Cooperation on Scientific Innovation, Supply Chains, and Geopolitical Risk in Northeast Asia
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Today’s world faces a wide range of risks and opportunities caused by rapid changes. The Chey Institute is committed to identifying and analyzing these risks and opportunities, along with offering practical ways to manage them so that the world can better prepare for the future.

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The views expressed herein are solely those of the participants and do not reflect those of the Chey Institute for Advanced Studies.
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This report includes developments through its completion in the winter of 2023 but does not cover later developments that occurred during its review period.
2022 CSIS-CHEY Expert Workshop Participants

Cooperation on Scientific Innovation, Supply Chains, and Geopolitical Risk in Northeast Asia

(Alphabetical order, positions as of May 2022)

**ROK Speakers and Facilitators**

Kang Kisuk, Professor, Seoul National University

Kim Dong-gyu, Vice President, SK Hynix

Lee Hongdeok, Vice President, SK Hynix

Lee Seok-Hee, Executive Chairman, Solidigm

Lee Sang Yup, Vice President for Research, KAIST

Park In-kook, President, Chey Institute for Advanced Studies

**U.S. Speakers and Facilitators**

Kristen Baldwin, Deputy Assistant Secretary of the Air Force (Science, Technology, and Engineering); Former Deputy Director for Strategic Technology Protection and Exploitation, Office of the Under Secretary of Defense for Research and Engineering

Sharon Burke, Former Assistant Secretary of Defense for Operational Energy

Rose Butchart, Former Associate Fellow, Defense-Industrial Initiative Group, CSIS

Kristin DeBord, Deputy Assistant Secretary (Acting), Office of Strategy, Policy, Planning, and Requirements, Office of the Assistant Secretary for Preparedness and Response, Health and Human Services

Cynthia R. Cook, Senior Fellow and Director, Defense-Industrial Initiatives Group, CSIS

Gerald Epstein, Distinguished Fellow, National Defense University

Megan Frisk, Director for Biotechnology Risk and Biological Weapons Nonproliferation, National Security Council
Brian Gabriel, Industrial Analyst, Office of the Assistant Secretary of Defense for Industrial Base Policy

David Honey, Deputy Under Secretary of Defense for Research and Engineering (DUSD(R&E))

Alex Jacquez, Senior Policy Advisor, National Economic Council

Seth G. Jones, Senior Vice President, Harold Brown Chair and Director, International Security Program, CSIS

Ilaria Mazzocco, Fellow, Trustee Chair in Chinese Business and Economics, CSIS

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2023 CSIS-CHEY Seoul Conference Participants

Cooperation on Scientific Innovation, Supply Chains, and Geopolitical Risk in Northeast Asia
(Alphabetical order, positions as of March 2023)

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Ahn Dukgeun, ROK Minister for Trade
Choi Joon, Senior Vice President and Head of Global Growth Strategy, SK Hynix
Kang Kisuk, Professor, Seoul National University
Jerome Kim, Director General, International Vaccine Institute
Kwon Seok Joon, Professor, Sungkyunkwan University
Lee Chung Min, Senior Fellow, Carnegie Endowment for International Peace
Lee Sang Yup, Vice President for Research, KAIST
Nam Ki Tae, Professor, Seoul National University
Park In-kook, President, Chey Institute for Advanced Studies
Park Minhee, Professor, KAIST
Seok Mingoo, Professor, Columbia University
Yeon Wonho, Chair of the Economic Task Force, Korea Institute for International Economic Policy

U.S. Speakers and Facilitators
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Mark Dallas, Associate Professor, Union College
Karson Elmgren, Research Analyst, Georgetown’s Center for Security and Emerging Technology
Alan Estevez, Under Secretary of Commerce for Industry and Security, U.S. Department of Commerce
Chris Fall, Vice President for Applied Sciences, MITRE

Gigi Gronvall, Associate Professor, Johns Hopkins Bloomberg School of Public Health

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Keynote Addresses on Technology, Supply Chains, and U.S.-ROK Cooperation

This joint report summarizes and derives its analysis from two events that explored cooperation by the United States and the Republic of Korea on technology sectors pivotal to Northeast Asia across scientific, economic, and geopolitical domains. As a preamble to this analysis, the addresses offered by senior government officials from both nations are included below. These keynotes, delivered by Dr. David Honey for the Washington workshop and by the Honorable Alan Estevez and Minister Ahn Dukgeun for the March 9 and 10, 2023, Seoul conference, have been edited for purposes of brevity and clarity.

Virtual Expert Workshop Keynote Speech

David Honey, Deputy Under Secretary of Defense for Research and Engineering (DUSD(R&E))

Dr. Jones, Ambassador Park, thank you for the kind introduction. It’s an honor to be a part of this important conference hosted by the Center for Strategic and International Studies and the Chey Institute. Let me also offer congratulations to the new president of the Republic of Korea, Yoon Suk Yeol, and his administration, who were sworn into office on May 10. We look forward to working with the new administration. For more than 70 years, the relationship between the United States and the Republic of Korea has been vital to stability and prosperity in Northeast Asia. Our alliance, established in 1953, remains the linchpin of peace and security in the Western Pacific and the Korean Peninsula. This alliance continues to maintain a robust combined defense posture to protect the Republic of Korea against any threat or adversary.
On a recent visit to the ROK, President Biden and President Yoon Suk Yeol discussed, among other things, ways to deepen and broaden cooperation on critical and emerging technologies, such as semiconductors, batteries, civil nuclear power, space development, and cyberspace. Fully recognizing that scientists, researchers, and engineers of the two countries are among the most innovative in the world, both presidents agreed to leverage this comparative advantage to enhance public and private cooperation and to protect and promote critical and emerging technologies, including leading edge semiconductors, eco-friendly EV [electric vehicle] batteries, artificial intelligence, quantum technology, biotechnology, biomanufacturing, and autonomous robots.

The Technology Cooperation Subcommittee (TCSC), established in 1990, continues to act as the main forum for DoD science and technology cooperation with the ROK and is intended to facilitate engagement among scientists, engineers, and international program office staff. As part of the TCSC, both sides agree to host an annual TCSC technology forum on a specific technology topic aligned with DoD critical technologies and cross-service in scope. The first technology forum will focus on space domain awareness and is anticipated to be held in late summer or early fall in the Republic of Korea. The TCSC can address far-ranging S&T capability gaps and stands ready to meet any challenge, whether that be a growing technology race with adversaries or addressing global supply chain issues.

Also, back in February of 2022, the White House released its Indo-Pacific Strategy of the United States. The strategy pointed to the U.S. commitment to a free and open Indo-Pacific that is more connected, prosperous, secure, and resilient. The ROK is a critical element of this strategy. Like the ROK, we aim to promote regional security through capacity building. The role of science and technology in achieving this vision is key to what we do in the office of the under secretary of defense for research and engineering where I work. The under secretary, Heidi Shyu, is the DoD's chief technology officer. She is responsible for developing and fielding critical technologies to deliver capabilities and strengthen capacity for our military and our allies. In February, the under secretary published her strategic vision for the organization. This established three pillars of effort to focus on for executing our mission to deliver top technology to the department. These are mission focus, foundation building, succeeding through teamwork, and today’s conference is about all three of these. This strategic vision also established fourteen critical technology areas we want to emphasize across the department. For the U.S.-ROK relationship and this conference, there are five areas we want to focus our attention on, as they impact global supply chain security. But we certainly look forward to continuing to build on the solid relationship we have with the new ROK administration. The five topics are:

**Artificial intelligence.** As AI, machine learning, and autonomous operations continue to mature, the DoD will focus on evidence-based AI assurance and enabling operational effectiveness.

**5G and Future G.** As fifth-generation wireless technology is adopted and provides building blocks for capability, the DoD will also look forward to Future G for leap ahead technologies to lead in creating future standards. The department will invest in Future G technology development to lay the groundwork for continued United States leadership in information technology, which is vital to maintaining our economic and national security. At the U.S.-ROK presidential summit in May of
last year, the U.S. and the ROK agreed to recognize the importance of telecommunications security and vendor diversity. The leaders also commit to work together to develop open, transparent, and secure 5G and 6G network devices and architectures using Open RAN approaches, both at home and abroad.

**Quantum science.** Quantum computing can provide unprecedented computational speeds and help solve the department’s hardest analytical problems. Quantum sensors promise us the ability to provide unprecedented accuracy and position, navigation, and timing. Our near-term technology focus is on advanced atomic clocks and quantum sensors to improve navigation and timing reliability beyond GPS and improve our access to the spectrum. We have engaged in basic QIS [quantum information science] research via joint funding calls and information exchange agreements with South Korea, including the U.S. Air Force through AFOSR, and also initiated joint funding with South Korea’s National Research Foundation (NRF) for university collaborations between Korea and the U.S.

**Biotechnology.** From fighting global pandemics and avoiding surprises to reducing logistics and sustainment costs and increasing energy efficiency, biotechnology can help change the way the department conducts missions, performs in contested logistics environments, and adapts to major global changes. Biotechnology innovation is largely through global collaborations. DoD partnerships, domestically and internationally, de-risk and accelerate the transition of research to operational demonstrations and capabilities.

**Renewable energy generation and storage.** Renewable energy generation and storage promises to decrease warfighter vulnerability and deliver new operational capabilities for the department. From more efficient batteries to diversifying energy sources and reduced fuel transportation risks, renewable energy generation and storage will add resilience and flexibility in a contested logistics environment.

The U.S. and the ROK have also agreed to enhance cooperation between our foreign investment screening and export control authorities related to critical technologies, which is necessary to prevent the use of advanced technologies to undermine our national and economic security. One of the ways we help facilitate this in USD(R&E) is via the Foreign Comparative Testing program. The Republic of Korea has been an active participant in the FCT program since 1983. DoD has funded 16 FCT projects to evaluate ROK technology, systems, and equipment. Four projects are ongoing: enhancing DoD concrete infrastructure repair, which evaluates a rapid setting polymer-based mortar for repair of critical infrastructure, reducing shipping costs by providing a qualified material source that meets performance requirements in theater; the supercavitating ammunition program, which tests small arms ammunition that leverages the physical properties of supercavitation to increase range and lethality in underwater environments, providing a new capability to enhance various maritime operational mission areas; artificial intelligence neuromorphic chip, which is evaluating an AI-enabled prototype gun tag to measure and record Stryker 120-millimeter mortar firing activity, demonstrating cost-effective AI at the tactical level while reducing weapons system life cycle maintenance costs; and fast inshore attack craft engagement, also known as FIAC. This
program helped test a fire-and-forget 2.75-inch rocket with an advanced imaging infrared seeker to provide an effective asymmetric capability against FIAC swarms in the maritime environment.

The U.S. and the ROK have also agreed to enhance cooperation between our foreign investment screening and export control authorities related to critical technologies, which is necessary to prevent the use of advanced technologies to undermine our national and economic security.

As you can see, we've had a long and meaningful relationship with the people of the Republic of Korea. I'm sure that more ideas will be discussed during this conference, and I look forward to many more years of fruitful partnership. Thank you.

Seoul Conference Keynote Speech
Alan Estevez, Under Secretary of Commerce for Industry and Security, U.S. Department of Commerce

Good morning. I'm Alan Estevez, under secretary for industry and security at the U.S. Department of Commerce. Thank you, Greg, for inviting me to speak today. And thanks to CSIS and the Chey Institute for hosting this conference. I wish I could be there in person and meet with the leaders and experts you’ve pulled together for this event. But it is my pleasure to speak to you from Washington.

At the Bureau of Industry and Security, or BIS, we operate at the nexus of U.S. national security, technology, and global commerce through many activities, including administering and enforcing U.S. export controls. For those of you who may not be familiar with our export controls, we regulate lower-level military items, including certain parts and components for military systems, dual-use items having both commercial and military or proliferation application, and purely commercial items. We work closely with other U.S. government agencies and with allies and partner countries to create a more secure world through controlling advanced technology and preventing it from getting into the hands of those who wish to do us harm.

As one of our closest allies, the Republic of Korea is a critical export control partner, and we greatly value our work with you. At no point has this close cooperation with allies on export controls been more central to our collective security than right now. One only needs to look at the impact they’ve had over the last year with regards to Russia’s unjustified invasion of Ukraine to see this urgency and importance. It’s been a little over a year since Russia invaded Ukraine, and over that time we’ve demonstrated the power of a strong multilateral response. Thirty-eight nations, including the Republic of Korea, have joined together in a global export control coalition to slowly strangle Russia’s ability to sustain its military power, effectively cutting off critical supplies and weapons systems from being used against Ukraine.
As one of our closest allies, the Republic of Korea is a critical export control partner. . . . At no point has this close cooperation with allies on export controls been more central to our collective security than right now. One only needs to look at the impact they’ve had over the last year with regards to Russia’s unjustified invasion of Ukraine to see this urgency and importance.

When this war started last year, Korea implemented the initial set of export control actions against Russia, in line with the global export control coalition. The goal of our coalition has been to choke off exports of technologies and other items that support Russia’s industrial base, including defense, aerospace, and maritime sectors, and to degrade Russia’s military capabilities and its ability to project power. These efforts have been effective. For example, global exports of semiconductors to Russia from official data sources are down approximately 70 percent. Russia is seeking to pull chips from household appliances and consumer electronics. Over 9,000 destroyed Russian tanks are unable to be replaced or fixed due to lack of materials and technology, and the Russians are struggling to replace their depleted supply of high-precision missiles.

Clearly, multilateral application of export controls is a force multiplier in cutting off Russia, and its enablers that seek to provide support, from the commodities, technologies, and software necessary to support advanced aerospace and maritime sectors. On February 24, we welcomed Korea’s Ministry of Trade, Industry and Energy announcement to add 741 items to its Russia controls, including automobiles and parts, industrial machinery, chemicals, and steel products. I commend Korea’s work with us on responding to Putin’s illegal war on Ukraine. Everything that’s been accomplished in the last year to degrade the Russian military would simply not have been possible without your participation, or that of our allies.

I’d like now to turn to export controls we issued last October, addressing critical technologies related to the production of advanced semiconductors and the development of advanced computing capabilities in China. We implemented these controls in a targeted way to address technologies that we believe are key to China’s military modernization and human rights abuses. Advanced computing chips are necessary to producing large-scale artificial intelligence models in very powerful supercomputers, which in turn allow China to improve the speed and accuracy of its military decisionmaking, planning, and logistics. They can also be used for cognitive electronic warfare, radar, signals intelligence, and jamming. And they can improve calculations and weapon design and testing, including for weapons of mass destruction.

Additionally, producing advanced semiconductors is needed for supercomputers, as well as for developing advanced weapon systems. These capabilities can also create foreign policy concerns when they’re used to support applications like facial or gait recognition surveillance systems for human rights abuses. It was for all these reasons that we implemented new restrictions on exporting, among other things, certain advanced computing chips and semiconductor manufacturing equipment to China. I want to emphasize that we did not implement these
controls for economic protectionism reasons. These are legitimate national security and foreign policy concerns. We have been engaged with industry around the world, including Korean companies, on the impact of these controls. We also plan to address public comments received in response to the rule.

Finally, I would like to touch on our dual-use controls working group. Back in November, we launched the U.S.-Korea Dual-Use Export Controls Working Group led by my colleague, Assistant Secretary Thea Kendler. U.S. and Korean companies are at the forefront of global technology, and this export control working group is tasked with identifying specific actions for both parties to advance export controls cooperation. This working group will see to the fruition of the working plan that United States secretary of commerce Gina Raimondo and Korean minister of trade, industry and energy Lee Chang-yang outlined earlier this year, executing on the following objectives. First, we’re seeking to enhance U.S.-Korean coordination and ensure that export controls are consistent with promotion of bilateral trade and the stability of the global supply chain in the field of advanced manufacturing. Second, we’re promoting [convergent] control approaches addressing new security challenges. And third, we’re ensuring efficient stakeholder engagement and support in the development and implementation of effective export control approaches.

We are pleased with the close cooperation we have had through the working group, and we’re excited to continue our strategic partnerships to ensure American and Korean safety for decades to come. It has been a pleasure to speak with you today. Thank you for your participation in this conference and for your time. I can’t emphasize enough how strongly the United States values its partnership with Korea. And I’m looking forward to continuing our work together in pursuit of making both Korea and the United States safer and stronger. I’m also looking forward to hopefully seeing many of you in person very soon. Thank you.

Seoul Conference Keynote Speech
Ahn Dukgeun, ROK Minister for Trade

It is my pleasure to greet you all. I am Dukgeun Ahn, Korea’s minister for trade. I would like to congratulate the Chey Institute and CSIS for hosting this timely and meaningful conference. Building on our unbreakable trust, the Korea-U.S. FTA has served as a solid foundation for ever-increasing trade and investment flows. Now, Korea and the United States are significantly interconnected as indispensable key partners in critical supply chains for semiconductors, batteries, energy, and so forth. For instance, in the semiconductor sector, the global supply chain would not function at all without each other. Korea’s manufacturing capacities and the U.S.’s leading technology are crucial elements to buttress the semiconductor supply chain. Numerous companies from both countries, ranging from Samsung and DuPont, constitute a strong and resilient industry ecosystem.
For instance, in the semiconductor sector, the global supply chain would not function at all without each other. Korea’s manufacturing capacities and the U.S.’s leading technology are crucial elements to buttress the semiconductor supply chain.

Distinguished guests. Industries and economies across the world have no choice but to adapt to a new normal with regard to supply chains. While the effects of the pandemic remain, we are facing mounting uncertainties as a result of ongoing geopolitical crises, including the war in Ukraine and changing trade policy, like resource nationalism. In fact, the world is on the brink of poly-crisis, in which economic, trade, political, and diplomatic risks are inextricably entangled. Major economies are increasingly striving to boost their resilience in the long run rather than opt for short-term efficiency. As we speak, growing numbers of countries are endeavoring to secure their own supply chains by adopting protectionist policies with respect to raw materials, intermediate parts and components, and advanced technology. And, as we understand, it is hard for any particular country to avoid this wave. Therefore, I believe that it is very much necessary to maintain global solidarity based on trust between allies.

To this end, countries opting for friend-shoring for their economic security should take the following points into consideration. Firstly, it is essential that economic security policies should be compatible with the international trade regime that has been grown by continuously widening memberships as well as expanding trade disciplines. The world trading system, created and evolved since the Second World War, can still accommodate important economic security concerns when it is properly reformed. Secondly, trust between countries should be maintained and enhanced by effective cooperative measures based on the good faith principle, including an early warning system and advance notice. Effective measures to enhance stability and resilience of supply chains should fortify the commitment among strategic partners. Last but not least, we need to ensure that the market and industries are provided with proper time and spaces to adjust to rapidly changing regulatory and policy reforms. We should not forget that it is the industries that actually restructure supply chains and industry ecosystems. We governments must find ways to alleviate transition costs for our industries as well as workers. Such imperatives are also very much in line with discussions at the G20 summit in 2020, during which member countries shared the common understanding that measures relating to national security shall be targeted, transparent, proportional, and temporary as well as compatible with international agreements.

With that said, I would like to touch upon a few of Korea’s policy initiatives pertaining to supply chains. Korea will continue to promote supply chain stability through the global trade linkage. Like many other countries with relatively small domestic markets, Korea tries to strengthen supply chain resilience by diversifying its trade relationships so that our industries can have more flexible alternatives at the time of unexpected supply chain disruptions. Thus, we will bolster global coordination on supply chains by arranging the Economic Partnership Agreement or the Trade and Investment Promotion Framework with many trade partners that do not yet have an FTA with us. In addition, we will continue to expand the supply chain cooperation arrangement
with like-minded and similarly situated countries, reaching beyond Australia, the United Kingdom, Indonesia, Vietnam, Mongolia, and many more. We are also actively participating in sector and bilateral discussions on the restructuring of global supply chains, including the Minerals Security Partnership and the Supply Chain Commercial Dialogue with the United States.

Moreover, Korea has fully committed to the Indo-Pacific Economic Framework (IPEF) negotiation that sets forth new models for supply chain partnerships, embracing both developed and developing countries with divergent levels of resource and technology abundancy. Korea will continue to play a crucial role in developing a supply chain arrangement for IPEF that will be a core element to strengthen economic partnerships for IPEF members.

Distinguished guests. Economic security is emerging as the centerpiece of national trade policies of major economies as well as international discourse. It is true that even the WTO agreement allows members recourse to various trade-restrictive measures to protect national security. However, such measures should be exercised under due process and with heightened scrutiny within the purview of the international rule of law system. When uncertainties persist due to the still-lasting pandemic, Russia’s aggression toward Ukraine, and the strategic competition in the Indo-Pacific region, our dependence on one another will keep growing ever [closer] than any time before. In this regard, the steadfast partnership between Korea and the United States, based on our seven-decade alliance and 11-year-old FTA, is of the utmost importance. And I know of nothing greater that will enable us to turn each crisis, no matter how daunting, into a new opportunity. With that said, I believe the insights shared at today’s conference will lay the groundwork for further strengthening the partnership between Korea and the United States. Thank you.
Introduction

In May 2022, President Joseph Biden of the United States and President Yoon Suk Yeol of the Republic of Korea (ROK) issued a joint statement affirming that “the future of the [U.S.-ROK] Alliance will be defined by common efforts to address 21st century challenges. . . . Both leaders also pledge to develop, use, and advance technologies in line with shared democratic principles and universal values.” Toward that end, both the United States and the Republic of Korea will encourage “people-to-people exchanges between experts” and promote “investment as well as research and development [R&D] cooperation” to support these and other critical and emerging technologies as important economic components to the U.S.-ROK relationship.¹

On June 9 and 10, 2022, CSIS and the Chey Institute convened a series of workshops that brought together a range of experts to explore the opportunities and risks posed by supply chains on three clusters of technologies that were specifically identified by the U.S. and ROK leaders as areas of focus to deepen and broaden cooperation between the two nations.² The three areas of focus were semiconductors, electric vehicle batteries and strategic and critical materials, and biotechnology and public health. The workshops were preceded by a keynote speech by David Honey, U.S. deputy under secretary of defense for research and engineering. Supply chains and geopolitical risk are interconnected in ways that are increasingly central to the future of the United States, the Republic of Korea, and Northeast Asia; the three technologies in this report have important implications for the economic security of both nations and are also directly relevant to the military alliance between them, which has spanned more than 70 years.³
CSIS and the Chey Institute reengaged on recent research concerning these technologies on March 9 and 10, 2023, for a two-day conference at the Chey Institute headquarters in Seoul. The conference featured keynote speeches from Alan Estevez, U.S. under secretary of commerce for industry and security, and Ahn Dukgeun, ROK minister for trade. Three moderated panels covered the technology clusters of the previous workshops: semiconductors and multinational coordination; biotechnology, public health, and preparing for crisis; and high-capacity batteries, critical and strategic materials, and common standards. The conference expanded on the workshops by adding two sessions with broader focuses, one on opportunities for technological cooperation and one on supply chains and geopolitical risk.

Global supply chains have been under siege as they face the ripples of the Covid-19 pandemic and geopolitical challenges. Semiconductors are a key enabler for a broad range of critical technologies—and shortages of this critical good can reverberate across the global economy. High-capacity batteries and critical and strategic materials are not only used in a wide range of devices but are vital to meeting nations’ climate change pledges, even as their production causes environmental problems. Finally, biotechnology can be a boon to public health, and biomanufacturing can reinforce supply chains in a range of fields. However, the democratization of biotechnology also increases the risk of accidental or intentional release of a harmful biological agent. Each technology has multiple clustered supply chains with distinct leading providers and levels of diversification. However, larger global trends provide a common context for all three technologies.

The current state of these three global supply chains was formed by globalization, national comparative advantages, labor market dynamics, and (at times) industry policy. After the Second World War, U.S. dominance in East Asia allowed the East Asian “tigers” (South Korea, Hong Kong, Singapore, and Taiwan) to begin to explore export-oriented economies while also making investments in their workforces and national capacity. The United States also began to open its markets, which allowed states in East Asia access to the world’s largest economy. With low labor prices, East Asian economies grew and became increasingly specialized in high-tech fields. China’s ascension to the WTO in 2001 shifted this dynamic by providing another venue for manufacturing and consumers. The free flow of goods across East Asia in the early 2000s led to flurries of investment as the market built tightly integrated multinational supply chains for complex manufactured goods. China would rise to prominence as a leading producer in rare earth elements, while Taiwan and Korea would remain dominant in some of the most complex forms of manufacturing. However, recent global crises and rising tensions have changed the trajectory of the global and East Asian economy. As Minister Ahn observed in his keynote, “major economies are increasingly striving to boost their resilience in the long run rather than opt for short-term efficiency.” As these dynamics continue to evolve, the future of trade in the Indo-Pacific will be increasingly governed by the following three factors:

**Diversity of suppliers and producers and knowledge of supply chains.** Increasing the diversity of sources reduces supply chain risks. For U.S.-ROK military innovation purposes, this will be especially important in the five emerging technology areas identified by Dr. Honey: artificial intelligence, 5G and future generation wireless networking, quantum science, biotechnology,
and renewable energy generation and storage. This holds true even when supply chains consist entirely of domestic sources, which can still be disrupted by natural disasters, changing economic circumstances (such as companies moving up the value chain), and the depletion of natural resources.\footnote{7} However, countries and companies often lack insight into lower tiers of their supply chains or into potential bottlenecks that may come from multiple producers relying on a single supplier. Experts at both 2022 and 2023 events emphasized the importance of diversifying fragile supply chains and increasing the supply chain insight necessary to do so. That said, domestic production remains the source of diversity that countries are most willing to fund. One example of this trend is growing U.S. policymaker comfort with industrial policy for sectors beyond the traditional defense industrial base.\footnote{8}

\textbf{Geopolitical relationship of key participants.} This past decade has seen countries wield their individual asymmetric advantages by restricting transfers to trading partners, with China’s 2010 rare earths embargo on Japan a classic example.\footnote{9} Trade disputes and sanctions, often used as an instrument to apply pressure in other conflicts, have been joined by weaponized interdependence that seeks to use control of networks to achieve foreign policy ends.\footnote{10} The potential of these tools has been enhanced by the fact that, unlike the separate economic blocks of the Cold War, present great power competition comes in a context where the United States and China have interconnected economies—with ties to China being especially strong for the Republic of Korea and some other regional U.S. allies. Incidents such as the multilateral sanctions on Russia after the invasion of Ukraine and Russia’s cutoff of natural gas to Europe suggest that geopolitical relationships will be a growing factor in future supply chain considerations.

\textbf{The important but unsettled future of economic security.} The conference keynote speeches by Under Secretary Estevez and Minister Ahn made manifest the extent of U.S.-ROK cooperation on supply chains with national security relevance. The ROK has joined in broad-based sanctions in response to Russia’s illegal and unprovoked invasion of Ukraine, which—in data reported by Under Secretary Estevez—has contributed to a 70 percent reduction in Russian semiconductor imports and over 9,000 Russian tanks kept off the battlefield. The United States and the Republic of Korea have also reached an accommodation regarding the October 7, 2022, initiation of semiconductor export controls, and both are parties to the Indo-Pacific Economic Framework for Prosperity.\footnote{11} However, this area of accord still leaves a gap on approaches to larger economic security questions, as evident from the difference between Minister Ahn’s remarks and subsequent declarations by leading U.S. officials. Minister Ahn argued that “it is essential that economic security policies should be compatible with the international trade regime that has been grown by continuously widening memberships as well as expanding trade disciplines.” In contrast, U.S. national security advisor Jake Sullivan suggested a change in approach on April 23, 2023: “In today’s world, trade policy needs to be about more than tariff reduction, and trade policy needs to be fully integrated into our economic strategy, at home and abroad.” \footnote{12} And regarding economic security, U.S. trade representative Ambassador Katherine Tai has argued that “trade is going to be part of the solution” but “the way that we have been doing trade has led us to a world of supply chains that reflect quite a bit of fragility.”\footnote{13} As the United States, the ROK, and other countries that share values work to converge on
principles of economic security, both cooperative and individual national expertise on these issues has become increasingly important.

The three sets of technologies covered in the workshops and the conference have been shaped by globalization and global demand, complementarity, and industrial policy in ways that put them in divergent contexts for pursuing diversification and incorporating concerns about geopolitical risk.

- **Semiconductors** are distinctive as an industry where a small number of U.S. allies and partners are pivotal to production. The Republic of Korea, Taiwan, Japan, the Netherlands, and Germany are all major players in the global semiconductor supply chain. The United States is still the central node in this supply chain and focuses on R&D-intensive activities, including equipment for design and manufacturing. As Minister Ahn noted, “in the semiconductor sector, the global supply chain would not function at all without each other. Korea’s manufacturing capacities and the U.S.’s leading technology are crucial elements to buttress the semiconductor supply chain.” China is a leading global consumer for the full range of semiconductors, but on the production side its role is currently largely confined to widely used but trailing-edge semiconductors, with the majority of advanced manufacturing taking place in Taiwan and the Republic of Korea. The Biden administration sought to have a small yard with a high fence around critical national security technologies, and advanced semiconductors have been its most important addition to these fenced technologies.

- **Electric vehicle batteries and strategic and critical materials** are markets where major growth is needed to meet the expected demands of the electric vehicle market and other green technologies. In the EV battery market, “ninety-seven percent of demand is supplied by battery firms from China, Japan, and the ROK,” according to Professor Kang Kisuk of Seoul National University. When it comes to strategic and critical materials that are precursors to batteries and a range of other goods beyond the scope of this cluster, China has made major investments and employed exploitative labor and environmental practices to become a leading producer; consequently, China currently dominates their processing.

- **Biotechnology and public health technologies** have more diverse supply chains. Advanced pharmaceutical precursors come from a variety of nations, although any given product may be highly reliant on a single provider. Biomanufacturing—producing products via biological systems that are engineered or synthetically employed—is beginning to shape production in the biotechnology and pharmaceutical field and may enable great flexibility and certainty for a wide range of supply chains. Much of the discussion focuses on R&D rather than any countries that lead commercial production for given goods.

This assessment is organized into four sections: the three technology areas explored by both the 2022 workshops and the 2023 conference, plus a fourth section devoted to the themes covered in the two additional panels of the conference. In each section, the assessment first summarizes key elements of the technology or issue’s importance to the defense industry before providing an overview of major takeaways from the 2022 workshop, when applicable. The section then explains the primary points raised during the 2023 conference, followed by an analysis of the key issues going forward. The paper concludes by synthesizing these sections to suggest a future path.
for cooperation in innovation and managing supply chains while navigating geopolitical risk in Northeast Asia.
Semiconductors

Semiconductors are the backbone of the twenty-first-century economy and are a critical enabler of innovations across all sectors, underpinning both U.S. Department of Defense (DoD) and commercial systems. The sector is undergoing technological shifts; as the MIT Technology Review reports, “the days when you could reliably count on faster, cheaper chips every couple of years are clearly over.” It is in the vital interest of both the United States and the Republic of Korea to not only have a stable supply of semiconductors but retain leadership in this globally competitive industry.

A critical policy debate in the semiconductor space is how to approach China’s role in the market. China has a commanding position in the production of some parts of the trailing-edge supply chain but does not have the capability to domestically manufacture the cutting-edge chips needed for modern consumer electronics, artificial intelligence, and advanced military equipment. Between the June 2022 workshop and the March 2023 conference, U.S. policymakers undertook a seismic shift in policy on October 7, 2022, enacting export controls relating to advanced semiconductors and the development of China’s computing capabilities.

The 2022 CSIS-CHEY expert workshop on semiconductors focused on the national security implications of the semiconductor supply chain and featured a panel of U.S. and ROK subject matter experts. The workshop discussed China’s role in the industry and the implications for the United States and its allies. One workshop panelist estimated that the potential impact of a Chinese invasion of Taiwan on the semiconductor supply chain would be a loss of 85 percent of leading-edge
microprocessors globally, a loss of two-thirds of all trailing-edge microprocessors, and a loss of half of all DRAM chips.

Since 2019, the United States has attempted to exploit this reliance by enacting targeted sanctions to keep certain types of equipment and chips from entering China. Some workshop discussants acknowledged the success of these efforts but raised concerns about the further expansion of sanctions impacting ROK and U.S. companies that have significant manufacturing operations within China. Participants pointed out that more aggressive sanctions could cause further supply chain stress, as production for these companies cannot be quickly relocated to outside of China. The chip shortage that began in 2020 was not caused by geopolitical strife but does demonstrate the difficulty of overcoming supply chain disruptions, as the U.S. automotive industry suffered an estimated “7.7 million units of vehicle production lost” with a cost of “$210 billion in lost revenues.” Under this line of thinking, a private workshop panelist explained, “foreign production sites of companies originating from U.S. allies must be protected from sanctions on semiconductor industry for efficient production and healthy supply chain. Selective control and sanctions on specific companies are required, not regional control as a whole.” There will have to be a well-choreographed balance between restricting China’s ability to access sensitive technologies and not unnecessarily impacting U.S. or ROK companies.

Some of the world’s leading semiconductor firms have become wary of their dependence on China and the complexity of the global supply chain. Despite attempts to decouple production from China, many firms remain dependent on the country, even if for just for a handful of critical goods. While fully decoupling the semiconductor supply chain from China may be difficult, reducing dependency for certain processes—like quality assurance and reliability—will make U.S. and ROK supply chains more secure and more resilient to geopolitical pressures. Workshop participants argued that the United States and its allies should diversify the semiconductor supply chain to mitigate risks and stabilize the market through bilateral manufacturing agreements based on a “win-win” economic approach.

One possibility mentioned would be to work closer to develop future technology and innovative products and create a new supply chain for those technology end products. The scale of the work at hand means that the DoD will have a limited role in building more resilient supply chains; its buying power is not substantial enough to sway the global market, as governments make up only 2 percent of global demand for semiconductors. Some participants advocated for the creation of joint microelectronics assurance standards that apply beyond military use. For discussants from both countries, the idea of U.S. companies opening R&D facilities in the Republic of Korea was appealing, although as was earlier discussed, the United States does have multiple concerns that cannot be addressed by focusing only on high-end and new semiconductors.

Discussants at the Washington workshop from both sides of the Pacific were focused on the role of human capital in the semiconductor supply chain. Participants pointed out that the greatest limiting factor in both semiconductor innovation and manufacturing was talent. Some participants raised immigration policy as a potential solution: panelists noted that in the United States at least 40 percent of those with relevant advanced degrees are born abroad, as are two-thirds of those in U.S.
graduate programs.\textsuperscript{23} One solution for gaps in human capital is for the United States to loosen visa requirements for recent graduates of relevant advanced degree programs.\textsuperscript{24} For the United States, one particular problem is country-based caps on green cards that greatly limit the pipeline on potential sources of third-country semiconductor talent, most notably from India. There were also calls for greater investments in education, in both the United States and the Republic of Korea, as part of a long-term effort to grow capacity in the semiconductor market—with the acknowledgment that such investments would take five to fifteen years to pay off.\textsuperscript{25} Investments could take a range of forms, including support for graduate student researchers, community college for technicians, apprentice and intern programs, and centers of excellence and innovation sites.

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The human capital question is increasingly important in the context of the CHIPS and Science Act. The bill, which has since been passed into law, would see $52.7 billion invested to cultivate U.S. domestic manufacturing capability.\textsuperscript{26} ROK firms will play a key role, with Samsung already making significant investments in the United States.\textsuperscript{27} However, there exist serious concerns about the U.S. talent pool, which may eventually restrict companies’ capacity to expand in the United States. Whether or not U.S. and ROK companies are successful in U.S. manufacturing will depend in large part on their ability to support and cultivate a highly skilled workforce.

As aforementioned, in the period between the U.S. workshops and the Seoul conference, the United States instituted export controls to impede China’s ability to source and manufacture semiconductor chips. The new export controls began on October 7, 2022, with the purpose of lessening the power of China’s current chips industry and military growth but also slowing its advancement in emerging technologies like AI and quantum.\textsuperscript{28} Under Secretary Estevez stated, “I want to emphasize that we did not implement these controls for economic protectionism reasons. These are legitimate national security and foreign policy concerns.” The United States provided the ROK semiconductor companies Samsung and SK Hynix with one-year licenses to exempt them from the new restrictions.\textsuperscript{29}

The subsequent 2023 CSIS-CHEY Seoul conference focused on the challenges of aligning interests and efforts regarding semiconductors in light of today’s fast-paced technology innovation and intensifying geopolitical dynamics. In an industry composed of highly specialized players distributed across concentrated regional clusters, coordinating policies and trade measures has become a sophisticated, but important, task.

In particular, ROK companies find themselves in an increasingly difficult strategic position amid intensifying U.S.-China relations, as access to Chinese markets translates directly to revenue,
and much of their memory chip productions rely on factories in China. While the United States is determined to continue preventing streams of leading-edge technologies and equipment from entering China, ROK private companies struggle to find ways to maintain a competitive edge in the Chinese market. Meanwhile, the U.S. Department of Commerce—through its “guardrail” measures—has looked to provide funds for foreign companies to invest on U.S. soil in exchange for future cooperation.

Looking ahead, participants proposed three topics to be considered in formulating strategies for multilateral technology coordination. First, the U.S.-China competition ushers in a new era of trade measures. Industry-driven digital technologies with unclear “dual use” implications necessitate a new, expansive framework that reaches beyond one industry (e.g., semiconductors) and spans a wide range of products and ecosystems. Professor Mark Dallas, from Union College, explained at the conference, “It’s very unclear: advanced nodes chips, AI, high performance computers, those are not inherently military technologies and there’s wide commercial availability for these things. Private companies are both the innovators and the users of these technologies.” Professor Dallas argues that in modular technology ecosystems such as information communication technology, a linear model of technology controls may prove inappropriate, as each system can innovate independently allowing for a range of potential paths for innovation to flow. Second, careful scrutiny must be given to how each country’s industrial policies will influence multilateral chip cooperation. Dr. Choi Joon with SK Hynix stated, “Judging from my conversation with U.S. government, they understand that it is important for any chip makers to have access to the Chinese market, but at the same time, for the national security reason, the U.S. government wants to control the technology advancement by the Chinese local chip makers.” Participants agreed on the need for coordinated efforts—bilateral or trilateral—among close partners to align national policies and initiatives to prevent a worrisome subsidy race and, consequently, a worldwide overcapacity for chip manufacturing. Third, there was a unanimous call for a larger role played by both the U.S. and ROK governments in navigating current uncertainties. In particular, one participant argued that the United States and its allies can spearhead efforts to coordinate and enforce multilateral export controls by agreeing on more seamless legal and trade standards.

Building a resilient and innovative semiconductor industrial base while coordinating an effective multilateral technology policy, especially in the case of dual-use technology, will require clear leadership from the governments in Washington and Seoul. Coordination and resiliency efforts require cooperation between U.S. departments and allies. As mentioned in Under Secretary Estevez’s keynote speech in Seoul, the U.S.-Korea Dual-Use Export Controls Working Group is one way both governments are taking steps toward better coordinating their policies for new technology. The U.S. government is also being attentive to ROK chip makers’ reliance on continuing business with China as the government replaced the licenses provided to Samsung and SK Hynix with indefinite waivers to continue their involvement with sites operated by multinational companies in China despite U.S. export controls.

The workshop and conference covered overlapping issues but dialed in on different avenues to bettering semiconductor policy. First, effective semiconductor export controls will be a difficult
challenge requiring ongoing adaptation. These efforts may be eased by improving legal and trade standard-setting as well as allowing time for adaptation. Second, governments and industry can target future investment by taking advantage of the relative strength and weakness of each country’s industrial base, exploring opportunities to codevelop on a bilateral or multilateral basis, and monitoring the duplicative aspects of industrial policy. Third, both countries should invest in their workforce and education, as this is necessary to address capacity shortfalls that could prevent both countries from staying on the leading edge of the industry as it balances commodification with continued innovation. All three avenues would benefit from a clear framework for dual-use technology, along with coordination on national and international policy.
High-Capacity Batteries and Strategic and Critical Materials

Demand for lithium-ion batteries is primarily driven by an increase in demand for electric vehicles (EVs) and a growing preference for renewable energy technologies, such as grid-scale storage. According to the Biden administration’s Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth 100 Day Supply Chain Review, demand for lithium batteries is expected to increase “by another factor of five to ten by 2030.” In addition to lithium, high-capacity batteries are manufactured from rare earth elements and other critical materials—such as cobalt, nickel, and graphite—that are key to both batteries and a wider range of technologies. China’s current grip on the mining and processing of rare earths and other critical materials makes it central to supply chains in this rapidly growing sector.

The 2022 CSIS-CHEY workshop on high-capacity batteries and strategic and critical materials focused on exploring avenues of cooperation between the United States and the Republic of Korea in the lithium-battery supply chain. At the workshop, the Honorable Sharon Burke, a former assistant secretary of defense for operational energy, noted that beyond EVs, the breadth of demand includes high-tech information technology like smartphones, medical technology like MRIs, and most of the devices showcased at defense technology tradeshows. As a result, she noted that some rare earths and critical materials are expected to have a “400 to 4,000 percent increase in demand.”

Workshop participants discussed how the United States and the Republic of Korea can work together to achieve greater diversity in their supply chains and respond to China’s comparative advantage in producing lithium-ion batteries and critical materials processing. As the Hon. Burke noted, “China looked at the future with a strategic eye and made key investments, and used all
the government tools at their disposal” to capture the market. As a result, the United States and
the Republic of Korea both rely on China’s preeminent role within the lithium-ion battery supply
chain, and they do not currently produce enough to meet domestic demand, let alone production
for export.34 More specifically, the United States and the Republic of Korea produce 9 percent and
3 percent of the global supply of lithium-ion batteries, respectively. Both states’ capabilities to
process the minerals within lithium-ion batteries are far surpassed by China’s capacity.35 Professor
Kang Kisuk noted that many of the players—especially in the raw material level and the primary
process sectors—are based in China. Professor Kang then cited the Federation of Korean Industries’
estimation that approximately 90 percent of the batteries manufactured in the Republic of Korea
include Chinese-processed materials. China processes approximately 80 percent of global cobalt,
and over half of the global lithium supply is under its “control or influence.”36 Additionally, the U.S.
Geological Survey estimated that in 2022 China produced nearly 70 percent of the world’s rare
earth elements, which includes vital precursors for lithium-ion batteries separate from lithium
and cobalt.37 The dangers of this asymmetry were demonstrated in September 2010 when China
“reportedly sharply reduced REE [rare earth element] exports to Japan on a temporary basis over a
maritime incident between the two countries.”38

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For 35 years, the U.S. DoD has been the stockpile manager for strategic and critical materials,
a mission that includes tracking and reporting on the supply chains for the materials and the
potential risks to supply in a national emergency scenario. Mr. Brian Gabriel, an industrial analyst
for the Office of the Assistant Secretary of Defense for Industrial Base Policy, noted that even in the
absence of a specific cutoff there has been “significant, significant inflation over the last two years.”
For example, the price for neodymium, a rare earth in high demand used in electrical vehicle
drivetrains, was up in price by 240 percent at one point compared to 2020 levels. Two key steps
taken within the DoD are working on standardization of batteries—including better leveraging of
ROK investments—and reversing the post–Cold War sell-off of the U.S. strategic and critical minerals
stockpile.39 However, the stockpile and the larger U.S. strategy is notably larger than the DoD; as Mr.
Gabriel observed, 80 percent of the predicted shortfalls take place in the broader civilian economy,
not for military goods.

The combination of the rising demand for batteries and strategic and critical materials and China’s
dominant market position led the Trump administration to develop a strategy—and the Biden
administration to go further—to, as the Hon. Burke described, “retrofit an industrial policy” despite
the United States’ “longstanding aversion or allergy” to economic planning.40 As noted by Mr.
Alex Jacquez, a senior policy adviser on the National Economic Council, U.S. actions on rare earth
materials are a model of a modern U.S. industrial strategy.\textsuperscript{41} The reliance on the Korean War-era Defense Production Act reflects that the management of the defense industry base is the instrument for which Congress authorized capacity to pursue the industrial policy.\textsuperscript{42} Recent legislation has been another major source of support—namely $7 billion to support the battery supply chain in the infrastructure bill and further support in the Inflation Reduction Act (IRA), which passed subsequent to the conference and included subsidies for electric vehicles that rely on domestic production capacity.\textsuperscript{43} Results can be seen in new production and manufacturing facilities and original equipment manufacturer EV investments.

Another aspect of this industrial strategy that Mr. Jacquez noted is an attempt to use the power of the U.S. market “to lift some of these standards nationwide and reshape global markets so that the cost differentials that you get from low road production are offset” by a global market willing to pay “marginally higher prices, if those come with the standards and the values that we all believe in.” However, Professor Kang warned that “even though the fundamental battery science is very strong in United States, the batteries have very tight margins, often require huge amount of capital investment, and bear incredible risk, with the possibility of massive quality recalls.” Professor Kang argued that “if you do not take the position to produce the cost-effective and high-performance battery on the timescale of 10 years, you are most likely to lose the growing market of EVs.” He thought that deliberate U.S.-ROK partnerships, such as between GM and LG or Ford and SK, would be crucial to production that was competitive on a dollar per kilowatt-hour basis.

The panelists highlighted battery recycling as a potential way for consumer nations to diversify supply chains by extracting critical materials and rare earth elements from depleted batteries.\textsuperscript{44} According to Mr. Jacquez, the Biden administration thinks that battery recycling is a critical investment that is “going to jumpstart a domestic industry in the middle of that supply chain to allow us to compete with overseas competitors, including China.” However, the United States’ current battery recycling capabilities will not offset its foreign dependencies; of the approximately 75,000 tons of expended lithium-ion batteries available in the United States, less than 5 percent are recycled.\textsuperscript{45} Professor Kang highlighted a lack of standardization among lithium-ion battery designs as a challenge to battery recycling’s potential to extract as many critical materials as possible. The variety of battery designs does not allow for an automated disassembly process that could capture value-added portions of the battery, such as a cathode and an anode, that are otherwise wasted if a battery is simply dissolved.

The emphasis on recycling ties into a larger irony: although lithium-ion batteries will be instrumental in combating global warming, the processing of this energy source’s precursor materials generates substantive pollution, which puts manufacturers with less stringent environmental and labor regulations at a substantial advantage.\textsuperscript{46} That said, research offers potential new extraction approaches for critical minerals that lower the environmental footprint while increasing efficiency. Under the auspices of a program called Environmental Microbes as a Bioengineering Resource, the Defense Advanced Research Projects Agency (DARPA) is researching methods to use biomolecules to extract rare earth materials from aqueous sources, according to Dr. Linda Chrisey, a DARPA program manager.\textsuperscript{47} Mr. Jacquez also referenced
investments the Department of Energy Advanced Research Projects Agency-Energy (ARPA-E) was making in extracting lithium from geothermal brine and a range of minerals from other unconventional sources.

The 2023 CSIS-CHEY Seoul conference on high-capacity batteries, critical and strategic materials, and common standards focused on the challenges of building a resilient supply chain in the face of China’s dominance. Since rapidly gaining market share in the mid-1990s, China has continued to nurture its critical minerals industries through government subsidies and export quotas that favor domestic firms.

Today, China dominates the mid- and downstream sectors (e.g., chemical processing, component manufacturing, and cell production) of EV battery supply chains by leveraging loose regulations and co-location of production sites. These sectors are particularly capital-intensive and inflexible, meaning that there is large inertia for newly competing players to overcome. Meanwhile, China continues to pour streams of investments into countries with access to mining resources, such as Indonesia, Chile, the Democratic Republic of the Congo, Australia, and Zimbabwe. On top of that, China also represents 50 percent of global critical minerals demand. The speed and scale at which China’s vehicle electrification takes place surpasses that of the rest of the world.

Dr. Fabian Villalobos, an engineer at the RAND Corporation, assessed that there is a high risk that China broadly leverages this dominance by deliberately disrupting the supply chain. Neither does China hold back on taking aggressive actions to streamline the operations of its players and increase volatility for their competitors. For example, the recent allegations regarding radioactivity faced by the Australian firm Lynas Rare Earths Ltd. operating in Malaysia were a product of a disinformation campaign by a China-backed cybergroup.

Against these odds, the United States and its allies must take measures to strengthen their industrial base and invest in a diverse set of sources. Panelists also agreed on the need for an effective mechanism to guard against China's unfair trade practices.

While the IRA helps strengthen energy security and domestic battery manufacturing for the United States, it also creates concerns for its allies. Professor Kang shared concerns that the new rules imposed by the IRA may delay worldwide distribution of clean vehicles. For example, according to Professor Kang only 30 percent of EV models currently on the market satisfy the requirements written in the IRA, and the subsequent upward revisions will eventually render all vehicles presently on the market ineligible. Given that developing new mineral sources requires years of commitment and investment, such sudden change may bear unintended consequences, undermine market competency, and increase unpredictability.

Looking forward, Professor Kang suggested that the United States work closely with the Republic of Korea and Japan to build a resilient supply chain. Affording room for flexibility and negotiation in implementing the IRA-related measures may also help to minimize short-term repercussions and alleviate the discomfort experienced by U.S. allies. On a concluding note, he suggested that the Republic of Korea and Japan may be able to leverage competency in manufacturing equipment and
tools, as the technological complexity involved in battery manufacturing has largely kept China in check in this area.

The rapidly growing size of the global market for high-capacity batteries has spurred major investments in both the Republic of Korea and the United States and heightened concern about Chinese dominance in the supply chain. Overreliance on China for critical material processing creates supply chain bottlenecks and degrades consumer nations’ ability to manage volatility. There are natural areas for cooperation in standardization and R&D to increase diversity and sustainability, such as recycling and new methods for extraction. Developing new international sources for minerals is another potential area for competition, but these efforts will face competing Chinese investments as well as unfair trade practices. However, there is also tension between efforts to maximize incentives for domestic production and the drive to build a common battery ecosystem shaped by higher shared standards. The IRA has heightened U.S. investments but also exacerbated the conflict. Effectively and flexibly managing this tension is critical for both nations to benefit from one another’s expertise, market share, and common goals in being leading producers to help the world achieve green technology transition.
Biotechnology and Public Health

Biotechnology is a field defined by the methods used to experiment and create new living tools for society. These methods include collection, sequencing, storage, synthesis, discovery, editing, growth, and conversion, and the products generated from these processes can include foods and biomarkers, organs and vaccines, synthetic materials, and energy sources like ethanol. In responding to Covid-19, the United States and the Republic of Korea were leaders in rapidly generating vaccines and diagnostic systems. Amid record investments in public health by the U.S. and ROK governments, biotechnology and biosecurity are clearly on the minds of policymakers.

The 2022 CSIS-CHEY expert workshop focused on biotechnology and public health and the role the bioeconomy may play in the future U.S.-ROK relationship. The global supply chain was an immediate concern for participants, as was the future of responsible innovation. Managing the global supply chain for biotechnology is a complex, inherently multinational task. Dr. Kristin DeBord, then acting director of the Office of Strategy, Policy, and Planning and Requirements at the Health and Human Services Office of the Assistant Secretary for Preparedness and Response (HHS/ASPR), observed that vaccines, therapeutics, and public health equipment and supplies more broadly are perhaps the most urgent issue for policymakers, as geopolitical instability and shocks to the global supply chain threaten to undermine global access. Dr. DeBord observed that the government needs solutions to ensure that “drugs [are] available to us when we need them most, especially at a time where some things come all from one country, one location.” Stockpiling and expanded production using biological processes is part of the solution, and her department
is developing a tiered list of essential medicines to aid in prioritizing these efforts, with the aid of outside experts.50

**Vaccines, therapeutics, and public health equipment and supplies more broadly are perhaps the most urgent issue for policymakers, as geopolitical instability and shocks to the global supply chain threaten to undermine global access.**

Dr. Gerald Epstein, a distinguished fellow at the National Defense University, observed that the federal government has a unique visibility into the supply networks that feed the bioeconomy. The bioeconomy is a vast network of industries that expand beyond traditional public health fields, and it includes industries like agricultural biotechnology and bioproduction.51 The Food and Drug Administration as well as the Commerce Department’s Office of Technology Evaluation have the ability to access proprietary data in order to take snapshot assessments of the entirety of the therapeutics supply chain. The ROK Food and Drug Administration also requires disclosure of the origin of ingredients at both product approval and sale. Dr. Epstein reported that for pharmaceutical products, the United States’ top suppliers were Italy, India, Germany, China, and France, with China focused on medical devices and precursors. While having the ability to monitor global supply chain information is a helpful tool for government, there are still real limits to visibility; in particular, Dr. Epstein noted the challenges “in trying to understand resilience and the foreign dependencies and supply chain interconnections,” as those relationships evolve while also making the data accessible to the public.52 Information also does not inherently provide solutions to the global commons problem that is at the heart of the therapeutics market.53 U.S.-ROK cooperation could help bring stability to the therapeutics market in both countries. However, the Republic of Korea only has 10 FDA-regulated pharmaceutical manufacturing facilities, in contrast to China, which hosts 292, and India, which hosts 797.54

While stewardship of the global supply chain is important to managing the current market environment, the U.S. and ROK panelists were also encouraged by the potential for innovation in the bioeconomy. Professor Lee Sang Yup, vice president for research from the Korea Advanced Institute of Science and Technology, heralded the promise of advanced biomanufacturing capabilities. These technologies are important for two reasons. First, bioengineering technologies can open the possibilities for new therapeutics, materials, and manufacturing processes that can advance the current technological limits while reducing environmental impact.55 In addition to biomedical products, these manufactured products can include plastics, chemical gasoline, and core ingredients to alternative meat. Second, bioengineering and manufacturing may be unconstrained by some of the traditional geographic and infrastructure requirements that have constrained manufacturing. Dr. Epstein did note, however, that bioengineering can still demand resources that are geographically limited, thereby requiring companies and nations to engage in the global supply chain.
Advancements in technology will still require global engagement and partnerships to be brought to fruition. Biotechnology, and more broadly bioengineering, is far less capital-intensive of an industry than semiconductors or large-scale battery production. Dr. Megan Frisk, director for biotech risk and biological weapon nonproliferation and member of the National Security Council, noted that “as more and more countries invest in bio as a core part of their economies—that means more laboratories, that means more and more people working with bio—there is then a commensurate increase in risk” even as it also creates more opportunities for innovation. Dr. Frisk noted the absence of a “general standard or kind of an agreed upon bar or norm to reach in biosecurity,” but the United States and the Republic of Korea have an opportunity to work together on shared standards and priorities to help bring lifesaving therapeutics and revolutionary technologies to market by leveraging both nations’ substantial capacity for innovation. It will also become increasingly important to guarantee that biotechnology is developed safely. As Dr. Epstein noted, “biological organisms are tremendous sources of data,” and cybersecurity will be critical for patient privacy reasons and throughout biotechnology development. Resilient cyber networks and shared safety standards are important components of responsible stewardship of the bioeconomy and crucial to managing the risks from illicit actors and potential proliferators.

The 2023 CSIS-CHEY Seoul conference focused on the rapidly expanding biotechnology industry and the array of public health crises that challenge multilateral efforts. The Honorable Dr. Chris Fall, vice president for applied sciences at MITRE, observed that active horizontal expansion is taking place in today’s bio industry as major multinational players are aggressively acquiring smaller firms. Consequently, the design, production, and assembly of biological components are taking place in increasingly concentrated regional clusters by highly specialized players. While such a trend closely follows the growth track of the global auto industry, the bio industry differs in that there is little to no barrier to entry. This implies that a bad actor can easily take advantage of a biotechnology to jeopardize its integrity and safety. Therefore, the global biotech community needs robust standards and norms as well as stringent enforcement mechanisms.

On the other hand, maintaining a healthy ecosystem of innovation and competition is also critical for this industry. Dr. John Newsam, chief executive of Tioga Research, stressed four factors that impact innovation in the biotech sector. First, disruptions to the global supply chain create uncertainties and impact R&D timelines. Such disruptions incur massive financial damage, especially for globally operating firms. Consequently, biotech firms today are forced to deal with increased costs and footprints associated with finding multiple sources and maintaining a larger inventory. Second, government actions that encourage employment, protect intellectual property rights, and expedite technology transfer can have a major impact on small early-phase ventures. Third, funding incentives encourage cross-border collaboration and new business models that incorporate new metrics such as greenhouse gas reduction or capital development. Fourth, access to a foreign market is important but difficult for businesses. Dr. Newsam suggested that the United States and the Republic of Korea can work together to promote peer-to-peer relations by easing accessibility to each other’s markets through government, industry associations, and sister companies or cities.
The outbreak of the Covid-19 pandemic has shown the importance of rapid, accurate, and readily available testing. Dr. Gigi Gronvall, a senior scholar and associate professor at the Johns Hopkins Bloomberg School of Public Health, anticipated the demand for testing and diagnosis to continuously grow in the coming years. She also stressed that standard setting is crucial to ensuring safe use in the commercial implementation stage of biotech development. For example, she observed that there are concerns regarding gene synthesis, a commonly used biological tool with the potential for safety issues when used without proper guardrails. She argued that while governments can initiate efforts to develop a legal framework for screening and regulating its use, experts must take an active part in the process. On a similar note, there need to be pathways for more biotech experts to enter government roles and promote biotech knowledge among government leaders.

More specifically, a system-level understanding is required to address multiple issues across the wide spectrum of the biotech industry. Professor Lee Sang Yup argued that developing an industrial-level biotech product (e.g., a microbial strain) poses various challenges along the supply chain, which spans from raw materials, strain development (upstream), and fermentation (midstream) to separation and purification (downstream). Over the past 30 years, engineering biology has generated many technologies with profound implications, such as genome sequencing and gene synthesis. Recently, the introduction of machine learning is streamlining the integration of these technologies across multiple sectors. As a result, a wide variety of chemicals can be commercially produced, which make up today’s nearly $4.8 trillion market. These bio-based engineering approaches, when combined with traditional chemical synthesis, can produce polymers, super-polymers, and natural compounds.

Following the statements by Dr. Gronvall, Dr. Jerome Kim, director general at the International Vaccine Institute, continued the discourse on pandemic preparedness and shared three major lessons learned from the later stages of the Covid-19 pandemic. First, it has shown that maintaining sufficient funding that can be dispensed during emergencies is critical. On top of that, there must be an incentive to fund broader research efforts to understand diseases at both the molecular and clinical levels. He argued that knowledge accumulated in such a way is critical in setting goals and game plans for subsequent drug development. Second, regulating agencies need to ensure efficient and safe procedures for approving clinical use of drugs. During the pandemic, drug-related agencies came under enormous pressure to speed up their clinical approval but faced criticism for late-occurring adverse events following immunization. Providing regulating authorities with regulatory documents (e.g., drug master files, draft protocols) in advance will help increase their efficiency. It is important for both drug developers and regulating authorities to agree on a clear set of criteria for evaluating vaccines. Third, while Dr. Kim recognized the salient role played by vaccine development platforms (e.g., viral vector, DNA, RNA) in accelerating vaccine availability during the pandemic, he also warned against overreliance, which may result in inflexibility that hinders working with different regulators, funding sources, and players.

Managing and cultivating the bioeconomy will require multiple lines of effort from policymakers on both sides of the Pacific. First, governments will have to work together on understanding supply
chains and the flow of information writ large. Times of scarcity have demonstrated the risks of interdependence as states seek to supply their own citizens first. Thoughtful policy from a close network of partners and allies is necessary to ensure adequate trusted manufacturing that is flexible enough to supply nations in times of need. There needs to be multilateral collaboration through multiple channels to speed up the flow of expert findings and public health data across borders. These collaborative efforts must take place not only across borders, but also across disciplines.

Second, governments should also develop norms and standards for biosecurity and cybersecurity that manage risks, risks that grow as the sector expands in fields like gene synthesis and bioengineering. There needs to be a robust inspection mechanism that international partners can agree on to ensure control over the quality and safety of bio-related products. In an industry that is heavily dominated by large multinational firms but has low barriers to entry by bad actors, how such inspection mechanisms can be effectively negotiated and implemented remains a question. In a related challenge, both the government and the scientific community must give thought to addressing the negative impact of misinformation. Participants noted that there is a worrisome level of misunderstanding—not only between the scientific community and the public, but also among scientists and health professionals—regarding the effectiveness of vaccination.

Third, governments will have to work to support future innovations in fields such as synthetic biology and metabolic engineering that will not only help build flexibility into a rigid supply chain but also harness the life-changing potential of breakthroughs in research. Machine learning is easing the integration of technologies across sectors. However, companies may still need help to access foreign markets and adopt hybrid venture models. Governments should also maintain a steady rate of funding for pandemic preparations, including testing. Innovation will also be necessary in regulatory approval processes that increase clarity and allow for efficiencies while still maintaining high standards of safety. If governments can simultaneously manage these parallel policy problems, then a more secure and robust bioeconomy can thrive while making strides in global health security.
Supply Chains, Geopolitical Risk, and Technology Cooperation

The 2023 CSIS-CHEY Seoul conference included two cross-cutting sessions that aimed to achieve two objectives: first, to examine the complex interplay between geopolitical risks and supply chains, especially involving the three sets of technologies central to this report; and second, to explore possible avenues of technology cooperation that can help countries minimize risks arising from supply chain issues. As noted by Hon. Fall, Covid-19 has taught everyone to pay extraordinary attention to all aspects of supply chains, ranging from material sources and manufacturing to transportation and local as well as regional distribution. Notably, countries have begun to view supply chains as an important component of national strategic competition. As such, paying great attention to various evolving elements that threaten the state of supply chains, especially in the geopolitical context, has become more critical than ever before.

Hon. Fall added that the future of these three technologies remains remarkably unsettled, leaving them prone to disruptions based on future technology developments. For example, the potential for disruption in the battery industry is great given that current batteries are not designed with a mind toward recycling. The recyclability of batteries could potentially bring new players into the game and impact the delicate balance of offshoring, friend-shoring, and onshoring policies. Complementing the assessment of Professor Kang that batteries are a winner-takes-all industry, Hon. Fall stressed that the only answer to surviving this competition is to “out-innovate, out-compete, and out-spend.” He also underscored the importance of collaborating and establishing technology standards and norms with allies and partners such as the Republic of Korea. The same can be said about the semiconductor industry.
According to Dr. Cynthia Cook, a CSIS senior fellow and director of the Defense-Industrial Initiatives Group, the concept of weaponized interdependence—the idea that nations controlling economic nodes can weaponize other countries’ dependence on them as an instrument of power—is particularly relevant when discussing Chinese strategy to tip the supply chain balance to its favor. Industrial policy has allowed China to be in a position of power or control over economic nodes in a number of technology sectors, including the three key technologies addressed in this report. According to the Institute of Energy Research, China in 2019 accounted for 80 percent of the world’s total outputs of raw battery materials such as rare earths, lithium, cobalt, graphite, and many more. In fact, China produces more cast products than the next nine countries combined. For the U.S. DoD, China’s dominance in these fields and the dual nature of these technologies have severe national defense implications, especially since it utilizes casting products for many of its defense systems. For the United States, one way of addressing this overreliance would be to onshore key technology components. The CHIPS and Science Act can be interpreted as an extension of such policy. According to Dr. Cook, however, onshoring will be expensive, difficult, and more importantly, cause the United States to cut itself off from some of the most advanced technologies the world has to offer. Instead, a different strategy would be to work with allies and partners to understand each other’s strengths and weaknesses so that they can better respond to the risks of weaponized interdependence and deter negative behaviors on the part of potential adversaries.

At the same time, the United States’s recent enactment of the CHIPS and Science Act and the Inflation Reduction Act (IRA) has placed considerable economic burden on the private sectors of its key allies, according to Dr. Yeon Wonho, chair of the Economic Task Force at the Korea Institute for International Economic Policy. The lack of coherence and the protectionist nature of these U.S. policies have led to growing confusion, frustration, and hesitation among ROK companies to invest more in the United States. With the 2016 THAAD incident fresh in their minds, ROK companies also have to worry about Chinese economic retaliation and secondary sanctions. For this very reason, close consultation and collaboration between the United States and its allies are more critical than ever to building resilient supply chains and coping with potential disruptions. Regarding the potential for collaboration between ROK companies and the U.S. government in terms of sharing supply chain information, Dr. Yeon remained skeptical that such cooperation could materialize, especially since the Republic of Korea’s approach to supply chains can be characterized as being ex post in nature rather than ex ante. In other words, unless significant disruptions to supply chains force the ROK government and private sector to share sensitive information with the United States, the country is unlikely to engage preemptively with the United States in such a capacity.

Throughout the 2023 CSIS-CHEY Seoul conference, speakers discussed specific and concrete ways the United States and the Republic of Korea can enhance cooperation and collaboration in the technology realm. According to Dr. Igor Mikolic-Torreira, director of analysis at Georgetown’s Center for Security and Emerging Technology, one area of immense potential for collaboration between the two countries is artificial intelligence. The Republic of Korea’s vibrant AI research community (on a per capita basis, it ranks number one in the world in terms of AI-related patents, and the country spends 5 percent of its GDP on R&D), its global leadership in cutting-edge semiconductor production, and government policies that spur innovation make the Republic of
Korea an ideal partner for the United States. Dr. Mikolic-Torreira identified four key areas where the two allies could engage in technology cooperation. The first and most natural starting point of this collaboration is joint research between experts and students in the two nations. The second could be coming up with AI-related—and, more broadly, technology-related—standards and norms. The Republic of Korea’s leading role in deploying 5G technology proves that it is already at the forefront of standard setting. The third would be to promote cross-country investments in emerging technology. Lastly, the Republic of Korea and the United States could work together to address a common difficulty in producing enough STEM graduates and AI talents.

Mr. Greg Sanders, a fellow and deputy director at CSIS, observed that the common theme across all sessions was the critical importance of supply chain diversity. However, diversifying fragile supply chains will require companies and governments to identify their level of fragility, which is often complicated by a lack of insight into lower tiers of supply chains. One area of cooperation that can lead to greater supply chain diversity is investing in scientific innovations that can generate opportunities for new sources of supply. Partners can improve or come up with shared standards and norms that help allies leverage their market power and avoid a race to the bottom. For semiconductors, building export investment control regimes that could mitigate impacts on ROK and U.S. businesses is a key point for cooperation. In terms of batteries, Mr. Sanders agreed with many of the other speakers that recycling could be an area where both the United States and Korea could become more cost-competitive. Norms and standards in biotechnology are critical, especially since the barriers to entry are virtually low to nonexistent and there is great potential for the sector to expand.

Diversifying fragile supply chains will require companies and governments to identify their level of fragility, which is often complicated by a lack of insight into lower tiers of supply chains. One area of cooperation that can lead to greater supply chain diversity is investing in scientific innovations that can generate opportunities for new sources of supply.

Throughout their long history, the Republic of Korea and the United States have made great strides in collaborating on critical technologies, according to Professor Nam Ki Tae. For example, the idea of the lithium-ion battery was first introduced by U.S. professors in 1977, but its global commercialization was made possible by ROK companies such as SK and LG. Another example can be found in quantum dot televisions, which were commercialized by Samsung Electronics but whose patent is owned by UC Berkeley and MIT. In this vein, Professor Nam stressed the importance of supporting people-to-people exchanges and fostering an ecosystem where allies can develop and share new technologies.
Technology cooperation in the military context was addressed by Dr. Lee Chung Min, senior fellow at the Carnegie Endowment for International Peace, who projected four major drivers that will necessitate such cooperation: the intensification of the U.S.-China military competition, a growing arms race in Northeast Asia, revolution in military affairs caused by modern dual technologies, and military manpower shortages. Dr. Lee observed that the United States is no longer the dominant power on global defense supply chains, especially with the rise of China and its commitments to power projection capabilities as well as to robust defense systems. In Northeast Asia, such growing military power by China—especially in its maritime assets—and North Korea’s growing nuclear threat have become sources of major security concern for the Republic of Korea. Dr. Lee added that space and intelligence, surveillance, and reconnaissance (ISR) is an area where the Republic of Korea and the United States have ample room for collaboration and cooperation, both in commercial and military applications. AI-driven wargaming and early warning systems to detect North Korea’s nuclear-powered submarines and nuclear-tipped submarine-launched ballistic missiles are two areas in which the allies could cooperate to the benefit of both. Dr. Lee stressed, however, that any collaboration or cooperation between the United States and the Republic of Korea must be carried out as “equal partners.” For example, in order to play a larger strategic role supporting U.S. missions, the Republic of Korea should be able to have submarines with greater range. Giving Australians preferential treatment vis-à-vis AUKUS and not allowing the Republic of Korea to do the same would be a mistake.
Conclusion

For all three technologies covered in the 2022 CSIS-CHEY expert workshops and the 2023 conference, the geopolitical implications extend beyond the industries in question. Semiconductors are a cornerstone of a range of advanced military capabilities and are central to evolving U.S. export controls on China. High-capacity batteries and electric vehicles will be pivotal in the response to climate change. Advances in biotechnology will help improve the health of the global population and will be vital for responding to any future pandemics. Robust U.S.-ROK cooperation in semiconductors, in electric vehicle batteries and strategic and critical materials, and in biotechnology and public health technologies will help reduce both nations’ geopolitical risks and address supply chain challenges.

As supply chains face risks of fragility, there are responses that could increase the diversity of supply. Scientific innovation offers the opportunity for new sources and allows new entrants or formerly uneconomical approaches to add resilience to the supply chain. Improved shared standards allow for countries with shared values to better leverage their market power and avoid races to the bottom. In the EV battery industry, a combination of standardization and innovation could allow consuming countries to recycle batteries at the end of their life, which could help decrease their dependence on foreign sources. Cutting-edge biotechnology could make traditionally environmentally destructive processes in other sectors of the economy safe enough to meet environmental and labor standards in highly developed nations, which could allow for the possibility of onshoring. Finally, automation holds promise across all sectors to make goods safely at globally competitive costs, allowing manufacturing to have a resurgence outside of traditionally inexpensive labor markets.
As companies seek to meet the ever-growing global demand for semiconductors, one of the greatest limiting factors for the supply chain is human capital. On both sides of the Pacific, vast amounts of private and government capital have spurred the development of new factories and research; however, training and retaining world-class talent is difficult. Corporate integration and immigration laws that allow for the freer flow of workers—not just between the United States and the Republic of Korea, but also from third countries like India—could help alleviate the labor market strain in the short term. Over the next several decades, both countries may need to reform policies to allow for increased immigration of skilled workers and make sizeable investments in education to train a future workforce that can meet global demand.

Securing access to critical materials will require a mix of multinational steps as well as progress on reducing costs to challenge China’s dominance in the global market, which derives from a long-term investment in rare earths processing. The United States and the Republic of Korea could partner and make targeted investments in countries with growing rare earth industries, such as Indonesia. Additionally, standards in highly developed nations could be applied to rare earths that are being imported, which could help develop cost-competitive alternatives. However, major U.S. subsidies in the IRA are targeted at building up domestic industry rather than empowering cross-national standards. Acting unilaterally, it will be difficult for high-cost producers with more stringent environmental policies to become cost-competitive with China when marketing to the rapidly growing global market. Innovation in the processing and refining of rare earths offers a promising approach. Nonetheless, supply chain diversification rather than a total exclusion of China is likely the most realistic path forward. This reality heightens the importance of both responding to efforts by China to compete in countries that provide new sources of materials as well as countering Chinese efforts to undermine international production efforts.

The biotechnology industry has wide-reaching potential for impactful innovation and cooperation. There are, however, risks associated with the development of advanced biotechnologies, and countries on the cutting edge of research must work together to develop shared norms. This is in large part because of the low capital costs and increased accessibility of key technologies in the biotech industry, meaning that relatively small players could present proliferation and misuse risks. The United States and the Republic of Korea already cooperate across the biotechnology and biosecurity space. This close cooperation is enabled, in part, by the exceptional supply chain visibility that both governments have through their safety regulators. That cooperation was strained by responses to the Covid-19 pandemic, including export restrictions and competition to snatch up scarce goods, which shows that there are enduring limits to cooperation. However, further investment and cooperation could further the biodefense goals of both nations and leverage a growing industry to address future biosecurity threats.

The industry where cooperation is most urgent—but will have to be managed with great care—is the semiconductor space. Because of the dual-use nature of all semiconductors and semiconductor-related equipment, sanctions intended to limit China’s military capabilities have a potential to hurt businesses in the United States and the Republic of Korea. ROK businesses are especially exposed to the Chinese market, due both to having manufacturing facilities in mainland China and to the
market that China provides. The United States and the Republic of Korea have been able to reach an accommodation, but there remains considerable risk in setting the scopes of sanctions such that they achieve results while minimizing the considerable business risk to a U.S. treaty ally. While providing investment incentives in the United States could be a partial solution, those subsidies are designed to favor U.S. companies, and likely they are not of equal value to ROK firms as access to the Chinese market. Quality assurance standards that give conforming companies privileged access to sensitive sectors such as finance, medicine, and defense might help address business risks.

As the United States and the Republic of Korea work to build more resilient economies in a time where geopolitical crises and conflict can disrupt supply chains, close and enduring cooperation is essential. In the near term, the United States and the Republic of Korea should work toward better understanding their supply chains for critical goods. In some sectors, like pharmaceuticals, policymakers have a strong starting point, but for the semiconductor industry a thorough understanding could take years to develop. Understanding supply chains is important due to the subtle nature of many risks and the risks of unintended consequences. The conference keynote speeches covered important bilateral and multilateral initiatives related to this challenge, including the Minerals Security Partnership, the Supply Chain Commercial Dialogue with the United States, and the Indo-Pacific Economic Framework for Prosperity. On economic security grounds, a better understanding of supply chains can also help determine whether interventions are worthwhile and aid their efficacy. For export controls, understanding also allows for narrower targeting and aids in anticipating and alerting industry of potential costs, but the challenges remaining are daunting. Both governments would benefit from investing independently as well as cooperatively to enhance their understanding of, and ability to shape, supply chains. Responding to challenges ex ante will likely prove inadequate in this highly dynamic environment.

The United States and the Republic of Korea sometimes find themselves economically competing, and while this is certainly expected between two major economies, governments must be careful that competition does not undermine strategic cooperation. Scientific innovation may hold part of the solution, as innovation across industries can add to the diversity of supply chains. Innovation and industrial policy will not solve all the problems facing the U.S.-ROK alliance; nonetheless, it can fulfill the spirit of an alliance borne of common sacrifice, a shared history, and a deep and abiding commitment to democracy and the rule of law. “Katchi Kapshida,” or “we go together” in Korean, is both the slogan of the U.S-ROK alliance and a call for partnership on key industrial issues.
Endnotes


2 The opening remarks to this conference and two of the sessions are available for viewing online and in transcript form at https://www.csis.org/events/csis-chey-conference-cooperation-scientific-innovation-supply-chains-and-geopolitical-risk. The semiconductor session was conducted on a non-attribution basis. President Yoon and President Biden identified “leading-edge semiconductors, eco-friendly EV batteries, Artificial Intelligence, quantum technology, biotechnology, biomanufacturing, and autonomous robotics” as emerging and critical technologies. This agreement built on similar pledges between President Biden and then president Moon to “work in close concert” on technologies “from semiconductors to EV batteries, pharmaceuticals to other cutting-edge manufacturing technology sectors.” The White House, “Remarks by President Biden and H.E. Moon Jae-in, President of the Republic of Korea at Press Conference,” Press release, May 21, 2021, https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/05/21/remarks-by-president-biden-and-h-e-moon-jae-in-president-of-the-republic-of-korea-at-press-conference/.


“Biomanufacturing and Synthetic Biology,” Centers for Disease Control and Prevention, The National


21 China is currently not able to produce cutting-edge chips. China does, however, play an important role in manufacturing precursor components and chemicals used in the production of advanced chips.


24 Ibid.

25 Participants generally agreed that investments in education would pay off in 10 to 20 years and were essential, especially for growing the U.S. manufacturing capacity.


While the global commons framework may not be as applicable in times with little supply chain stress, in times of scarcity the therapeutics market can exhibit many of the behaviors seen in global commons, especially as demand begins to outstrip supply. While there are regional, regulatory, and logistics problems that may exacerbate scarcity, supply is relatively inelastic in the pharmaceutical industry.

“Generic Drug Facilities, Sites and Organization Lists,” FDA, https://www.fda.gov/industry/generic-drug-user-fee-amendments/generic-drug-facilities-sites-and-organization-lists. While there are relatively few FDA regulated facilities in the Republic of Korea, the industry as a whole is substantial. A potential pathway for growth would be for U.S. regulators to encourage the entrance of ROK companies in the U.S. market. For discussion on the ROK pharmaceutical industry, see “Overview of Korean Pharmaceutical Industry,” KDRA (Korea Drug Research Association), http://www.kdra.or.kr/english/03web01.php.


Some have argued that the low barrier to entry in the biotechnology space creates a potentially dangerous environment where adversaries seeking to cause harm or degrade the rules-based international order could relatively easily make or alter pathogens to harm living organisms. Managing this risk is a critical challenge for policymakers around the world. For further discussion, see Elsa Tsioumani, *Biosafety: Ensuring the Safe Use of Modern Biotechnologies* (Winnipeg, Canada: International Institute for Sustainable Development, 2021), https://www.iisd.org/articles/deep-dive/biosafety-ensuring-safe-use-modern-biotechnologies.


See Hunt and Zwetsloot, The Chipmakers.
