies are not aware of a lot of the collaboration that's occurring because it's informal in nature and it's been encouraged to be that for a very long time. And to make matters worse, as I point out in my written testimony, there are deliberate efforts for the PRC institutions to obfuscate who they really are and what they really do.

And so, at an individual university or even an individual researcher, is it fair to require that individual to have a knowledge or a basis to make that kind of assessment on, hey, there may be ethical concerns about because of who I'm dealing with or there may be national security concerns. And so, the issue is so large that you really need some support mechanism to allow universities. And my approach is not to have necessarily the government have a very specific set of rules, although there can be guidelines or rules in terms of, for example, maybe the DoD should not be providing funding to researchers in the U.S. that are collaborating formally with any of the defense schools in China.

Like, that maybe should just be a policy, and that could be decided by the federal agencies. But beyond that, there has to be a process where the information can be provided to academia so that they can make those more informed risk assessments at that level before you even have to step in with issues like export control or ethical issues. That's where I think it's needed.

COMMISSIONER FRIEDBERG: I can predict that many of my colleagues who are in the physical sciences would say, fine, thanks very much for that information. This is the way science works. We're cooperating with our colleagues who are physicists or whatever in China. Don't tell us we shouldn't do it or can't do it.

MR. STOFF: Well, I would just say that it's really important and I've written several studies on this to know who your partners are. And I think it matters. Yeah, it's open science, but are you training? And the knowledge transfer is not all published. And that background and experience, if there's a direct application that they're trying to divert it towards and we can show that, then maybe they don't deserve to be in the same openness as the rest of the community.

COMMISSIONER FRIEDBERG: I think what's really required to make this work is kind of a cultural shift where people don't think about dealing with China or any entity or individual in China as they would about counterparts in democratic countries.

MR. STOFF: I completely agree. Just to follow up, my whole rationale is that authoritarian nations research even in the open space. Research collaboration with authoritarian nations requires a higher level of nuanced and robust risk assessment than it does with the rest of the developed world. Thank you.

COMMISSIONER FRIEDBERG: I agree.

COMMISSIONER BOROCHOFF: Commissioner Fiedler.

COMMISSIONER FIEDLER: Mr. Stoff, earlier in your verbal testimony, you mentioned CETC and Norinco, otherwise known as China North. Do you have any recent information about their participation in our defense critical supply chain?

MR. STOFF: Thank you. It's a great question. And the short answer is, no, sir, I don't. Really what I was trying to show and understood also related to Mr. Scissors' point was the scale and the scope of this is so large that we don't really have a good handle.

Whether or not something is in on the entity list, my point was just there are hundreds, if not thousands of organizations that could be part of a supply chain. I don't know if it's part of a current supply chain. But there are semiconductor firms that are subsidiaries of subsidiaries of subsidiaries, none of which you can directly without some substantial research determine that it's part of CETC.

And as a result of that, how do we know whether it's affecting our supply chain. And so, this is the level of research and knowledge that we need to build up to be able to answer that question. Thank you.

COMMISSIONER FIEDLER: Let me get on to a similar but different subject. So, the Biden administration last year, about a year ago, rationalized the Trump administration executive order limiting investment in publicly traded Chinese military-related companies. The other day, they apparently allowed U.S. investors to continue to hold those stocks. Do you have any comment on that?

MR. STOFF: No, sir. I don't really have a good comment on policy. I would just reiterate that the more information we have on those organizations, their structures and missions, I think the better we can make those types of decisions. And then maybe there would be more information to warrant whether there should be more restrictions or not.

That's a difficult one. But I think that's only scratching the surface in my opinion. And there are many others that we need to really uncover to determine whether there should be that type of outbound or inbound investment restriction.

COMMISSIONER FIEDLER: Are you aware of additional companies that should be on the list that the Biden administration did not put on the list?

MR. STOFF: Yeah. Well, in my written testimony, I would argue that a lot of these -- so, for example, if you just look at the major defense conglomerates, there's about 11 or 12 of them, they keep reorganizing, I'm not sure of the exact number now, that are centrally state-owned. And each of those has hundreds of subsidiaries.

We haven't really done any systematic way to map out all of those organizations, subordinate structures, subordinate tax research institutes and whether or not they're in our supply chains or there's collaboration of some concern. And I think that needs to be done together. And the last point related to that is that, by the way, these state-owned enterprises, they also are attached to and have partners with major universities.

And then those universities also have commercial spinoffs that are part of the defense supply chain in China. And so, are our U.S. research institutions collaborating and enabling with particular subdivisions of universities that are actually commercializing and weaponizing this because their system is different than ours? These are the questions that we have. This is the scale and the scope that we're dealing with. Thank you.

COMMISSIONER FIEDLER: Thank you. I'm done.

COMMISSIONER BOROCHOFF: Thank you. I have a question. And before I ask the question, I want to make sure that Mr. Stoff and Ms. Bisceglie know that I, 100 percent, agree that if you want to do government work for the DoD, you have to disclose what you're doing.

And I'm aware of the example you used in your written testimony at the very beginning, Mr. Stoff, about the fellow who had the hearing aid. I know about that, and I know that it was blatant. I mean, they moved him to China and gave him a big lab and half a million dollars.

And I'm familiar with other coercion. So, there's no doubt there's a problem there. And I'm appalled by it and want to see it fixed. But I have a great interest in how we're going to increase innovation and reduce the number of sole source contracts that are out there.

And I really believe that needs to happen. And in our last panel when we had a person in management -- senior management for the Department of Defense here, she said that they're really pursuing innovation and trying to get smaller startups, new businesses, folks with great ideas to come aboard. So, my question is, how do you square those two things?

She said they're going to have a mentorship office, I guess, to help folks do that. I don't think -- and I think she said this too, that people don't think they can do business with the government or they don't trust it with the Department of Defense. Or they don't trust it because they don't think there's stability.

You've got to spend a fortune and then maybe the next year there's no contract. I think that they're working to overcome that. So how do you square that with the idea that we're going to make it more difficult to do business with DoD? Either one of you. I'm sorry.

MS. BISCEGLIE: So, let me just make sure. I understand most of the last part when you talk about adding security as a requirement. That makes it more difficult.

COMMISSIONER BOROCHOFF: I'm saying that, yes, it depends on how heavy it's going to be. I may be misunderstanding what you're saying. But I think that it's already very difficult. I know this from experience. I've done that.

So, I'm saying it took years to do one contract, and a lot of that was due to the fact that we were an 18-million-dollar company and we had never done business with the Pentagon before. And we eventually did it. But in today's world, a several year ramp up to start solving some of these problems to me sounds unacceptable.

MS. BISCEGLIE: So, there's a couple. So, we've been a government contractor for over 17 years. And so, we've lived a similar life that you just mentioned.

I think the government as a whole has done some really great things to allow to get access to innovation with the smaller businesses. I was there for the passing of the women's business owner set-aside. And so, there are things that are there.

I go back to -- and I heard the other panelists talk about regulation. I think there's a smoothing over. No business can continue to operate public or private sector competitively if it's a whack a mole approach to regulation, right? That's a whole different discussion.

I go back to the theme of this session when you talk to me about military readiness and national security. We don't have a choice. You don't have a choice unless you mandate the transparency of knowing who you're doing business with so that you can make a decision of should you be doing business with them.

I did want to touch on for the same answer. If I tell you that so we're a subscription service, technology. We map and monitor over 350 million global business entities every single minute of every single day. The cost to a very large A&D prime, pick the one of your choosing, is between a million to two million dollars a year.

COMMISSIONER BOROCHOFF: Oh, okay.

MS. BISCEGLIE: That's it.

COMMISSIONER BOROCHOFF: That's a lot less than I expected.

MS. BISCEGLIE: We're not talking hundreds of millions which is why I said if they come back and they tell you it's a very lazy answer, there are technology to do it. Is it 100 percent? Is a perfect? It will never because the supply chain is dynamic by nature.

But there are ways to get access to innovation and to answer the question. And there's updating the FAR and the DFAR. There are other things that we do as a government that make it really hard to do business with us. But when it comes to national security, we simply do not have a choice but to mandate this.

COMMISSIONER BOROCHOFF: I brought that up in the last panel talking about the defense logistics, DLA. Just the CAGE number along can be daunting initially. It takes a while to get it. And just in my opinion that needs to be streamlined. Mr. Stoff?

MR. STOFF: I would just like to add one possible way. This doesn't necessarily get at the specific regulation. But if you had, if you will, a national center that especially supports the smaller businesses and the startups that don't have the capacity to really do the kind of risk assessments that are needed and then you feed that or incentivize so that there's some form of either certifications saying, yeah, we have a system in place and we've done our vetting and our due diligence.

And therefore, we should be more -- at a higher tier eligible, for example, a DoD contract or other transaction authorities. That could be a way to do that. And then you're kind of crowd sourcing in some ways and not having the burden laid on the smaller businesses in the heart of the innovation. Thank you.

COMMISSIONER BOROCHOFF: You answered the question. My only comment on all of that is I wasn't talking, for instance, about the janitorial service. I'm talking about the guy that wakes in his little business one day and says, wow, I came up with an idea that will make launching a satellite cheaper. And it works and he patents it and he goes forward.

And the question, how does he carry that out? And I think you both answered it. If there's an effort being made and you all think there's a way to develop a slightly easier way for someone like that, then I think that accomplishes it. Thank you. Commissioner Bartholomew?

COMMISSIONER BARTHOLOMEW: Thanks very much and thank you to our three witnesses for interesting testimony. Mr. Brown actually, I think I want to focus my question on yours. We have not surprisingly here been talking about the responsibility of the federal government to address some of these issues.

But for 40 years, there's been an increased emphasis on just-in-time manufacturing. And I'm just wondering what the impact of that has been on supply chain issues. And with the responsibility of companies who are contracting with the federal government for mission critical things have to make sure that they have sufficient inventory on hand.

MR. BROWN: That's a great question, and thank you for that. Just-in-time is asleep right now. It's taking a little nap. That's what we've been all kind of kidding around about because now some of our customers that are Tier 1 DoD, they've gone into warehousing mode.

They have spent millions of dollars with companies to do research on how to keep the supply chain moving. And we have been making parts now to go into critical supply into warehousing. So now we've gone back to that.

We stepped away from just-in-time. And part of that is due to the labor shortage, due to COVID. And it's now going to increase due to gas prices, due to lack of minerals, lack of materials to make supplies.

So, you're seeing a lot of these companies now are starting to warehouse a lot more material than they ever have. Warehousing space has become so critical in the United States. And I can only speak for Indiana.

Around the Indiana area warehousing has become such a premium that companies are willing to pay almost anything that we've seen for warehousing space. And it's too bad that we've gotten here, but we're here. So, to keep everything moving along, companies are having to start to warehouse more.

We even are having to warehouse more. If we could buy ahead on certain things, we would. And we're not put on allocation necessarily, but we're not being able to buy more than what we've been able to need over the last six months. So, to answer your question, just-in-time is asleep for a little bit.

COMMISSIONER BARTHOLOMEW: When do you think it'll come back?

MR. BROWN: I have no idea because one of the other panelists said the rippling effect over the next few years. We have not even begun to see the rippling effect in my opinion, whether it's food or materials or whatever the case may be. I mean, it's going to affect the whole entire world.

So, I think some things will be just-in-time, some of the simpler things. But I think it's going to be a huge rippling effect over the next few years. I don't know when it's going to come back.

And we're all going to try to be just-in-time as best as we can. But it's very difficult right now. And it's what keeps CEOs up. And she's exactly right. It's making -- CEOs make the calls in the morning, finding out where we can do this, how we can get it, and how we can make this all happen because we need to make this happen.

COMMISSIONER BARTHOLOMEW: All right. Thank you very much. No other questions for me.

COMMISSIONER BOROCHOFF: Okay. We're going to do a quick second round. And Commissioner Wessel.

COMMISSIONER WESSEL: Thank you. I'm going to return to a question I've asked each of the panels in the past. Congress is considering legislation that would impose an outbound investment review mechanism to identify outbound investments and critical supply chains to first map them. Have the transparency that is wanted.

Second, where those might interfere with U.S. national security interests, potentially mitigate those investments or off chance potentially prohibit them. If each of the witnesses could indicate whether they think that's a good or a bad idea, I'd appreciate it. Jeff, do you want to start?

MR. STOFF: Sure. Thank you. So, I think that the execution of it -- the devil is in the details in the execution of such a policy and which gets back to most of what I've put in my written testimony. And that is in order to do a robust outbound investment review process, you would have to have a supporting infrastructure in place to really be able to do the nuanced due diligence and risk assessments. And based again just on my personal experience, for example, my written testimony, I worked with the CFIUS process while I was in the government. And there was a systemic failure to even exploit domestic PRC sources of information to do any sort of threat assessments.

COMMISSIONER WESSEL: So, you would say the authority is not needed, not important? Or you don't think it's going to be utilized appropriately?

MR. STOFF: I think in order to be as effective as intended, you would need to bolster the supporting infrastructure, the research collection analysis to really understand the end user so to speak of where that investment is going. To really understand the national security implications or the ethical implications of where this money is going, you have to be able to do that kind of robust due diligence. And I haven't seen that. In my testimony, there's so much that's not on an entity list, that's not on the sanctions list, that's not on the military company's list, and it's not being done in CFIUS. So, I just question the ability for the government to be able to do this effectively unless you properly change or resource and incorporate some of these risk assessments and these methodologies that I mentioned earlier to make it effective.

COMMISSIONER WESSEL: Okay. Jennifer?

MS. BISCEGLIE: I think it's a great idea. I think that --

COMMISSIONER BOROCHOFF: I'll stop there.

MS. BISCEGLIE: I think it levels the playing field. I actually think it keeps the costs down. It turns competition -- much of the question you just asked -- back to providing the best products and services to the government with the highest quality of national security, just levels that out.

I couldn't agree more with the comment here, though, that if you don't have the supporting mechanisms so when you get that information as the government, are you really paying attention to it? Do you know what you're looking at? Because if not, the contractors are just going to throw everything at you and the kitchen sink and really not answer the question.

But what I think it does is it starts the conversation. And I really do -- and sorry if I'm too honest here. But just don't know how we consider national security without asking for transparency in the supply chain.

So I think it's a great idea. We talked earlier. We've coined -- we started talking about this concept, the supply chain washing. So, you think about money laundering. If you don't have transparency for your supply chain, Russia, Iran, pick a country. They're all coming through.

They're exporting into the states and the U.K. It's been proven repeatedly. There's many studies out there about it. It's just the cost of doing business anymore. I think it's great.

COMMISSIONER WESSEL: Thank you. Mr. Brown, do you have a view on that?

MR. BROWN: Sure. You know, they answered it from one aspect. I'd like to answer it from another aspect is every year we fill out conflict minerals reports. And that's for the government to have where our minerals and where our rare earths are coming from.

And we fill those out every year. So, it's not that our government hasn't known that we are being heavily supplied by China, Russia, Ukraine, Turkey, India, other countries. But it's what you do with that information, correct? And I heard somebody else say that earlier.

And we spent a lot of time and money filling out all these reports for our customers and for the government. And I don't know what we're doing with that. So, it's being filed somewhere. Something is being collected.

But are we acting upon that to say, look, all of our -- I'll just say castings. All of our castings that are coming to -- that are being made for the DoD, the minerals are all coming from overseas. Not all the minerals, but a lot of them. And where's the red flag with that?

COMMISSIONER WESSEL: Thank you.

COMMISSIONER BOROCHOFF: Commissioner Scissors.

COMMISSIONER SCISSORS: I have a really simple question as I'm standing between us and adjournment. It's for Mr. Brown again. In public policy, we've heard it today. We hear it a lot talking about supply chains. There's the interconnectivity of everything.

I'm just wondering from your perspective. Let's say the government was going to intervene to boost a domestic American industry. What would be the industry that would be most helpful to you?

That could be on the supplier side. It could be on the consumer side. What industry if the government was to help -- and I don't mean handing them money necessarily. But the government says, we want to help you guys. What other industry, not yours, would be most useful to you to get a spur from public policy?

MR. BROWN: Wow. That's a great question. Probably some more on the energy side. Energy would be good. I mean, I know we're trying to do a lot of things, but energy has become very costly. It's become very complicated, and it's something that we all talk about a lot. And it's something that our industry uses a large amount of.

COMMISSIONER SCISSORS: Thank you.

COMMISSIONER BOROCHOFF: Anybody else like to have a follow-up question?

(No response.)

COMMISSIONER BOROCHOFF: Okay. Then we're going to adjourn. I want to thank you all very much. Great panel. Mr. Brown, I know you were a little under the weather. Thank you so much for making the effort today.

And to the two that came here in person, thank you so very much. Our next hearing will be August 3rd, U.S.-China relations. And we stand adjourned. Thank you.

(Whereupon, the above-entitled matter went off the record at 4:02 p.m.)

QUESTIONS FOR THE RECORD

Response from David Bulman, Jill McGovern and Steven Muller Assistant Professor of China Studies and International Affairs, Johns Hopkins University School of Advanced International Studies

USCC Questions for the Record Responses
David Bulman
July 12, 2022

Are there examples of how "locally-adapted industrial policies [that] proliferate sub-nationally" (page 7) impact critical supply chains?

One main point of my testimony was that nearly all of China's industrial policies are necessarily "locally-adapted" given China's vast size and the importance of sub-national and sub-provincial governments in policy implementation. Sub-national governments are responsible for 85% of fiscal expenditure and the implementation of almost all economic policies. In this sense, any critical supply chain is likely affected by locally-adapted industrial policies.

Specifically, my testimony highlighted examples in the three cases I presented on pages 11-17. I argued that local policies can support central policy goals when their implementation does not contradict local short-term economic growth incentives. But when these central goals have short-term costs, such policies are unlikely to be effectively implemented, i.e., local adaption will undermine policy goals.

In the case of rare earth elements, the key local adaptation was actually just a disregard of central industrial policies to cut capacity and limit environmental damage by shutting down local illegal production and limit environmental damage. For decades, local officials have largely ignored these central efforts. And indeed, as central efforts have strengthened through new production quotas and taxes, resulting price increases have given local governments even more incentive to cooperate with local illegal mines.

In the case of semiconductors, the key local adaptation was which firms were actually targeted by new policy-based funding. The all-out financial efforts led by the central government since the 2014 creation of the National IC Industry Development Fund has been matched by at least 300 billion RMB of local guidance funds. But although central policy emphasizes cutting edge technologies and innovative new firms, local officials governments have incentives to get money out the door fast to pre-existing top firms. Little investment goes to long-term R&D, but focuses instead on lagging technologies. And even in these cases, there has been considerable evidence of fraud and waste at the local level, leading the center to promise to clean up the chaotic industry, but with few details on how this could happen in the current governance environment.

In contrast to these cases, at other times locally adapted industrial policies can be very effective, particularly when central goals do not contradict local incentives for rapid short-term growth. In the case of emerging industries with no dominant incumbent domestic or foreign players, broad demand-side policies and local protectionism have proven to be more aligned with local incentives, making them more effective. High capacity batteries are a key example. Local subsidies have supported domestic battery producers over foreign producers (and non-local domestic producers). Local governments have also competed to set up charging infrastructure. And the most effective policies have been demand-side support for EVs, including mandated government purchases, consumer subsidies, and other forms of support for EV purchases, including lower license plate fees and free parking. As a result of local procurement policies, China now has 421,000 electrically-powered buses, compared to only 300 in the U.S. In the case of high-capacity batteries, then, locally-adapted policies have very much echoed and reflected central policies and central policy goals.

In defining advantages, you reference China's "well-educated yet cheap labor force" (page 4). How do you define well-educated? This seems relevant to concerns about CCP ambitions to rise in the value chain and accelerate technology innovation. What are your assumptions about the link between education levels and their success and our risk to U.S. supply chains?

When I referenced China's "well-educated yet cheap labor force" as a developmental asset, I was referring largely to the 1980s and 1990s as China emerged as a global trade powerhouse, and I was comparing China to other developing countries. When the reform era began in 1978, China was one of the world's poorest countries on a per capita basis, but had a literacy rate above 90%, considerably higher than even middle income country levels. Compared to developed economies, China's average education levels remained low when measured by years of schooling.

But although education was one of China's strengths in the 1980s and 1990s, under-investment in education in the reform era itself has now led to education becoming one of China's key weaknesses. China has invested heavily in tertiary education since 1999, and now produces more STEM graduates than any other country. And China's top few universities have risen the global ranks. But most colleges in China are not providing quality education,[1] and, more problematically for China's development ambitions, massive underinvestment in rural and migrant education since the 1980s has led to a highly undereducated workforce. China today has a lower share of its labor force with a secondary or tertiary education than most other middle income countries, and less than half the share of each as compared with OECD countries.[2] No country with so low a share of its population with a secondary education (excluding oil exporting economies) has ever become high income, and this is one of the key reasons why I am skeptical about China's future growth and ability to become a high-end innovative challenger to the United States. One study estimates that this underinvestment in rural education will result in a human capital deficit that will prevent future growth from exceeding 3% annually, thus preventing a convergence with the US on aggregate terms.[3]

If desired, elaborate on the 85 percent revenue source, as it relates to developing supply chains.

Please see my response to the first question. Local governments are responsible for 85% of fiscal expenditure, not revenue (closer to 50%). This extremely high degree of decentralization is one of the most important reasons why a focus on local policies and local policy implementation is so essential for understanding China's approach to developing supply chains.

[1] See: Loyalka, Prashant, et al. (2021). "Skill Levels and Gains in University STEM Education in China, India, Russia and the United States." *Nature Human Behaviour* 5: 892904.
[2] See the latest updates of the Barro and Lee educational attainments dataset: Barro, Robert and Jong-Wha Lee (2013). "A New Data Set of Educational Attainment in the World, 1950-2010." *Journal of Development Economics* 104: 184-198.
[3] Li, Hongbin, Prashant Loyalka, Scott Rozelle, and Binzhen Wu (2017). "Human Capital and China's Future Growth." *Journal of Economic Perspectives* 31(1): 1-17.