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Broadening the Alliance: New Frontiers in US-South Korea Cooperation

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Preface

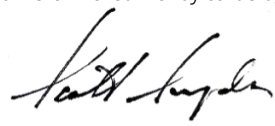
The Korea Economic Institute (KEI) is pleased to issue Vol. 2, Issue 2 of its new flagship journal, Korea Policy. Our new journal carries forward the objective and spirit of KEI's previous publications, the Academic Paper Series' (APS) On Korea publication, and the Joint US-Korea Academic Studies publication. Like our previous publications, Korea Policy identifies and explores the array of security, economic and political issues and policy trends related to Korea and the US-Korea alliance. The journal offers academically rigorous and policy-relevant research.

Korea Policy papers are written by academic scholars and policy experts from the United States, South Korea, and around the globe. The objective is to provide opportunities for recognized specialists and new voices to present fresh research and innovative thinking on Korea, the region, and related international issues. Each issue covers a broad, unifying theme and is arranged into two sections of articles. Before publication, the articles in the first section are presented as working papers at hybrid panel events in partnership with universities around the country. The articles in the second section are presented as part of our Korea Policy series at KEI's Washington, DC office.

The papers in Vol. 2, Issue 2 exemplify the breadth and depth of policy issues relevant to Korea and the US-Korea alliance. They are original pieces written exclusively for this issue over the last six months. KEI distributes the final publication to individuals in governments, the private sector, policy institutes, and educational communities around the world, and features the digital publication on the KEI website for the broader public.

Contributions in this issue fall under the theme: Broadening the Alliance: New Frontiers in US-South Korea Cooperation. The first section explores US-South Korea cooperation in critical and emerging technologies, including in the areas of artificial intelligence and quantum computing, semiconductor supply chains and technology, clean energy technology, and biotechnology and biomanufacturing. Those papers were presented at UT Austin in partnership with Clements-Strauss Aspolicy Program. The second section examines new and evolving areas of alliance cooperation, specifically in space, cyber, and defense industrial cooperation, including South Korea's potential role in AUKUS Pillar Two.

For over 40 years, KEI has produced objective and informative analyses and highlighted important policy research on Korea. I hope you find this volume of Korea Policy to be a useful contribution.



Scott Snyder
President and CEO
Korea Economic Institute of America
May 2024

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About KEI

The Korea Economic Institute of America (KEI) is a US policy institute and public outreach organization dedicated to helping Americans understand the breadth and importance of the relationship with the Republic of Korea. Through our publications, social media, programs, and public events, KEI seeks to advance scholarship and understanding of Korea in ways that will inform policy makers and the American public of the security, economic, and political implications of our connections to the Korean Peninsula.

For more than 40 years, KEI has been promoting dialogue and understanding between the United States and the Republic of Korea through insightful and in-depth conversation and analysis. KEI draws on the expertise of its resident staff; provides a platform on which leading writers, thinkers and commentators from the United States, Korea, and third countries can share their research and opinions; promotes scholarship by commissioning and publishing original articles; and hosts public and off-the-record conversations among policy makers and opinion leaders.

KEI maintains connections with partner think tanks and with the academic community throughout the United States. Our "Korea Policy Series," "New Academic Symposium," and "University Programs" ensure that the best in research and scholarship on Korea are shared among experts and are available to students and the general public.

Although most of our activities take place at our Washington, DC headquarters, KEI is committed to going beyond the Beltway—engaging with communities across the United States to discuss how the two countries are navigating the shared challenges of our time. Programs such as the "Future of Korea," held in partnership with the World Affairs Councils of America, and the "Ambassadors' Dialogue" bring Korean and American diplomats to venues across the country to discuss current events and the overall US-ROK relationship.

In an increasingly digital age, KEI is committed to expanding our virtual engagement. Through our blog, "The Peninsula;" video series, "Korea in Five"; and livestreamed and recorded events on a wide variety of Korea—and transpacific issues. We are able to connect with people from across the globe who are interested in Korea.

The US partnership with the Republic of Korea is built on enduring values and interests, but it cannot be taken for granted. The bonds between the two nations are maintained through the efforts of diplomats, service members, scholars, students, artists, and everyday Americans and Koreans. KEI is dedicated to contributing to this undertaking—helping to ensure a safer and more prosperous world.

Section 1

Critical & Emerging Technology Cooperation

From Security Alliance to Comprehensive Technology-Centered Partnership

By Scott Snyder

The Joe Biden and Yoon Suk-yeol administrations have embraced the expansion of economic cooperation within the alliance between the United States and South Korea, or the Republic of Korea (ROK), leading to an unprecedented strengthening of the relationship. The development of the economic dimension of the relationship has included significant inward Korean investment into the United States, which has reached upwards of USD 140 billion during the Biden administration, mainly in the areas of chips, batteries, and clean technology.[1] These investment flows, stimulated by the US commitment to promote its clean energy transition under the Inflation Reduction Act (IRA), have supported the expansion of the US-ROK alliance from a security-centered alliance in which the one-way US commitment to defend South Korea from external aggression was the primary alliance mission to a mutual relationship in which South Korean investment in the United States creates US jobs and enables South Korea's integration into US markets alongside longstanding US security commitments.

The emergence of South Korea as a valued technology partner of the United States is powered not only by the Korean desire to expand its exposure to economic opportunities in the United States but also by the convergence in views between the Biden and Yoon administrations regarding the securitization of technology. This development is a direct response to the perceived threat posed by China's aspirations for global economic leadership and its threats to weaponize economic interdependence for its own benefit. Shared concerns about China's rising influence and expanded security concerns around China's efforts to achieve technological leadership have fueled US-South Korean efforts to strengthen bureaucratic coordination, integration, and alignment of efforts among like-minded countries in the technology sphere.[2] As part of its strategy of revitalizing alliances with like-minded countries to gird for technological competition with China, the Biden administration has enlisted allies to work together to both strengthen economic security and supply chain resiliency and deepen the integration of research and development (R&D) efforts to develop the critical and emerging technologies (CETs) of the future. South Korea has willingly joined those efforts as part of its own embrace of the global comprehensive strategic alliance with the United States and as an important element of its own aspirations to become a global pivotal state.[3]

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Thus, the Yoon administration's embrace of a foreign policy framework that prioritizes expanded alliance cooperation with the United States has generated an *era of institutionalization* in the US-ROK alliance, characterized by a broadening and deepening of governmental consultative efforts to align regulatory incentives, coordinate export controls to promote supply chain resiliency, and deepen coordination in response to emerging threats and chokepoints in alliance cooperation.

The broadening and deepening of the alliance was manifest during President Yoon's state visit to Washington, DC, in April 2023, when at least a dozen new institutionalized mechanisms were announced through which the US and South Korean governments are aligning aspects of economic and trade policy and functional cooperation in space, cyber, and commercial policy coordination.[4] Additionally, the US and South Korean national security advisors announced ambitious plans to upgrade technology cooperation "in strategic technologies that will be of greatest consequence to bolstering economic prosperity; enhancing resilience against supply chain disruptions; and securing competitive advantages for our two nations and like-minded partners."[5] The areas selected for cooperation through the inauguration of a US-ROK Next Generation CET Dialogue include semiconductor supply chains and technology; biotechnology; batteries and clean energy technology; quantum science and technology; digital connectivity; and artificial intelligence (AI).[6] These efforts to develop an integrated platform for research and development of upstream technologies signify the expansion of a partnership among like-minded countries intended to preserve technological superiority over common adversaries.

Purposes and Prospects for Alliance Coordination on Critical and Emerging Technologies

This issue of *Korea Policy* examines the commitments of the two governments to cooperate on the development of critical and emerging technologies. There is no question that the formal identification of these areas and the designation of these pathways for cooperation have opened the way for deeper government-to-government coordination and have provided guidance for mobilizing cooperation that will extend to non-governmental educational and private sector actors across many different fields. The most ambitious and complicated component of this effort that potentially requires the greatest long-term commitment involves the building out of government-led and private-sector-supported frameworks for joint work on critical and emerging technologies in a wide range of areas.

Evaluating Efforts to Expand Cooperation on Critical and Emerging Technologies

The papers in the first part of this issue analyze the development of the semiconductor supply chain, as well as R&D in emerging technologies such as AI and quantum mechanics, cooperation on new technologies in the context of efforts to address climate change, and efforts to collaborate more deeply on joint R&D in biotechnology.

Soyoung Kwon of George Mason University evaluates the emergence of US-South Korean coordination on semiconductor supply chains, including the Supply Chain and Commercial Dialogue within the alliance and the Minerals Security Partnership (MSP) more broadly, describing how rising techno-nationalism has led to the prioritization for decoupling from China and resiliency as alliance priorities. Kwon notes that differing policy and business interests and levels of exposure to the Chinese market may serve as an inhibition or even a source of friction between the United States and South Korea while both countries have deepened cooperation to promote resiliency of semiconductor supply chains based on their mutual interests and expectations for expanded mutual prosperity. Kwon recommends further dialogue to deepen semiconductor supply chain cooperation, public-private partnerships, institutional development within the semiconductor supply chain ecosystem, and coordination on export controls and investment screening mechanisms to promote supply chain resiliency.

Sanghyun Han evaluates the progress and development of US-South Korea cooperation in the development of AI and quantum technologies. Han concludes that the United States and South Korea are well-suited to enhance cooperation on AI, with a primary initial focus on government-level coordination among agencies and national laboratories to promote a common approach to standardization and government-led tie-ups with the private sector and critical educational institutions to promote joint research. However, due to South Korea's more limited capabilities in quantum technologies, cooperation in this area is limited primarily to the promotion of long-term research collaboration and the development of public-private partnerships.

Elan Sykes explains how addressing climate change has led to US-South Korea public-private collaboration on a variety of solutions, including battery supply chains, clean hydrogen, and the development of the civilian nuclear power sector. Sykes describes, in concrete terms, how governmental coordination to support R&D and the provision of incentives for market development can effectively stimulate the private sector to provide solutions and drive the sector's expansion by pursuing clean energy pragmatism in pursuit of the adaptation to low carbon emission technologies.

Finally, Zeena Nisar explores US-South Korea cooperation in the spheres of biotechnology and biomanufacturing. As with other sectors, the desire to enhance resiliency to reduce or eliminate dependency on China has been an active motive behind biotechnology-related cooperation between the United States and South Korea, as well as technological cooperation with India. Nisar outlines the alignment of the research and innovation ecosystems of both countries in pharmaceuticals, medical devices, and biomanufacturing through the promotion of research tie-ups between research institutions and the facilitation of biotech investments in the pharmaceutical sector, addressing supply chain vulnerabilities in active pharmaceutical ingredients (API) and contract development and manufacturing organization (CDMO). Nisar also describes US-South Korea cooperation on agricultural biotechnology, including the alignment of regulatory systems and standards.

Evaluating US-South Korean Defense Cooperation in Space, Cyber, and the Defense Industrial Base

The expansion of technological cooperation, in turn, has implications for future-oriented defense cooperation between the two allies in both emerging and longstanding areas. Such implications include space and cyber cooperation as well as the alignment of industrial bases to support efficient and technologically superior procurement both within the US-ROK alliance and in the context of technology development and defense cooperation with Australia and the United Kingdom under AUKUS. The papers contained in the second part of this issue examine the pathways, opportunities, and constraints that will guide efforts to deepen cooperation across these areas.

Space and cyber, first identified as "frontier" areas for alliance cooperation during the Barack Obama administration in 2015, appear to have gained significant new momentum in recent years. US-South Korea cooperation in these areas has deepened as South Korea has developed new capabilities and as competitors and adversaries have made progress in ways that expand the threats and risks of non-cooperation.

Regarding US-South Korea cooperation in space, Katherine Melbourne and Sam Wilson outline how the development of South Korean capabilities, such as the successful testing of a space-launch vehicle and the launch of a suite of low orbital earth satellites, are enabling South Korea to become an increasingly engaged partner in the space sector. This encompasses cooperation on space exploration and the growth of the commercial space sector. Melbourne and Wilson discuss the ways in which South Korea's latest space development plans have developed, parallels with US space infrastructure and priorities, and

prospects for expanding cooperation in a range of areas, including a proliferated network of payloads; position, navigation and timing (PNT) capabilities; the development of space situational awareness and protection of space assets through environmental warning and forecasting; and joint space exploration.

Primarily in response to North Korea's aggressive deployment of a suite of cyber capabilities for both resource capture and intelligence gathering purposes, Jenny Jun and So Jeong Kim chart the extensive evolution of US-South Korea cooperation in cybersecurity policy and its implementation through cyber policy consultations and senior steering groups, the adoption of bilateral advisories and sanctions against North Korean entities, the conduct of a joint cybersecurity drill, and the establishment of trilateral cybersecurity cooperation dialogues with Japan. The main driver for this activity has been the need to respond to the expansion of North Korea's cybertheft and malware and the country's efforts to secure new platforms for its illicit cyber workforce. Jun and Kim also outline efforts by the United States and South Korea to align their respective deterrence doctrines for adaptation to the cybersecurity domain.

Bo Ram Kwon discusses South Korea's policy approach toward defense industrial cooperation and alignment with the United States in the incorporation of new technologies into the defense industrial base. Kwon discusses the 2023 US National Defense Industrial Strategy as a departure point for analyzing ways in which US efforts to enhance supply chain resilience and strategic alignment with its allies are creating new opportunities for US-South Korea defense cooperation and South Korea's institutional adjustments to take advantage of those new opportunities. Kwon also analyzes the ways in which reliance of defense procurement on commercial technologies and the emergence of China as a threat to military supply chains have influenced both US strategy and the opportunities for US-South Korea defense industrial cooperation. Kwon discusses the development of US-South Korean institutional arrangements, including Security of Supply Arrangements (SOSAs), naval maintenance, repair, and overhaul (MRO), and reciprocal defense procurement arrangements (RDP-A) as ways in which the United States and South Korea are institutionalizing and integrating mechanisms for defense procurement going forward.

Finally, Wade Huntley and Yosep Kim examine prospects for South Korea to engage in technological development under Pillar Two of AUKUS, with a focus on promising areas of cooperation. The paper outlines Korean reactions to the announcement of AUKUS, including mixed responses to the arrangement's ambitious plans for nuclear submarine development and production, considering South Korea's own intermittent debates over whether to develop a

nuclear-powered submarine. Huntley and Kim also review the menu of potential Pillar Two projects and prospects for South Korean cooperation therein, including undersea capabilities, quantum technologies, AI, cyber, hypersonic, and electronic warfare capabilities, as well as the potential for cooperation on innovation and information sharing.

Envisioning and Managing Comprehensive Integration for the Long Term

The task of simply enumerating the new dimensions of coordination between the US and South Korean governments underscores that there is now an extensive array of inter-governmental consultations undergirding the relationship that itself requires centralized coordination via the respective national security offices of the two presidents and that reflects unprecedented depth, complexity, and levels of integration.[7] The expansion of the scope of the alliance to include technologically driven economic competition as a critical dimension of its core mission is binding the two allies together in new ways, but it is also generating new challenges, complexities, and risks.

For instance, the US effort to reshore, friendshore, and ally-shore global supply chains across a wide range of sectors requires the establishment of government-led public-private partnerships. These partnerships are assumed to embrace the same strategic objective of countering the threat from Chinese aspirations to dominate the production of critical technologies and from the momentum China has gained in modernizing its defense capabilities. But private sector actors used to seeking global supply chain efficiencies are being required to adapt to the securitization of the US-China technology competition by pursuing redundancy and safety of supply chains over efficiency and profitability. Companies are being asked to cooperate with allied governments to navigate demands to refashion global supply chains to minimize strategic risks while also preserving profitability. The task of setting new rules of the road in response to a changing security environment requires both intensified policy dialogue between governments and expanded cooperation with the private sector to achieve these objectives.

As a next step in deepening cooperation between governments, the two governments are pursuing a roadmap for close cooperation in R&D and standardization of approaches to the development of future technologies. This effort is ambitious and far-reaching, but the scope and nature of the effort generate new challenges, including how to establish a balance between government coordination for achieving greater synergy and private-sector-based competition that drives innovation.

Categories of Technology-Driven Cooperation Within the Global Comprehensive Strategic Alliance

The papers in this volume illustrate that as government-to-government dialogues broaden and deepen, there are four types of cooperation that reflect the respective needs and motives behind the pursuit of more frequent government-to-government policy dialogues between the allies on particular issues. Each type of cooperation has slightly different implications, depending on the issue area.

The first type of cooperation involves convergence or alignment in response to the shared perception or identification of China as a common threat. However, the focus on China may be stated or unstated as part of the rationale for enhancing coordination, depending on the issue area. For instance, a major premise underlying US-South Korea cooperation on critical and emerging technologies—such as semiconductors, batteries, and biotechnology—is that such cooperation will enable the United States and its allies to maintain a critical lead in the development of new technologies, deny China certain technologies that might strengthen its defense industrial base, eliminate supply chain vulnerabilities resulting from inclusion of Chinese components in the supply chain that comprises the allied defense industrial base, and link US and allied capabilities to develop upstream technological innovations.

The United States and South Korea may be motivated to pursue aligned actions in cybersecurity in response to a set of specific threats from China and North Korea, and US-China competition is an often-unstated rationale motivating US-led multilateral cooperation in space development. China is the "pacing threat" driving efforts to restructure the US defense industrial base and to incorporate contributions from allies as a means by which to redistribute financial burdens and enhance efficient technology development.[8] Moreover, the aim of AUKUS is explicitly to deepen cooperation to maintain an edge over China in defense technologies and through the joint development of an effective nuclear submarine force.

A second type of cooperation involves the institutionalization of government-to-government policy dialogues. Such efforts to hold more frequent policy dialogues enhance the capacity of alliance partners to make a unified response to an external threat. The proliferation of government-led dialogues on cybersecurity shows a willingness to coordinate on issues while preserving their capacity to undertake separate and parallel responses. Institutional coordination mechanisms stitch governmental partners together, but in this type of policy dialogue, the level of cooperation stops short of a combined and integrated response. Governmental coordination that is short of forging an

integrated response may be the best option for governments in instances where the level and capacity of responses between partners is unequal or when cooperation is desirable, but respective parties prefer to maintain a degree of freedom of action. For instance, the United States and South Korea have identified quantum as an area of potential technology development, but the differential in capabilities between the United States and South Korea may preclude full-scale coordination. Additionally, South Korea may have interests or exposure to third-country markets such as China in an area like semiconductors that might make coordination desirable but would preclude deeper integration.

A third type of cooperation involves the creation of combined mechanisms in which both sides work together in an integrated fashion to achieve a unified policy response. The CET dialogue identifies a variety of public- and private-sector-led policy responses, including the establishment of long-term institutional cooperation in upstream R&D on AI and quantum, private-sector-based alliances in biotechnology, and government and private-sector tie-ups on applications of clean technologies in the areas of batteries, hydrogen, and civil nuclear power production. US-South Korea defense industrial cooperation to enhance supply chain resiliency involves the integration of technology development, weapons production, and maintenance and repair of defense articles. Significant progress has been made toward joint responses to North Korean malicious cyber activities, including the release of joint advisories, application of joint sanctions, and interdiction to claw back some portion of North Korea's cyber loot. The integration of operations and development of a combined response bind allies together at a level that may make policy adjustments more difficult in the event that a political transition leads to a leader in the United States or South Korea who wants to pursue a different policy approach.

A fourth type of cooperation involves the embeddedness of alliance cooperation into a broader ecosystem of like-minded countries moving together with a common purpose. Alongside the deepening of institutional cooperation within the US-ROK alliance, embeddedness involves cooperation with like-minded partners with similar threat perceptions and policy preferences that facilitate cooperation in a values-based multilateral framework. Governments have laid the foundation for trilateral cooperation on R&D among the United States, South Korea, and Japan in critical and emerging technologies. Likewise, the authors of this volume point to prospects for trilateral cooperation in cyber, space, and clean technologies. In addition, the establishment of the MSP and the Indo-Pacific Economic Framework (IPEF) promotes multilateral supply chain resiliency and cooperation. Finally, the establishment of AUKUS, Korea's possible cooperation on technology development under Pillar Two, and the

possible development of a multilateral approach to defense industrial cooperation are instances in which the US-ROK alliance is increasingly embedded in broader multilateral cooperation frameworks.

Prospects for and Challenges to A Comprehensive Technology-Centered Alliance

The papers presented in this volume of Korea Policy are intended to capture major changes in the depth of cooperation reflected in the intensification and expansion of policy dialogues between various parts of the governments of the United States and South Korea in the spheres of both technology development and the defense industrial base. The expansion of US-South Korean policy dialogues has been motivated by the alignment of US and South Korean threat perceptions around the emergence of China as a common threat and is intended both to deepen policy coordination and to encompass the development of an integrated response across a broader range of issues than ever before. In parallel with US efforts to develop policy coordination mechanisms with other like-minded countries, the expansion and inclusion of South Korea as a participant in dialogues on supply chain resilience and integration, as well as the development of critical and emerging technologies, also serves to embed the alliance within a broader multilateral network of like-minded countries with the aim of maintaining technological superiority over common adversaries. This effort is truly ambitious in the scope of envisioned cooperation in an effort to reframe the terms of competition in the global system around maintaining leadership in the production of the world's most cutting-edge technologies. But is a US-ROK technological alliance or a US-led drive among liberal democracies to maintain a competitive technological edge against China truly sustainable? There are at least four critical factors the papers identify that will flesh out the answer to this question.

Maintaining a Technology-Centered Like-Minded Coalition

First, will the United States, South Korea, and other like-minded alliance partners maintain a united view of the threat environment and especially of the paramount need to counter China's drive to achieve technological supremacy? Factors that may threaten allied solidarity in the face of China's drive for technology dominance include the lure of gains that might accrue from participation in the Chinese market at the expense of shared technology denial objectives, needs for capital that Chinese partners may be willing to provide in exchange for access through technology-oriented economic exchanges, and the possible emergence of differences between allies over the implementation

of export controls or other curbs on economic cooperation with China. China's development of competitive or superior technologies and applications in selected areas might pose a particular challenge to the solidarity of economic coordination between the United States and South Korea, especially if Korean firms are tempted to engage in tie-ups with Chinese firms as a means to gain access to such technologies.

China's policy shift toward discrimination against South Korean companies in China's domestic market represented both an instance of China's weaponization of economic interdependence to achieve political retaliation following the 2017 South Korea deployment of the U.S. Terminal High Altitude Air Defense (THAAD) system and a shift in approach by the PRC government regulation of China's domestic markets towards a privileging of indigenous corporate innovation at the expense of foreign companies. South Korean companies such as Samsung and SK Hynix still have exposure to China due to their ownership of semiconductor plants in China that may become a source of political friction between allies if the Trump administration decides to remove exceptions to or to strengthen current US export control laws. As US export controls and curbs on foreign investment grow stronger, China may provide new incentives to outside companies, including South Korean firms, to procure needed foreign technologies. Moreover, if China is able to surpass the United States in the development of new technologies, South Korean firms may be sorely tempted to establish tie-ups with Chinese firms to gain access to newly developed world-leading technologies that would only be available through cooperation with China.

Political Transition and the Sustainability of Technology-Driven Cooperation

Second, will political leaders across the coalition of like-minded technological partners maintain commitments to deep policy integration required by the technology competition that the Biden administration has outlined? Political transitions in either the United States or South Korea—or both—may result in shifts in priorities that could threaten national commitments to the joint development of technologies. President Trump's penchant for transactional approaches to alliance partners may undermine the trust necessary to pursue a deep integration of joint technology projects. Meanwhile, a future South Korean president who seeks greater flexibility or distance from US objectives may feel unduly bound by institutional integration.

In this respect, the Biden administration has led an unprecedented approach to cooperation within alliances in the sphere of technology research and development that differs markedly from past US practice. Both the

establishment of AUKUS and the establishment of a framework for US-South Korea Next Generation on Critical and Emerging Technologies reflect an approach by the Biden administration that attempts to establish cross-national frameworks for the development of cutting-edge technologies, in contrast to the prior approach that pursued basic research on its own and enjoyed exclusive initial access to technologies that might be exploited and brought to market in various sectors. For instance, the US jealously guarded the ownership and development of proprietary technologies and maintained strict export control curbs under the International Traffic in Arms Regulations (ITAR) of the Arms Export Control Act (AECA). But the premise underlying joint research and development of critical and emerging technologies is that the US will cooperate with others in technology development. Such an approach acknowledges that technological innovation is increasingly taking place in the private sector and not primarily through government-funded research projects. But such an approach will require a loosening of US export control regulations to allies surrounding advanced technologies. It remains to be seen whether the Trump administration's America-first foreign policy framework will preclude the relaxation of technology controls that might enable wide multinational cooperation on research and development.

Government Framing of Technology Cooperation vs. the Role of the Private Sector

Third, will the private sectors in each country follow the leadership of their respective governments to collaborate on technology development? The government-led drive for cooperation on critical technologies and supply chain resiliency requires unprecedented levels of public-private cooperation across the alliance. Governments may provide seed funding for specialized research and coordinate upstream cooperation with educational institutions within the alliance in addition to providing incentives to support business development in newly emerging critical technology sectors. However, private sector firms will naturally compete to capture technological innovations, develop new designs, and market new products that incorporate cutting-edge technological innovations as a major source of profits. The task of coordinating technological cooperation at the government level while also securing cooperation with the private sector is a very ambitious task.

As part of its focus on supply chain resilience, the Biden administration has reached out to both domestic and foreign private sector actors for consultations as it has developed industrial policies and enhanced export control and inward

investment regulations in a number of key sectors. These efforts to rebuild the US industrial base and strengthen regulations have necessitated active consultations with the businesses involved in critical sectors. But it is unclear whether greater government direction of and support for cutting-edge technologies will necessarily lead to or become an obstacle to the promotion of an effective innovation ecosystem. As Soyoung Kwon notes in her paper, "In technological cooperation, corporate interests do not always coincide with state interests." As a result, there is a limit to the ability of governments to secure cooperation with the private sector, and such government-led coordination efforts have to involve the imposition of an attractive mix of cost-imposition and profit-enhancing measures in order to succeed.

Stretching the Concept of an Alliance

Fourth, will expanding the concept of an alliance beyond its core security-centered logic add new layers of resiliency to the relationship or create added points of tension that might, in the end, serve to weaken or undermine the alliance itself? The papers in this volume point to several instances in which the expansion of traditional deterrence frameworks at the heart of the security alliance may generate tensions or conflicts requiring the attention of alliance managers even as the scope of the alliance is being enlarged.

For instance, the traditional security logic of the alliance that relies on deterrence principles may not be readily applied to the cyber domain, as Jun and Kim illustrate in their discussion of the gaps between South Korea's "offensive cyber defense" concept emphasizing retaliation and the US Defend Forward concept emphasizing prevention and managed competition. As previously noted, the logic underlying coordination and deterrence in the security domain may not be compatible with the logic and approaches employed in the economic sphere. Even the motives behind US and South Korean cooperation in space may not be fully aligned, as the US framework includes both multilateral cooperation on exploration and efforts to maintain a strategic advantage in the space domain, and the South Korean framework is primarily motivated by opportunities to participate in the space economy and to exploit new discoveries in space for economic gain. In this respect, the development of a global comprehensive security alliance encompassing many different domains would seem to be a step forward, but if newly emerging internal contradictions in the scope, purposes, and justifications for alliance cooperation are not properly managed, the expansion of the scope of the alliance might have the effect of weakening rather than strengthening the capacity and durability of the relationship.

Concluding Thoughts

The Biden and Yoon administrations have emphasized a revitalization of the US-ROK alliance to an unprecedented degree as they have sought to expand and operationalize cooperation across many domains and on a global scale during what might be termed an era of institutionalization in alliance cooperation. The papers in this volume illustrate the progress that has been made, with a special focus on the deepening of cooperation on critical and emerging technologies and the impact of the focus on supply chain resiliency for efforts to revitalize and integrate the defense industrial bases of the two countries. US and South Korean alliance partners have become more closely aligned in response to the perception of a common threat from China, enhanced coordination through a wide range of inter-governmental consultations, and have even pursued the integration of R&D efforts to enhance contributions across a range of critical and emerging technology domains. The two sides have also sought to incorporate new technologies into their respective defense industrial base as well as to embed alliance-based cooperation efforts as part of trilateral US-South Korea-Japan coordination as well as between the US-ROK alliance and AUKUS.

As the alliance management baton passes from the Biden to the Trump administration, an important question will be whether the Biden administration's efforts to "lock in" institutionalized cooperation both within the alliance and through the implementation of minilateral groupings such as AUKUS and the US-South Korea-Japan partnership are sustainable through the US political transition. But such efforts to "lock in" institutionalized coordination across such a broad range of topics and embed the alliance within a latticework of US-led minilateral cooperation mechanisms will only be successful with "buy-in" from President Trump and his new administration. The Biden administration is leaving an expansive alliance architecture and an impressive array of government-to-government consultations; the question for the immediate future is how and whether the Trump administration decides to build on it.

Endnotes

[1] "South Korea: Background and U.S. Relations," Congressional Research Service, updated October 25, 2024, https://crsreports.congress.gov/product/pdf/IF/IF10165.

[2] Coordination as used here reflects the effort on the part of bureaucracies in the respective governments to consult and share views on respective policies and approaches to their formation. Integration means the development of a joint and combined response on the part of both governments to a particular issue. Alignment means the choice to pursue coordination and/or integration of policies in response to a common external threat.

[3] The White House, "U.S.-Republic of Korea Leaders' Joint Statement," May 21, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/21/united-states-republic-of-korea-leaders-joint-statement/; Yoon Suk-yeol, "South Korea Needs to Step Up," *Foreign Affairs*, February 8, 2022, https://www.foreignaffairs.com/south-korea/south-korea-needs-step-yoon-suk-yeol?check_logged_in=1.

[4] The White House, "Leaders' Joint Statement in Commemoration of the 70th Anniversary of the Alliance Between the United States of America and the Republic of Korea," April 26, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/04/26/leaders-joint-statement-in-commemoration-of-the-70th-anniversary-of-the-alliance-between-the-united-states-of-america-and-the-republic-of-korea/.

[5] The White House, "Joint Fact Sheet: Launching the U.S.-ROK Next Generation Critical and Emerging Technologies Dialogue," December 8, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/12/08/joint-fact-sheet-launching-the-u-s-rok-next-generation-critical-and-emerging-technologies-dialogue/.

[6] The White House, "Joint Fact Sheet: Launching the U.S.-ROK Next Generation Critical and Emerging Technologies Dialogue."

[7] This phraseology is primarily intended to describe a system of alliance coordination involving parallel coordination dialogues and mechanisms across a broad range of issues and branches of government.

[8] US Department of Defense, "Official Talks DOD Policy Role in Pacing Threat, Integrated Deterrence," June 2, 2021, https://www.defense.gov/News/News-Stories/Article/Article/2641068/official-talks-dod-policy-role-in-chinese-pacing-threat-integrated-deterrence/.

The US-South Korea Global Comprehensive Strategic Alliance: Cooperation on Semiconductor Supply Chains and Technology

By Dr. Soyoung Kwon

Introduction

The alliance between the United States and the Republic of Korea (ROK), a steadfast and enduring security arrangement, is a testament to the long-term commitment of the two countries to foster stability in East Asia and deter potential threats. Forged initially as a security pact through the 1953 Mutual Defense Treaty, this bilateral alliance was primarily aimed at protecting South Korea from North Korean and Chinese aggression during the Cold War. It featured an asymmetric security relationship that focused on containing communism through a strong US military presence and joint defense strategies.

In the shifting geopolitical landscape of the post-Cold War era and with growing Korea's capabilities, the alliance took on new missions, including managing North Korea's provocations, monitoring China's increasing regional influence, and expanding cooperation on non-traditional security issues like climate change, human rights, and energy. Over the decades, the alliance—centered on traditional defense and security issues—evolved into a broader, more comprehensive, and strategic bilateral relationship that accommodates non-military forms of cooperation to meet new security challenges in an ever-changing international environment.[1]

Today's security landscape is becoming ever more complex with the intensifying rivalry between the United States and China, increasing competition in critical and emerging technologies, and the revolution in military affairs driven by artificial intelligence (AI), unmanned aerial vehicles (UAVs), robots, and cyberspace. To meet the multifaceted security environment, US and South Korean leaders envision an alliance that integrates military, technological, and economic interests. In May 2022, US President Joe Biden and South Korean President Yoon Suk-yeol agreed to further advance the alliance into a "global

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comprehensive strategic alliance" and "strategic economic and technology partnership" rooted in shared values and rules-based international order to highlight bilateral cooperation in military, economic, and diplomatic areas in the Indo-Pacific region and beyond.[2] As part of this evolution, the alliance is now closely connected with broader minilateral and multilateral frameworks of cooperation among like-minded allies and partners on semiconductor supply chain resilience, technological advancement, and a new global economic order.

There are concerns over the excessively securitized discourse surrounding the semiconductor supply chain and industrial sectors, with the increasing use of "technology or semiconductor alliance" to define cooperation in the new economic and technological domain, which conflates the concept of an alliance with that of a partnership.[3] Alliances and partnerships differ significantly in terms of the level of institutionalization, the nature of commitment, and the range of cooperation for agreed-upon purposes.[4] Despite reservations, this trend has profound implications for evolving alliance dynamics, motivations for alliance-like behaviors in the technological domain, and application of tenets of security alliances to semiconductor cooperation.

This paper navigates the complex dynamics of the US-ROK alliance, especially in the context of economic security and technological cooperation amid intensifying US-China competition. It offers a comprehensive analysis of US-South Korea cooperation in the semiconductor supply chain within the framework of a global comprehensive strategic alliance, highlighting its achievements, identifying opportunities for further development, addressing potential challenges, and suggesting ways to enhance future collaboration within the alliance framework.

The Security Logic to Supply Chain Resilience and Technology Cooperation

With technological advancement, semiconductors and the resilience of their supply chains have become crucial in various critical and emerging technology sectors, such as electronics, telecommunications, AI, and robotics. Semiconductors also run military equipment, power AI targeting and information analysis, and model nuclear weapons design. The control over semiconductor technology thus underpins a technological and military edge over peer competitors. The strategic importance of semiconductor supply chains, which are vital for advancing high-tech industries, securing military advantages, and ensuring economic growth, has resulted in the securitization of the semiconductor ecosystem.[5] The semiconductor supply chain issue has now become a critical component of national security.

US-China Competition in Supply Chains

Semiconductors were previously a symbol of globalization.[6] Under the global value chain structure, the semiconductor ecosystem was based on interdependent supply chains and a highly efficient division of labor. Despite ideological and systemic differences, countries participating in the global supply chain for semiconductors were closely interconnected as mutual consumers and suppliers and cooperated by leveraging their unique strengths under the free-trade-based liberal order. The United States, South Korea, Japan, and Taiwan led the semiconductor business in research, development, and chip design. The Netherlands led the world in advanced semiconductor manufacturing equipment, South Korea and Taiwan dominated in advanced manufacturing, and Japan excelled in supplying other essential materials and equipment. Assembly, testing, and packaging were primarily outsourced to countries with lower labor costs, such as China, Malaysia, and Vietnam. This division of labor enabled cost optimization, technological innovation, increased efficiency, and the concentration of critical stages of production and key suppliers in specific regions.

Recent trends in de-globalization and US-China strategic competition are rapidly dismantling the existing semiconductor supply chain. Recognizing the vulnerabilities of interdependencies, countries involved in the global semiconductor industry are devising goals and strategies to secure the semiconductor supply chain based on their strengths and weaknesses. Countries are diversifying their supply chains to de-risk and secure stability for key products. They employ protectionist and nationalistic policies to build domestic production facilities, stockpile large quantities of goods, and acquire STEM talent. The rise of techno-nationalism is causing greater instability in global supply chains and higher supply costs, which will ultimately result in a decline in global economic growth. Yet, a security-driven logic has entered this domain of competition in the name of economic security, diverging from the traditional liberal economic logic centered on efficiency and growth.

Economic Security Goals and Threats

Economic security has two components: the recognition of potential threats targeting a nation's economic stability and the ability to safeguard the national economy against deliberate attempts of disruption and coercion.[7] Given its complex nature, however, many countries face challenges in defining the scope of economic security, identifying potential threats, and balancing the tensions between maintaining open economic exchange and addressing national security concerns.[8] While prioritizing the resilience of supply chains

against external shocks as a key security objective, the United States, China, Japan, and South Korea have distinct concerns, goals, and strategies of protection, promotion, and partnership regarding economic security.[9]

The United States views China's rise in high-tech manufacturing as a key threat.[10] In response, the United States prioritizes technological innovation, focusing on industries and competition strategies while ensuring supply chain resilience, particularly in sectors like chips, batteries, biotech, and rare earth metals. The United States is on a mission to restructure the global chip supply chain by investing in its domestic semiconductor industry and bringing back chip manufacturing to the United States to complete the semiconductor production ecosystem and prevent supply chain disruptions in the future.[11] A sweeping set of export controls aims at preventing China from acquiring higher-end chips, chip designs, and chip-making equipment, thus acquiring certain advanced capabilities in semiconductor technology.[12]

China, on the other hand, perceives hostile foreign forces as a threat and focuses on achieving "innovation-led growth" through technological self-strengthening. China aims to localize semiconductors by building an independent, self-sustaining semiconductor ecosystem to counter US control. Its priorities include strengthening industrial policies, increasing research and development (R&D) investment, and promoting domestic consumption. At the same time, China's economic statecraft employs tactics such as import and export controls, public boycotts, and other coercive economic measures, particularly concerning key minerals.[13]

Japan faces threats from geopolitical instability and its reliance on overseas resources. It prioritizes de-risking by expanding domestic production, reducing dependency on foreign technologies, and enhancing global competitiveness in critical emerging technologies (CETs). Japan aims to revitalize its semiconductor industry based on equipment material competitiveness by securing advanced semiconductor technology and ensuring production capacity. Japan's policies focus on promoting strategic autonomy, preventing technology leakage, and achieving economic growth through innovation.[14]

South Korea aims to expand its semiconductor ecosystem and find trust-based resilient supply chains that can complement its lack of competitiveness in system semiconductors and equipment materials while highlighting its global competitiveness in the memory semiconductor field.[15] South Korea, heavily reliant on China and influenced by major power rivalry, focuses on diversifying its dependencies as a means of de-risking. South Korea's strategies

involve strengthening its semiconductor supply chains, partnering with like-minded countries, and developing a comprehensive China policy to balance security and economic interests.[16]

In short, the United States and China are primarily concerned with each other's actions, while Japan and South Korea are more attentive to vulnerabilities caused by major power rivalries and overseas dependencies. These differences drive distinct strategies, reflecting a broader divergence in how each country prioritizes and responds to economic security threats. Responses include both offensive measures to enhance the country's power and influence and defensive measures to safeguard the country's economic interests against external threats and vulnerability.

Offensive and Defensive Strategies for Economic Security

In the context of economic security and supply chain resiliency, offensive strategies focus on growth and expansion, while defensive strategies prioritize protection and stability. The respective US and Chinese defensive and offensive strategies regarding semiconductors have had complex and varied effects on South Korea's chips-related economic security. The US defensive strategy strives for increased self-reliance by promoting high-tech and strategic industries. Its goals are to revive the US semiconductor industry with subsidies and tax incentives to chip companies, construct semiconductor production facilities in the United States, and process a US-centered semiconductor supply chain reorganization.[17]

The US offensive strategy aims to contain China's rise by blocking technology transfers to China. The United States implemented export controls on semiconductor manufacturing equipment, fab expansion restrictions as part of the CHIPS and Science Act, and inbound and outbound investment screenings for national security reasons, rallying like-minded partners to align their policies.[18] The US strategy is to check China's access to advanced semiconductor technologies and manufacturing capabilities, not only to restrict the pace of technological progress development but also to degrade the peak technological capability of China's semiconductor industry.

China's defensive strategy focuses on boosting self-reliance and technological resilience by promoting domestic consumption, developing self-sustaining supply chains, and advancing homegrown technologies. Beijing is taking concrete steps toward increased legalization and institutionalization of economic security measures.[19] On the offensive side, China employs economic coercion as a strategic tool, using import and export controls and the weaponization of interdependence to penalize foreign entities and individuals who adhere to sanctions against China.

Table 1. US and Chinese Economic Strategies in Semiconductor Supply Chains[20]

	Strategy	Purpose	Policy	Effect on South Korea
United States	Defensive	Increase self-reliance	**Promote High-Tech and Strategic Industries** • CHIPS abd Science Act, IRA< EO14081 • FAB 4, MSP, IPEF	Positive
	Offensive	Contain China's rise	**Protect US Technology Transfers to China ("Small Yard, High Fence")** • Export controls • Inbound/outbound investment screening	Negative
China	Defensive	Increaase self-reliance	**Dual Circulation and Tech Self-strengthening** • Domestic consumption and self-sustaining supply chains • Indigenzie fundamental technologies	Negative
	Offensive	Weaponize interdependence	**Economic Coercion** • Penalize foreign entities complyting with sanctions against China • Import / export controls	Threats

South Korea actively partakes in the US defensive strategy while being passive toward the US offensive strategy. The South Korean government has been expanding semiconductor cooperation with the United States while cautiously navigating export control policies that could negatively impact South Korean chip factories in China. While the Netherlands, Japan, and Taiwan quickly aligned their export control policies toward China, South Korea has been more hesitant, weighing the risks and benefits of aligning with the United States outside of traditional multilateral frameworks and abandoning the Chinese market.[21]

China's defensive strategy of greater self-sufficiency adversely affects the supply of raw materials and the export of Korean semiconductors, causing South Korean chip-making firms to lose profit. China's offensive strategy of

economic sanctions directly threatens South Korea. China's growing use of economic leverage to achieve political objectives increases the risks associated with dependence on or interactions with China. Whether the United States can provide security assurances or a safety net against China's offensive strategy remains a point of contention in Korea. Therefore, the key to economic security for South Korea is to avoid vulnerabilities while increasing supply chain resiliency and reducing dependence on China.

Collective Economic Security: Chip 4, IPEF, and MSP

From the outset, the Biden administration has aimed to "repair" traditional alliances to restore US global leadership and "reinvent" partnerships to address shared priorities and emerging challenges, including by enhancing collaboration in response to the evolving semiconductor supply chain landscape.[22] Emerging technologies are now seen as a strategic asset for securing future global leadership. The United States has sought to complete a trusted value chain that excludes China and expands bilateral and multilateral consultative bodies with allies and like-minded countries.

The Chip 4 alliance is one such consultative body. The Chip 4 grouping was initially proposed by President Biden in early 2022 to invite Asian countries with relative strengths in the semiconductor sector to counter China's emerging chip industry. The grouping envisioned semiconductor cooperation that combines US design and source technology, Japanese semiconductor materials and equipment, and Korean and Taiwanese memory and non-memory semiconductor manufacturing capabilities. However, the proposed Chip 4 alliance, officially named the "US-East Asia Semiconductor Supply Chain Resilience Working Group," has not been formalized nor systemized in its operation. It features a close cooperative entity focused on stabilizing the semiconductor manufacturing supply chain rather than an exclusive alliance that explicitly identifies adversaries. Still, this alliance has critical potential. Membership among the United States, Japan, South Korea, and Taiwan constitutes almost the entire global semiconductor industry, accounting for 82 percent of the global market share and 74 percent of the global semiconductor value chain.[23] The influence of the four countries will likely spread rapidly to other key industries that depend on semiconductors.

Additionally, the Indo-Pacific Economic Framework for Prosperity (IPEF) is a US-led economic framework aiming to strengthen economic ties with like-minded countries in the Indo-Pacific region to advance supply chain resiliency. Under US leadership, IPEF was officially launched in May 2022 with the objectives of "advancing resilience, sustainability, inclusiveness, economic growth, fairness, and competitiveness" in the four pillars of trade, supply chains, clean economy,

and fair economy.[24] Since its inception, IPEF has held six negotiating rounds and five ministerial meetings to make a proposal for ensuring resilient, reliable, and efficient supply chains. In February 2024, the IPEF Supply Chain Agreement was enacted, establishing a framework for deeper collaboration to prevent, mitigate, and prepare for supply chain disruptions.[25]

The Minerals Security Partnership (MSP), launched in June 2022, is another multilateral platform led by the United States that includes the European Union and 14 countries around the world with the commitment to enhance the resilience of the critical minerals supply chain. Focusing on the minerals and metals supply chains most relevant for clean energy technologies, the MSP aims to accelerate the development of diverse and sustainable supply chains for critical energy minerals by working with host governments and industries to facilitate targeted financial and diplomatic support for strategic projects along the value chain.

The Chip 4 alliance and other US-led minilateral groupings, which are linked to a restructuring process of the semiconductor supply chain, have presented Seoul with strategic concerns. Membership could provide South Korea access to advanced technology, shared R&D resources, and supply chain resilience. The trade-off is increased dependence or competition within the alliance, potentially reducing market share and pricing power for South Korean semiconductor manufacturers and further limiting South Korea's independence and flexibility to protect its proprietary technologies or critical semiconductor technologies. The South Korean government and private sector were wary of such implications and the potential restrictions that might be imposed by Chinese economic sanctions or export and import controls.

Addressing these economic security concerns regarding the securitization of the global supply chain necessitates enhanced intra-alliance consultative mechanisms between the United States and South Korea that can reinforce commitments and partnerships in emerging sectors. Such a fortified consultative architecture will empower both nations to proactively tackle shared challenges and the vulnerabilities associated with economic disruptions, ensuring that they remain resilient against potential economic threats. For this purpose, the US-ROK global comprehensive strategic alliance gains prominent importance in navigating the complexities of today's dynamic security environment.

Charting Leader-Level Commitments and Working-Level Progress in Semiconductors and Technology Cooperation

The May 2022 Biden-Yoon summit upgraded the US-ROK alliance into a global comprehensive strategic alliance, highlighting a strong commitment at both the leader and working levels to strengthen bilateral cooperation in military,

economic, and diplomatic areas. As part of that process, the two leaders agreed to promote resilient global supply chains, enhance public-private partnerships to protect CETs, support R&D exchanges, and develop collaboration within IPEF. Whereas the 2022 summit agreement outlined broad and somewhat vague commitments on supply chain resilience and cooperation in CETs, the April 2023 US-South Korea summit clarified and formalized such commitments with specific plans like the establishment of dialogues and working-level frameworks to implement the alliance's goals in a more tangible way.

Deepening and Broadening Cooperation

Coinciding with the 70th anniversary of the alliance, the leaders' joint statement of 2023 reaffirmed their previous commitment to enhancing the alliance to reflect a broader, more integrated approach to regional and global security rooted in shared values and strategic interests. Yet, of particular salience was their commitment to upgrade the alliance into a strategic economic and technology partnership by establishing the Next Generation Critical and Emerging Technologies (CET) Dialogue to lead advanced technology cooperation.[26] The joint statement once again underscored the importance of aligning with like-minded countries to enhance resilience and detect potential disruptions in the global supply chains. It also highlighted the need for greater collaboration to counter the challenges of economic coercion.

Following the April 2023 summit, South Korea has shown a more substantial commitment to take an active role in US-led international cooperation on supply chain resilience. In July 2023, South Korea hosted the fourth IPEF negotiating round, which reaffirmed the grouping's commitment to detect and address potential supply chain disruptions and strengthen resiliency within the IPEF institutional framework. When the IPEF supply chain bodies—Supply Chain Council, Crisis Response Network (CRN), and Labor Rights Advisory Board—officially launched and entered the implementation phase in July 2024, Korea was elected as the inaugural chair of the crisis response network under the IPEF supply chain agreement to lead the cooperative mechanism for the global supply chain.[27]

Building upon the US-ROK Energy Security Dialogue held in March 2023 and the US-ROK Senior Economic Dialogue in February 2024, the two countries expanded their bilateral cooperation within the 13-member MSP, focusing on joint research policies for emerging strategic technologies and securing access to critical minerals. South Korea assumed chairmanship of the MSP in July 2024, leading collaboration among members to strengthen the critical minerals supply chain.[28] The importance of US-Korea-Japan trilateral cooperation in

aligning economic and technological priorities was also emphasized by the Camp David Summit in 2023, the Defense Trilateral Talks in April 2023, and the Trilateral Leaders' Summit in August 2024.

Enhanced Public-Private Collaboration

In line with the commitments and plans outlined at the leader level, various bilateral working groups, task forces, and collaborative research projects have been created at the working level to facilitate substantive cooperation in the semiconductor supply chain and technology. Enhanced public-private collaboration was reflected in the official December 2023 launch of the Next Generation CET Dialogue, led by the two countries' national security advisors, focusing on semiconductor supply chains, biotechnology, batteries, and AI.[29] Cooperation on semiconductor supply chains and technology between both governments, industry, and academia was upgraded to provide the US and Korean research teams preferential access to advanced technology nodes for expanded joint R&D opportunities. The two governments committed to enhancing cooperation between their respective public and private research organizations, including establishing the US National Semiconductor Technology Center and the Korean Advanced Semiconductor Technology Center. A symbolic STEM exchange program was launched, inviting 2,023 students from each country to foster expertise in CETs.[30]

Furthermore, the Supply Chain and Commercial Dialogue (SCCD), led by the US Department of Commerce and the ROK Ministry of Trade, Industry and Energy, laid the groundwork for deeper economic and commercial collaboration. There has been substantive progress with the working groups to discuss deepening semiconductor investment cooperation and collaboration between the public and private semiconductor R&D organizations through sharing best practices and aligning R&D priorities.[31]

The commitments in the semiconductor sector have led to three key achievements in enhancing the technology partnership between the United States and South Korea. First, joint initiatives, such as the US-South Korea Semiconductor Forum and the planned AI Semiconductor Innovation Centers at major US universities, foster collaborative R&D efforts. Second, the STEM talent exchange program enhances collaboration in advanced technology sectors, including semiconductors, by building expertise and driving innovation. Third, the regular ministerial-level Supply Chain and Commercial Dialogue (SSCD) and the US-Korea Semiconductor Forum promote closer collaboration between industrial, academic, and government stakeholders to discuss the promotion of resilient supply chains for key products, workforce development, and R&D.

Table 2. US-ROK Global Comprehensive Strategic Alliance in CET and Supply Chain

	Leader-Level Commitments	Working-Level Progress
Critical and Emerging Technologies (CET)	**2022 Summit: (General Commitments)** • Pledged to "enhance public and private cooperation to protect and promote critical and emerging technologies, including leading-edge semiconductors, eco-friendly EV batteries, Artificial Intelligence, quantum technology, biotechnology, biomanufacturing, and autonomous robotics." **2023 Summit: (Institutionalization)** • Commitment to establish the Next Generation CET Dialogue led by the two countries' national security advisors. • Agreed to implement the STEM Educational Initiative, inviting 2,023 Korean and 2,023 US students.	**Public Sector Cooperation** • Next Generation CET Dialogue: The countries officially launched the dialogue in December 2023, agreeing to cooperate on semiconductor supply chains, biotechnology, batteries and clean energy, quantum science, digital connectivity, and AI. • Supply Chain and Commercial Dialogue (SCCD): US Secretary of Commerce Gina Raimondo and ROK Minister of Trade, Industry and Energy Chang-Yang Lee signed a Memorandum of Understanding to launch the US-Korea Supply Chain and Commercial Dialogue on May 21, 2022. • Minerals Security Partnership (MSP): South Korea has been a member country since its establishment in 2022. South Korea assumed one-year chairmanship in July 2024. **Private Sector Cooperation** • South Korean semiconductor and EV battery corporations, including Samsung, SK, LG Energy Solution, and Hyundai Motor, are constructing manufacturing facilities in the United States. • Establishment of the US National Semiconductor Technology Center and the Korean Advanced Semiconductor Technology Center.
Supply Chain Resilience	**2022 Summit: (General Commitments)** • The two countries agreed to "continue working together to tackle immediate and long-term challenges in the supply chain ecosystem." • South Korea agreed to join the Indo-Pacific Economic Framework for Prosperity (IPEF). **2023 Summit: (Institutionalization)** • Reaffirmed their commitment to "to detect and address potential supply chain disruptions and strengthen resiliency." • South Korea hosted the fourth IPEF negotiating round in Busan from July 9 to 15, 2023. • South Korea was elected as the Crisis Response Network Chair under the IPEF supply chain agreement in 2024.	

Predictable Environment for Business Activities and Bold Investment

On the private sector front, the US and South Korean leadership have committed to close consultations to ensure that legal measures foster a favorable and predictable environment for corporate investment in the United States.[32] The need for close consultation has been spurred by mounting apprehension among Korean businesses over the Inflation Reduction Act (IRA), the CHIPS and Science Act, and the guardrails provision.[33] The guardrails provision intends to restrict the recipients of subsidies and tax benefits under the CHIPS Act from investing in countries of concern, including China, which had been a significant burden for Korean companies that previously established production bases in China. The Korean government and businesses requested extended exemptions from semiconductor equipment export controls, and the US government incorporated some of the requests. Under the finalized guardrails provision of the CHIPS Act, South Korean chipmakers, including Samsung and SK Hynix, can process "routine upgrades" of their production facilities in China.

Supported by substantial funding and subsidies from the US government, significant investments are being made by Korean companies in the United States—the United States provides tax credits up to 25 percent of the amount invested in the United States. Currently, Samsung is building a new semiconductor manufacturing facility in central Texas with USD 6.4 billion in US government funding, while SKC Corporations' subsidiary company *Absolics* is constructing a semiconductor facility in Georgia for the development of advanced packaging substrates technology with USD 75 million in US funding.[34] SK Hynix is also receiving USD 450 million in direct subsidies and USD 500 million in loans to manufacture high bandwidth memory (HBM) high-end packaging and to establish R&D facilities in Indiana. Hyundai is constructing an electric car plant in Georgia to manufacture batteries for electric pickup trucks.[35] These investments are part of a broader effort by the United States to build resilient supply chain ecosystems for critical technologies and strengthen R&D collaboration in the field of leading-edge semiconductors, advanced packaging, and advanced materials. They also reaffirm the importance of public-private partnerships and business-to-business cooperation between the United States and South Korea in navigating global competition.

Although it may be too early to fully evaluate the visible outcome of these efforts, the global comprehensive strategic alliance has reaffirmed leader-level commitments and established working-level communication channels and platforms that support the convergence of economic and security concerns

through strategic partnerships. It has also set a collaborative mechanism for a resilient supply chain structure that operates under the norms of collective security that is institutionalized through regional strategic frameworks.

Changing Dynamics of the US-ROK Alliance: Implications and Challenges

The global comprehensive strategic alliance and strategic and economic partnership frameworks have significantly altered the nature and scope of the US-ROK alliance. Traditionally, the US-ROK alliance was grounded in formal agreements on military cooperation and mutual defense against external threats. As the scope of the alliance expands to include partnerships in high-tech areas beyond military cooperation, it facilitates a transition from an asymmetric security relationship focused on threats to a strategic partnership based on mutual interests. This transformation blurs the line between security and economic cooperation, as well as the military and strategic partnership frameworks, introducing complexities in how the alliance functions.

By expanding cooperation into new areas and stretching the concept of the alliance itself, the global comprehensive strategic alliance framework may strain traditional alliance mechanisms that are not suited for addressing the evolving goals of an economic and technological partnership. Moreover, incorporating economic security into the alliance presents challenges insofar as conventional alliance theory is not designed to fully address the complexities of economic and technological interdependence. Such conceptual stretching raises pertinent questions. Do states behave like allies when engaging in technological cooperation? Are existing alliance mechanisms fit for the purposes of technological cooperation among allied states?

In attempting to answer these questions, various distinctive challenges stand out, highlighting South Korea's apprehensions regarding its partnership with the United States, particularly in the reconfiguration of semiconductor supply chains.

Entrapment-Abandonment Dilemma

One challenge relates to the broadening of the alliance into a strategic economic and technology partnership, which can lead to mixed signals among allies, particularly when their respective threat perceptions and economic security objectives differ. The United States and South Korea share common threat perceptions regarding China's illiberal practices in technological development, illegal theft, and economic aggression. However, US and South Korean threat perceptions diverge in terms of their nature and perceived urgency, which

highlights the challenge of adopting a unified approach. Washington is more concerned about the military implications of Beijing's semiconductor technology, while Seoul is more focused on the economic implications of Beijing's technological ascendancy. US initiatives to restrict China's access to cutting-edge semiconductor technologies are framed through a national security perspective, seeking to reduce dependency on China and enhance supply chain resilience.[36]

South Korea prioritizes economic interests, competitiveness, and its own manufacturing strengths in micro-process technology and memory conductors. South Korea's challenge lies less in China's rapid semiconductor advancements and more in the escalating US-China tensions. China remains the biggest market for South Korean semiconductor companies, with over 50 percent of semiconductor exports going to China.[37] While South Korea's security depends on the United States, South Korea's industry is heavily reliant on the Chinese market. This dual dependence puts South Korea in a diplomatic dilemma, caught between the competing interests of its key security ally and its largest trading partner.

The entrapment-abandonment dilemma complicates South Korea's strategic calculation. A state engaged in an alliance must constantly consider the prospect of being abandoned by its ally for non-cooperation while also being concerned about potential entrapment in its ally's disputes with other states.[38] As the United States pushes for closer technological cooperation and supply chain realignment, South Korea must balance its security commitments to the United States with its economic ties to China. Strong demands from the United States—a key ally—could pressure South Korea to compromise its policy autonomy and take the risk of being entangled in unwanted economic and technological conflicts that may not align with its national interests.[39] While participating in multilateral semiconductor cooperation talks, South Korea has kept a low profile, wary of becoming overly dependent on US-led initiatives and getting caught in the US-China tech rivalry.

One solution to this issue is strengthening shared understanding between Washington and Seoul regarding Beijing's economic coercion and introducing an economic version of extended deterrence. In 2017, South Korea faced China's coercive retaliatory measures following the deployment of the THAAD system, highlighting the critical need for defensive measures and the diversification of supply sources.[40] The US government's 2022 National Security Strategy also emphasizes China's coercive statecraft as a key reason to strengthen collaboration with allies and like-minded countries.[41] Therefore, sharing concerns regarding threats and reinforcing deterrence against common threats, particularly China's economic coercion, should be the primary focus of the technological alliance between the United States and South Korea.

Collective Resilience and Deterrence

Another challenge revolves around the alliance moving beyond the traditional US-led hub-and-spokes model to adopt more inclusive and flexible intra-spoke security frameworks that form a new regional security and economic architecture.[42] This architecture includes regional allies and partners joining multilateral economic and security platforms like the MSP and IPEF. While these initiatives aim to enhance supply chain resilience among US allies and reduce their over-dependence on critical materials in China, there is a limit to applying collective security to the economic and technology realm.

An alliance is traditionally built upon a legally codified, mutual defense commitment to come to a fellow alliance member's defense in the event of an external attack. Such treaty-based alliance commitments often result in a well-institutionalized division of labor, wherein each alliance members' respective authorities, roles, and responsibilities are clearly delineated. However, an economic and technological partnership is not based on a binding, formal agreement or well-institutionalized architecture. In the absence of a clear or well-institutionalized framework, establishing collective deterrence or formulating a collective strategy or response in the realm of economic security presents various challenges.

While allies and partners would be better off by cooperating, the collective action problem is exacerbated by their divergent perceptions and strategic objectives, prioritization of the immediate cost-benefit analysis of their national interests, and skepticism regarding the US political will to respond on their behalf in the event of Chinese economic coercion. In some cases, a coordinated retaliatory response would not benefit one's commercial interests. These various challenges are evident in the effort to reconfigure the semiconductor supply chain, including the failure to effectively establish a cohesive Chip 4 alliance.

The collective deterrence of and responses to economic coercion remain under-institutionalized. At the policy level, there is an ongoing discussion about how to institutionalize a collective response against China's economic retaliation. As Victor Cha suggests, collective resilience could "use the threat of punishment with trade retaliation to impose significant and unacceptable costs on China if it attempts to coerce others economically."[43] Yet, these policy initiatives have not yet fully materialized or been tested for tangible outcomes. The collective resilience platform suggested by the Group of Seven (G7) is not yet a firm base for collective defense, and thus, it will not resolve the collective action issue.[44]

Value-Based Alliance vs. Profit-Based Cooperation

The upgraded US-ROK alliance, within which shared values have gained prominence, presents another challenge. In an increasingly uncertain and unpredictable security landscape, alliances are advancing to minilateral groupings of like-minded countries that share values and a collective identity that emphasizes democratic governance and a rules-based international order that is free, open, prosperous, and secure. Economic and technology cooperation is increasingly linked with these shared values, which implicitly—and sometimes explicitly—calls for countering authoritarian states. A values-based alliance, however, does not always align with the economic incentives of the private sector. While governments focus on strengthening values-based cooperation for economic security, private firms primarily seek absolute profit, making it difficult to fully apply the logic of national security to private sector behavior.[45] In technological cooperation, corporate interests do not always coincide with state interests. Companies can and do resist costly measures like relocating production or changing suppliers, as these actions may conflict with their economic interests and shareholder expectations.

South Korean chipmakers have vigorously expressed concerns over the uncertainty surrounding US subsidies and competitive pressures in global markets.[46] These companies expect governments to provide clear incentives with subsidies or regulatory measures to align private sector actions with broader national security goals and de-risking strategies.[47] The cost of fully joining US-led efforts to reconfigure global semiconductor supply chains is that South Korean chip firms active in China will lose their largest market and will need to make up for the losses. The benefit, however, is that joining the US-led effort will help technological progress and enable Korea's involvement in the global semiconductor supply chain in the long run. Yet, as noted, the public and private sectors utilize different logics in their respective cost-benefit analysis. Whereas the government favors long-term benefits over short-term costs, the private sector favors maximizing benefits and minimizing costs.

Domestic Political Considerations

While deepening and broadening the alliance is feasible and desirable in today's complex security environment, there are additional challenges regarding domestic political considerations. South Korea's polarized domestic political environment presents obstacles to its commitment and cooperation

with the United States and Japan on advanced technologies. For one, Japan's imposition of export curbs in 2019 against South Korea on semiconductor fabrication materials left lasting mistrust and skepticism toward Japan as a collaborative partner. Moreover, US policies, such as the CHIPS Act, have been criticized as protectionist measures that favor US interests under the guise of semiconductor cooperation and supply chain resilience. Concerns about whether the United States was exploiting South Korea's vulnerable position were intensified by US National Security Advisor Jake Sullivan's comment that "the economic losses suffered by allied and partner countries for joining the US industrial policy driven by national security concerns should be considered as part of the shared defense burden."[48]

These concerns are compounded by the uncertainty surrounding the future direction of the incoming administration of President-elect Donald Trump. While the overall direction of the US economic security strategy focused on techno-nationalism and US-led supply chain reconfiguration is expected to persist regardless of the electoral outcome, Trump's specific approach likely will differ. Under Trump, there may be a shift toward more protectionist policies and fair-share rhetoric, which may strain alliances and disrupt existing frameworks of economic cooperation in the Indo-Pacific. A return to former President Donald Trump's China policy and America-First industrial strategy could possibly lead to a more radical agenda characterized by strategic decoupling, stringent high-tech controls and a resurgence of maximum pressure tactics.[49] Trump's campaign stance on reducing tax benefits for non-US companies and imposing stricter regulations on foreign investment is creating growing unease among semiconductor businesses in the United States.[50] Radical policy shifts in the next US administration could force the South Korean government to reassess its commitments and strategies within the alliance regarding advanced technology and supply chain cooperation.

Alliance Endurance

Alliances endure when they are founded upon common interests and objectives, dependability and credibility in commitments, equity in the benefits and costs, and strong domestic support.[51] An economic and technology partnership within the global comprehensive strategic alliance should, ultimately, be based upon the same tenets. States should have confidence that allies will honor their commitments, especially regarding mutual defense and the broader goals of the alliances. Strong leadership within the alliance is also needed to organize and coordinate the alliance's activities and maintain cohesion and commitment.

Additionally, domestic support for an alliance significantly impacts its endurance—leaders with strong public backing are better positioned to sustain commitments, while domestic opposition can pressure them to reconsider.

While the US-ROK alliance meets most of these conditions, there are some aforementioned concerns regarding diverging threat perceptions, credibility, collective deterrence, and domestic political dynamics within both countries. As the alliance evolves into a more nuanced relationship—one where reciprocity is needed in order to become more balanced partners on the global stage—the United States and South Korea should focus on mutual interests and common objectives in economic security rather than on countering external threats.[52] Thus, the alliance's sustainability and effectiveness will hinge on converging economic interests and strategic goals to enable deeper integration of supply chains and technological collaboration.[53]

Conclusion: Path for Further Progress

US-South Korea cooperation within a global comprehensive strategic alliance framework offers new opportunities. The broadened alliance framework provides Korea with a platform to deter emerging security threats and increase its capabilities and resilience in semiconductor supply chains and critical infrastructure. It also enables Korean chipmakers to participate in the emerging international semiconductor landscape, providing access to a secure and stable supply chain as well as new market opportunities. Furthermore, the alliance could provide South Korea with access to cutting-edge semiconductor manufacturing technologies and processes, enhancing its competitiveness in the global semiconductor industry in the long run. With the upgraded alliance, the United States can complete its semiconductor supply chain reconfiguration centered on allies and like-minded states, thus establishing a new order in the technological ecosystem that deters China's advancements and solidifies US leadership in the global CET market.

From an economic security perspective, the alliance provides a vital platform for strengthening integration, coordination, and joint initiatives between Washington and Seoul. The focus is on achieving a careful balance of mutual interests, clear communication, and adaptable strategies for semiconductor supply chain and technology cooperation. The policy recommendations outlined here are designed to be purposeful yet flexible, ensuring that both allies can effectively build on the progress already made within the given framework.

- ***Enhance bilateral strategic dialogues, such as the US-ROK Next Generation CET Dialogue, to regularly address semiconductor supply chain challenges and opportunities.***
  Such platforms should promote in-depth consultations on economic security perspectives, ensuring alignment on policies and minimizing friction. A key focus should be understanding how US industrial policies impact South Korea and how South Korean policies and chipmakers' behaviors should interact with US imperatives. Policy coordination must be continuous, with a commitment to building confidence and trust between the two nations.

- ***Encourage public-private partnerships to bolster the semiconductor industry's resilience, leveraging the strengths of both governments' support and industrial innovation.***
  Governments must engage with the private sector, which remains the primary driver of innovation in the technology industry, to encourage the diversification of supply chains. Government support is critical in providing incentives for the private sector while balancing security and competitiveness. A transparent and collaborative framework is essential to ensure effective public-private cooperation, with policies that maximize compliance and industry engagement.

- ***Strengthen the platform for consensus building and institutional development among allies and partners.***
  Enhancing trust-based bilateral and minilateral cooperation requires better intra-alliance politics focused on consensus building and institutional development based on shared interests and objectives.[54] Member states must engage in negotiation and compromise to build a shared vision for deeper cooperation and balance different power dynamics and divergent national interests involving burden- and cost-sharing. Intra-alliance politics should involve managing threat perceptions and reconciling these differences to agree on a unified strategic approach.

- ***Align and adapt toolkits for technology protection, including export controls and investment screening mechanisms, and build a collective defense mechanism to ensure a secure semiconductor supply chain.***
  Shared recognition and response to economic coercive measures should be institutionalized, with collective response principles and specific action plans. The agenda should include how to define unjust economic coercion and how to actively counter it in a collective manner among countries in similar situations. The United States should consider international collective deterrence measures to assure allies and partners partaking in the US-led supply chain and bolster its supply chain resilience.

The global comprehensive strategic alliance will serve as a vital platform that can further align and coordinate the shared interests of the United States and South Korea, advancing greater cooperation in supply chain management and technology. As both nations navigate the complexities of global economic shifts, this upgraded alliance will not only enhance their strategic capabilities but also foster innovation and resilience against potential economic disruptions. This proactive approach will pave the way for a more dynamic and mutually beneficial partnership, setting the stage for deeper engagement that goes beyond traditional security measures and ultimately contributes to shaping a new security architecture in East Asia.

Endnotes

[1] The United States and South Korea affirmed their commitment to build a constructive alliance based on "common values, trust, and peace." See The White House, "Joint Vision for the Alliance of the United States of America and the Republic of Korea," June 16, 2009, https://obamawhitehouse.archives.gov/the-press-office/joint-vision-alliance-united-states-america-and-republic-korea; Scott A. Snyder, *The US-South Korea Alliance: Meeting New Security Challenges* (Lynne Rienner Publishers, 2012); Seengho Shin, "A Smart Alliance in the Age of Complexity: In the 21st Century," East Asia Institute, June 1, 2009, https://www.eai.or.kr/new/ko/pub/view.asp?intSeq=12591&board=kor_issuebriefing%27,%27kor_workingpaper%27,%27kor_special%27,%27kor_multimedia&keyword_option=board_content&keyword=%EC%8A%A4%EB%A7%88%ED%8A%B8%20%EB%8F%99%EB%A7%B9&more=.

[2] In May 2022, Presidents Biden and Yoon agreed to further advance the alliance into a comprehensive global strategic alliance that envisions a heightened role in advancing freedom, peace, and prosperity in the Indo-Pacific region and beyond. See The White House, "The United States-Republic of Korea Leaders' Joint Statement," May 21, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/21/united-states-republic-of-korea-leaders-joint-statement/.

[3] June Park, "Is Economic Security National Security? Defining South Korea's Economic Security for Future Industries," *Korea Policy* 1, no. 3 (2023): 52–69; Junghyun Yoon, "Supply Chain Security in the Age of Techno-Geopolitics: 'FAB 4' Case in the Semiconductor Industry," *The Korean Journal of International Studies* 21, no. 1 (April 2023): 27–60.

[4] An alliance is a formal agreement between nations, usually in the realm of national security and mutual defense, that commits each nation to support the other in the event of external aggression or attack. In contrast, partnerships are less formal, help build relationships between nations without the need for a treaty with specific terms and conditions, and can be short term. See Claudette Roulo, "Alliances vs. Partnerships," US Department of Defense, March 22, 2019, https://www.defense.gov/News/Feature-Stories/story/Article/1684641/alliances-vs-partnerships/.

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[6] Since the WTO Information Technology Agreement entered in force in 1997, semiconductor-related products, materials, and equipment have been subject to the lowest tariff rates in global trade. See Il-seok Oh, "반도체 공급망 경쟁에 따른 디지털 진영화와 우리의 대응 [Digital Fragmentation Following Competition on Semiconductor Supply Chain and Our Response]," *The Institute of National Security Strategy Strategy Report*, no. 162 (2022): 1–26, https://inss.re.kr/upload/bbs/BBSA05/202205/F20220502165519492.pdf.

[7] Emily Benson, Catharine Mouradian, and Andrea L. Palazzi, "Toward a U.S. Economic Security Strategy," Center for Strategic and International Studies, July 9, 2024, https://www.csis.org/analysis/toward-us-economic-security-strategy.

[8] For instance, Korea's Framework Act on Supporting Supply Chain Stabilization for Economic Security defines economic security as a "state in which national security is maintained and economic activities are unhindered by ensuring the smooth inflow of essential items of the nation's economic activities and preventing inappropriate outflow, regardless of domestic and international variables." See Ministry of Foreign Affairs, "The Yoon Suk Yeol Administration's National Security Strategy," June 2023, https://www.mofa.go.kr/eng/brd/m_25772/view.do?seq=16&page=1.

[9] Jungmi Cha et al., "세계경제안보 현황과 한국경제안보에 대한 제언 [The Status of Global Economic Security and Recommendations on South Korea's Economic Security]," *The National Assembly Futures Institute Policy Report* 23, no. 14 (December 2023).

[10] The United States saw that China would be enlarging its military capabilities and engaging in overt conflict against its neighboring states to pursue regional hegemony, which could destabilize regional peace and weaken US influence over the region. The US National Security Strategy clearly indicates the change in US threat perception and the rationales for the strategic importance of alliances in the Indo-Pacific region. See The White House, "The National Security Strategy of the United States of America," December 2017, https://trumpwhitehouse.archives.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf; The White House, "National Security Strategy," October 2022, https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf.

[11] Legislation such as the Inflation Reduction Act (IRA) for batteries and rare metals and the CHIPS and Science Act for semiconductors serve such purposes.

[12] Paul Triolo "South Korea: Caught in the Crosshairs of U.S-China Competition Over Semiconductors," *Korea Policy* 1, no. 3 (2023). https://keia.org/publication/south-korea-caught-in-the-crosshairs-of-u-s-%E2%88%92china-competition-over-semiconductors/.

[13] Ausdrye Wong, "China's Perspective on Economic Security," *Korea Policy* 1, no. 3 (2023): 76–79. https://keia.org/publication/chinas-perspective-on-economic-security/.

[14] Kazuto Suzuki, "Japanese Economic Security as Derisking," *Korea Policy* 1, no. 3 (2023), 38-50 https://keia.org/publication/japanese-economic-security-as-derisking/.

[15] Kyusup Shin and Songyi Seol, "주요국의 반도체 산업정책과 공급망 변화 전망 [The Semiconductor Industrial Policy of Major Countries and Prospects of Changes to the Supply Chain]," *KITA Trade Report* 17 (2021), https://www.kita.net/pdf/iit/TR17_Semiconductor/index.html; Kangsun Shin and Soonjoo Koh, "주요국 반도체 정책과 AI반도체 정책에의 시사점 [Semiconductor Policies in Major Countries and Implications of AI Semiconductor Policies]," *Electronics and Telecommunications Trends Analysis* 39, no. 2 (April 2024), https://doi.org/10.22648/ETRI.2024.J.390207.

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[17] The Chips and Science Act raised USD 54.2 billion in funds to support the semiconductor industry. The bill includes USD 10 billion in federal grants and a maximum of 40 percent tax credit to encourage the establishment of semiconductor plants in the United States. Tax incentives were not only available to US companies (e.g., Intel), but eligibility was also extended to non-US companies. See The White House, "Fact Sheet: CHIPS and Science Act will lower costs, create jobs, strengthen supply chains, and counter China," August 9, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/.

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[31] US Department of Commerce, "Joint Readout: United States-Korea Supply Chain and Commercial Dialogue Ministerial Meeting," June 27, 2024, https://www.commerce.gov/news/press-releases/2024/06/joint-readout-united-states-korea-supply-chain-and-commercial-dialogue.

[32] The leaders' joint statement in April 2023 stated, "President Biden and President Yoon affirmed the need to make bold investments to build clean energy economies and to build and strengthen mutually beneficial supply chain ecosystems for our critical technologies. In that regard, the two leaders appreciated the recent efforts made by the ROK and the United States to alleviate concerns of Korean businesses over the Inflation Reduction Act (IRA) and the CHIPS and Science Act. The two Presidents committed to continue close consultations with a view to ensuring those Acts encourage mutually beneficial corporate investment in the United States by creating predictable conditions for business activities." See The White House, "Leaders' Joint Statement in Commemoration of the 70th Anniversary of the Alliance between the United States of America and the Republic of Korea," April 26, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/04/26/leaders-joint-statement-in-commemoration-of-the-70th-anniversary-of-the-alliance-between-the-united-states-of-america-and-the-republic-of-korea/.

[33] US national security "guardrails" attached to US funding for the semiconductor industry restrict South Korean companies applying for US funding from expanding chip-making capacity for advanced semiconductors in China by more than 5 percent of their current capacity for a duration of 10 years. See Ben Fackler et al, "CHIPS Act Guardrails: Congressional efforts to limit investment in China," Arnold & Porter, July 22, 2022, https://www.arnoldporter.com/en/perspectives/advisories/2022/07/chips-act-guardrails.

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[38] Glenn Snyder's theory of abandonment and entrapment elucidates the security dilemma within alliances. See Glenn Synder, "The Security Dilemma in Alliance Politics," *World Politics* 36, no. 4 (1984): 461–495.

[39] The autonomy-security trade-off thesis posits that alliances in which the major power offers security in exchange for concessions, which increase its freedom of action or influence over the minor power, may lead to entrapment. See James D. Morrow, "Alliances and Asymmetry: An Alternative to the Capability Aggregation Model of Alliances," *American Journal of Political Science* 35, no. 4 (1991): 904–933.

[40] Darren J. Lim and Victor A. Ferguson, "Informal Economic Sanctions: The Political Economy of Chinese Coercion During the THAAD Dispute," *Review of International Political Economy* 29, no. 5 (2022): 1525–1548.

[41] The White House, "National Security Strategy," 23-24.

[42] The hub-and-spokes system for alliances is a structure where a central power (the "hub") maintains separate bilateral relationships with several smaller, often weaker, allies (the "spokes") without the spokes having strong direct relationships or coordination with one another. This creates a centralized network in which the hub is the key player connecting all the spokes, allowing it to exert significant influence and control over the network, thus serving the US interests better than a multilateral alliance. See Victor Cha, "Powerplay: Origins of the US Alliance System in Asia," *International Security* 34, no. 3 (2009):158–196; Victor Cha, "Informal Empire: the Origins of the US-ROK Alliance and the 1953 Mutual Defense Treaty Negotiations," *Korean Studies* 41 (2017): 221–252.

[43] Victor Cha, "Collective Resilience: Deterring China's Weaponization of Economic Interdependence," *International Security* 48, no. 1 (2023): 91–124.

[44] Jaechon Kim, "한미동맹의 협력확장과 집단복원력 [The Expansion of Cooperation of ROK-US alliance and Collective Resilience]," Asan Institute for Policy Studies, October 20, 2023, https://www.asaninst.org/contents/한미동맹의-협력-확장과-집단-복원력collective-resilience/.

[45] Ling S. Chen and Miles M. Evers, "Wars without Gun Smoke: Global Supply Chains Power Transitions, and Economic Statecraft," *International Security* 48, no. 2 (2023): 173.

[46] Drawing on interviews with public and private stakeholders in Korea's semiconductor industry, it is evident that government and private companies view economic security differently. This is part of my current research project, titled "The Conceptualization and Operationalization of Economic Security in the Contemporary Context: South Korea's Economic Security in Semiconductor Supply Chain Reconfiguration."

[47] "삼성전자·SK하이닉스·TSMC까지…미국에 현지 공장, 돈 쏟아붓는 까닭 [Even Samsung Electronics, SK Hynix, and TSMC…Reasons for Pouring Money into US Factories]," *Kyunghyang Shinmun*, April 9, 2024, https://www.khan.co.kr/economy/economy-general/article/202404092132005.

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[49] Jungmi Cha, "트럼프 2.0 시대, 미중관계와 국제질서의 미래 [Era of Trump 2.0, US-China Relations, and the Future of the Global Order]," National Assembly Futures Institute, July 8, 2024, https://eiec.kdi.re.kr/policy/domesticView.do?ac=0000185979&pg=&pp=&search_txt=&issus=&type=&depth1=; Sungjun Park, "미국대선과 중장기 통상기조 [The US Presidential Election and Mid to Long-term Industrial Policy Principles]," National Assembly Futures Institute, August 26, 2024.

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[52] Junghyun Yoon, "기술지정학 시대의 반도체 공급망 재편과 대응전략 [A Review of Techno-Geopolitics: Semiconductor Supply Chain Restructuring and Strategic Considerations]," *Institute for National Security Strategy Report* 15 (2022), https://www.inss.re.kr/upload/bbs/BBSA05/202302/F20230209150444771.pdf.

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Canvasing Variations in US-South Korea Cooperation on AI and Quantum Technology

By Sanghyun Han

Introduction

The rapid development of AI technologies, exemplified by innovations like ChatGPT, has turned emerging technologies into critical instruments for states seeking to gain a competitive edge. As noted in the 2022 US National Security Strategy, "[t]echnology is central to today's geopolitical competition and to the future of our national security, economy, and democracy."[1] As a result, the notion of technology competition has become pervasive, with maintaining technological leadership now a key national objective. This competition spans both military and economic spheres, prompting governments to employ various tools—such as industrial policies—to either maintain or catch up with technological advancements. This dynamic is particularly evident in the US-China relationship, where competition over emerging technologies has become increasingly pronounced.

While technology is often seen as a tool of competition, it is equally a means of cooperation and collaboration. The complexity of global innovation ecosystems ensures that even in highly competitive fields, states must engage in partnerships and regulatory coordination to manage shared technological advances responsibly. Despite efforts by states to achieve self-sufficiency in critical technologies, the global value chain makes it virtually impossible for a single state to develop entire technological ecosystems independently. While some states strive for autarky in areas crucial to their security, full self-reliance remains impractical. This interconnectedness drives states to implement regulatory policies, such as export controls and lists of critical and emerging technologies, to limit the unintended diffusion of sensitive knowledge and research. However, the requirements for coordinating multilateral approaches highlight the challenges of any single state maintaining predominant influence over technologies, emphasizing the necessity of international cooperation in technology regulation.

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Before presenting an analysis of AI and quantum technology cooperation between the United States and South Korea, or the Republic of Korea (ROK), two key points need clarification. First, technology cooperation refers to collaborative efforts between two governments, including administrative bureaus focused on a specific technology, and cooperation involves adjusting and coordinating policies to achieve mutual objectives.[2] Therefore, technology cooperation, as defined here, emphasizes joint efforts between governments in pursuit of shared goals to develop and cultivate certain technologies. Under this approach, private sector-led cooperation or partnerships between a national government and private firms from another state are not included as a type of technology cooperation unless these initiatives are elevated or strongly endorsed by both governments. This is not to suggest that private sector-driven technology cooperation is insignificant or lacking in importance, but this distinction ensures that this article's analysis focuses on official state-level interactions and their alignment with national objectives rather than purely private-sector engagements.

Second, the data used in this article serves as a proxy indicator to measure technology competency, but it is neither comprehensive nor robust enough for a definitive analysis. These sources primarily assess technology capacities by focusing on research metrics, such as citation impact, researcher affiliations, and even LinkedIn-listed skillsets. For example, the OECD AI Policy Observatory measures AI human resources by counting LinkedIn profiles that list AI engineering and AI literacy as skills. Similarly, the Emerging Technology Observatory's Country Activity Tracker data tracks contributing authors' affiliations, using higher citation counts to avoid duplication.[3] While useful for identifying comparative technical advantages, these indicators have limitations. They often overlook critical factors like regulatory frameworks, infrastructure, human resources, and education systems, which are essential for a holistic understanding of technological capacity. Despite these limitations, the data provides valuable insights into the comparative strengths of different states in emerging technologies.

This article outlines the current landscape of technology competencies in AI and quantum technologies in the United States and South Korea while providing a brief introduction to each technology and examining trends in bilateral cooperation in these fields. While building domestic technological capabilities through policy initiatives and infrastructure offers significant potential and leverage for technology cooperation, this article focuses on bilateral cooperation rather than unilateral efforts to illustrate the landscape of technology collaboration between the United States and South Korea. In AI, the United States holds a dominant leadership position, while South Korea

demonstrates strengths in certain areas, though not across the board. Cooperation in AI primarily focuses on standardization efforts, with significant involvement of the South Korean government in partnership with the US private sector, as well as private-sector-led bilateral research initiatives. In contrast, South Korea's capabilities in quantum technologies are far more limited. Nevertheless, cooperation in this domain is largely centered on research collaboration, with both governments actively participating alongside international research consortia led by the United States. The differing focuses—standardization in AI and research collaboration in quantum technologies—reflect the respective strengths and needs of the two countries in these critical fields. Emphasizing the necessity to secure competent human resources based on both states' environments, this article offers policy recommendations to enhance technology cooperation between the United States and South Korea, from expanding research collaboration to adopting multilateral approaches through existing and new initiatives.

Artificial Intelligence

What is AI?

Generally speaking, AI is "a set of technologies that enable computers to perform a variety of advanced functions," imitating the way a human mind thinks and makes a decision.[4] Similar to how neurons in the human brain transmit stimuli through synapses, artificial neural networks mimic this structure to transform information from input to output layers. While definitions of AI vary, they typically center on three components: data, algorithms, and computing capacity.[5] Data serves as the foundation for analysis, while algorithms, consisting of a series of defined steps, guide the machine in achieving specific objectives. Essential to this process is computing capacity, as greater and faster processing capabilities allow AI to handle more sophisticated tasks.[6] A notable example of contemporary AI is large-language models like OpenAI's ChatGPT, which generate responses to prompts based on extensive training data.

AI's ability to analyze vast amounts of data and support decision-making with accuracy makes it an adaptable and foundational technology across various fields. In this sense, AI is anticipated to bring significant transformation to society and the global community, leading to its application across various fields. Private sector entities such as Bloomberg and JP Morgan, as well as the US government, including the Department of Homeland Security, have developed or adopted AI-powered models. Notably, the Joe Biden administration has committed to integrating AI technologies into national security activities, signaling an increase in government adoption and usage.[7]

Technology Competency

Both the United States and South Korea possess significant capabilities in AI technologies, though the United States has a clear advantage. In July, the ROK Ministry of Science and ICT (MSIT) published the *Global R&D Strategic Map*, which assessed technological advancements, research output, and commercialization stages across various countries.[8] The United States was found to dominate in all AI-related disciplines while South Korea ranked fifth or sixth in four different sectors—AI infrastructure, AI modeling and decision-making, safe and trustworthy AI, and innovative AI—among 12 countries. Notably, the gap between the United States and South Korea in terms of AI capacity ranged from four to nine times, with China ranking second in all categories but still trailing significantly behind the United States. This suggests that while the United States is the undisputed leader in AI, other countries, including South Korea, occupy limited but relatively robust capacity compared to the top two players, the United States and China.

Similarly, according to the *Top-Ranked AI Nations* (TRAIN) Scorecard, published by Tufts University's Digital Planet project, South Korea ranks ninth out of 25 leading AI nations, while the United States holds the top spot, followed by China.[9] South Korea's strengths lie in data and capital drivers for AI technology, highlighting the country's ability to generate vast, complex datasets and its resources in terms of human capital, financial investments, and computational capacity. However, South Korea scores lower in areas related to rules and innovation, reflecting strong digital infrastructure but limited research output and administrative support in the form of stringent regulatory policies and privacy protections. Furthermore, data from the *Country Activity Tracker for AI* (CAT-AI) shows that US researchers collaborate most frequently with China, while South Korea ranks seventh in collaborations with the United States, whereas the United States is South Korea's top research partner in AI.[10] While both countries possess AI technology competencies, South Korea's capabilities are relatively lower than those of the United States, which is likely to influence the dynamics of their collaboration.

AI Technology Cooperation

When Washington and Seoul opened a "new chapter" of their alliance in 2021, it marked the first time that AI was recognized in a joint statement as part of emerging technologies.[11] During South Korean President Yoon Suk-yeol's first visit to Washington, DC, in 2022, AI was again mentioned in the joint statement, emphasizing the need for "public and private cooperation to protect and promote critical and emerging technologies."[12] Despite sporadic cooperation in the private

sector driven by industrial demand, which will be discussed in the following section, national-level AI cooperation remains relatively late and limited.

The principle of AI cooperation was also articulated in the joint statement among the United States, South Korea, and Japan at Camp David in August 2023. The leaders recognized AI as "a transformative technology" and agreed to facilitate international governance and develop safe, secure, and trustworthy AI.[13] Publishing such a joint statement requires extensive negotiation, which suggests that AI cooperation—at least for these three countries—focuses on building international governance and ensuring safety and trust in AI. This broad direction was reiterated in the follow-up U.S.-ROK Information and Communications Technology (ICT) Policy Forum led by US Ambassador at Large for Cyberspace and Digital Policy Nathaniel Fick and ROK Vice Minister of Science and ICT Yun-Kyu Park. They reaffirmed an "inclusive approach to developing AI governance that supports the development of trustworthy AI" and highlighted the "need for global discussions on principles" to address challenges posed by emerging technologies.[14]

The inaugural U.S.-ROK Next Generation Critical and Emerging Technologies (CET) Dialogue in December 2023 included a section titled "AI and Standards," announcing the launch of a bilateral AI working group to develop international standards, advance joint research, and foster interoperability in AI policies.[15] The dialogue also called for a rapid conclusion of the Memorandum of Understanding (MOU) between the US National Institute of Standards and Technology (NIST) and the Korean Agency for Technology and Standards (KATS), both responsible for technological standardization.

AI cooperation on standardization culminated in the 2024 U.S.-Korea Standards Forum, where national standard development organizations signed an MOU to share strategies for emerging technologies and exchange knowledge.[16] Both the United States and South Korea play crucial roles in AI standard setting. The American National Standards Institute (ANSI) serves as the secretariat for the International Organization for Standardization/International Electrotechnical Commission's Joint Technical Committee 1/Subcommittee 42 (ISO/IEC JTC 1/SC 42), the first international body to establish AI standards, while KATS hosted the most recent plenary session of SC 42 in April 2024. Additionally, SC 42 approved ISO/IEC 5259-1:2024, focusing on data quality assessment, a standard led primarily by South Korea.[17] While this particular standard may not result directly from bilateral cooperation, the active participation of both states in the subcommittee and their ongoing communication through various channels is likely to facilitate the process of standardization.

National-level technology collaboration is still in its early stages. Beyond bilateral cooperation, a notable initiative began in December 2023, when the United States, South Korea, and Japan agreed on a trilateral framework for CETs based on "mutual benefit, equality, and reciprocity."[18] This initiative was formalized in April 2024, with representatives from the three countries signing a memorandum of cooperation (MOC) involving three US national laboratories (Los Alamos, Sandia, and Lawrence Livermore).[19] According to a press briefing by MSIT, the joint steering committee will prioritize suggestions from experts in the three countries, focusing on human resource exchange, the use of national research facilities, information sharing, and joint research. While this initiative underlines the importance of joint research and development (R&D) among the three countries, details such as the specific technologies for cooperation or the approach to joint research remain unclear. The briefing also indicated that discussions are ongoing, with no concrete timeline or specific technologies decided yet.[20] Although it is premature to conclude that technology collaboration is a lower priority than AI standardization, the latter appears to be more active and well-established between the United States and South Korea.

In addition to AI standardization efforts, both countries emphasize leading international discussions and hosting forums. For instance, the United States announced the Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy, while South Korea co-hosted a series of AI summits with the United Kingdom and the Responsible Artificial Intelligence in the Military Domain (REAIM) Summit, which stems from the US-led declaration.[21] While these initiatives focus more on normative approaches than standardization, they share the common goal of fostering dialogue and cooperation among multiple states. The earlier a state participates in such discussions, the better positioned it is to influence the global agenda and shape emerging norms. By initiating international norms, both the United States and South Korea align their efforts with broader technology cooperation, prioritizing these discussions as a way to influence global standards over direct technological development.

Another form of technology cooperation is the South Korean government's support for the US private sector. The ROK Ministry of Trade, Industry and Energy (MOTIE) established the Korea AI and System IC Innovation Center in San Jose, California, in September to promote collaboration between the United States and South Korea, focusing on AI-advanced semiconductors. Five US firms are currently based in the center and receive support from MOTIE.[22] Additionally, MOTIE announced an investment of USD 505 million

over five years to fund 45 projects through Global Industrial Technology Cooperation Centers (GITCC). These centers, in partnership with prominent research universities, aim to accelerate joint R&D, facilitate expert exchanges, and secure and internalize original technologies.[23]

A more advanced cooperative initiative is the Global AI Frontier Lab in New York, jointly funded by MSIT (USD 33.8 million) and NYU (USD 31.5 million). This lab is part of the broader ROK Institutions-NYU AI and Digital Partnership, which also established research collaborations with the Korea Advanced Institute of Science and Technology (KAIST). Based on a memorandum of agreement signed in May 2024, the initiative will focus on fundamental, convergent, and responsible AI research over a six-year term.[24] While the Korea AI and System IC Innovation Center provides financial and administrative support to firms, the Global AI Frontier Lab exemplifies collaborative technology development. The specifics of joint research will be determined by a selection committee, but the existing 12 joint projects between KAIST and NYU outline the nature of this collaboration.[25]

Despite the early stage of AI technology and its implications for cooperation, US-South Korea AI collaboration emphasizes the development of international standards for secure and trustworthy AI, while joint practical technology development remains limited. This approach was highlighted during the first AI working group session in May, led by Acting Special Envoy for Critical and Emerging Technology Seth Center. The meeting covered key topics such as South Korea's hosting of international AI summits, AI standards, policy interoperability, and global governance.[26] While research collaboration was mentioned, the emphasis remains on standardization and multilateral engagement rather than direct joint development. Current government-led AI initiatives lack detailed bilateral research engagement, with much of the cooperation focusing on the South Korean government partnering with US universities rather than fostering comprehensive government-to-government collaboration. Further advancements in AI cooperation are anticipated, but the existing framework remains primarily focused on standardization rather than on direct technology development.

Quantum Technology

What is Quantum Technology?

Quantum technology, which encompasses the application of quantum physics principles, has diverse applications across various fields. Quantum

information science, focusing on technical applications in information technology, is defined in the 2018 National Quantum Initiative Act as "the use of the laws of quantum physics for the storage, transmission, manipulation, computing, or measurement of information."[27] Additionally, quantum technology can be applied in areas such as encryption, communications, optics, sensing, and materials.

The three key areas of quantum technology are computing, sensing, and communication. Quantum computing transforms conventional binary bits, represented as 0 or 1, into quantum bits (qubits), allowing these bits to exist in superposition, which significantly enhances computational capacity and efficiency. This increased capacity enables private sectors to calculate vast combinations and possibilities. For example, manufacturers such as Volkswagen and Airbus use quantum computing to evaluate optimal chemical compositions for electric vehicle batteries or the most efficient flight paths.[28] Second, quantum sensing leverages the sensitivity of quantum states to environmental changes, enabling high-resolution and precise measurements. Atomic clocks, for instance, use quantum transitions in atoms to provide highly accurate time measurement, which is essential for applications requiring precise synchronization, such as satellite navigation and energy network management.[29] Quantum communication enables faster and more secure data transmissions. In this method, the key for decrypting data is generated by qubits, ensuring virtually unbreakable security against hacking attempts. One prominent application of this technology is quantum key distribution, which supports secure communication by leveraging the principles of quantum mechanics.[30]

In addition to economic opportunities in the private sector, quantum technology's broad range of applications has drawn significant interest from national security sectors, particularly for its potential in military and security affairs.[31] Quantum computing can enhance computational capacity, enabling militaries to optimize logistical routes and simulate complex tactical scenarios. Meanwhile, quantum communication and sensing are vital for secure data transmission and accurate environmental detection, making them essential capabilities for national security.

Technology Competency

The global landscape for quantum technology differs significantly from that of AI, with South Korea demonstrating marginal capacity in quantum technologies. According to MSIT analysis, the country ranks last in all key quantum

disciplines—quantum computing, quantum communication, and quantum sensing.[32] This is in stark contrast to South Korea's stronger performance in AI technologies. Furthermore, the United Kingdom's quantum strategic document highlights that South Korea is not particularly specialized in quantum technology, as evidenced by its relatively low international patent activity in this field.[33] This limited capacity is also reflected in the Australian Strategic Policy Institute's Critical Technology Tracker (CTR), which further underscores South Korea's weak position in the global quantum technology landscape.[34]

US and Chinese leadership in quantum technology present a perplexing picture, with varying analyses offering different perspectives. Although this illustration may not be directly relevant to US-ROK cooperation in quantum technologies, the distinct environment, especially when compared to the AI field, suggests that South Korea must consider additional factors in its technology development strategy. While some sources, like the MSIT analysis, assert that the United States leads in all key areas—quantum computing, quantum telecommunications, and quantum sensors—others highlight China's rapid progress, particularly in quantum communication. Despite a significant gap in quantum computing and sensing, China is portrayed as quickly closing in on US leadership.

In contrast, the CTR data suggests that China has already surpassed the United States in post-quantum cryptography, quantum communication, and quantum sensors, using research paper citations to measure progress. This dataset, which tracks both yearly and cumulative research outputs, reveals that the United States originally held dominance in these areas, but China has gained ground, especially in quantum communication and sensors. The Australian government further documents that China now leads in quantum research, commercialization, and international collaboration.[35] On the other hand, analyses by the Information Technology and Innovation Foundation and the Center for Strategic and International Studies counter these claims, asserting that the United States still maintains an edge in specific areas such as quantum computing. These reports emphasize that China's advancements are heavily driven by state-led investment and government funding, which have played a crucial role in propelling its quantum technology innovation. This divergence in assessments underscores the ongoing competition between the United States and China, each excelling in different aspects of quantum technology.[36]

Quantum Technology Cooperation

Compared to AI cooperation, quantum technology collaboration between Washington and Seoul focuses more on joint R&D. Recognized in the May 2022

joint statement, quantum technology is the only area explicitly highlighted in the subsequent meeting between Alondra Nelson, head of the US Office of Science and Technology Policy (OSTP), and Jong-ho Lee, ROK Minister of Science and ICT.[37]

Subsequent joint research initiatives include the establishment of the Korea-US Quantum Technology Cooperation Center in Washington, DC. This center serves as a research platform connecting research and commercialization efforts in both countries, organized into six principal research clusters with funding of approximately USD 4.5 million in 2022.[38] Additionally, South Korea joined the Entanglement Exchange, an initiative aimed at facilitating international quantum technology cooperation by creating "a portal for highlighting international exchange opportunities for students, postdocs, and researchers in quantum information science."[39] Initiatives such as establishing research centers and gaining memberships expand South Korea's research infrastructure into the United States, serving as a foundation for promoting research and human resource exchanges.

The joint statement between the US OSTP and ROK MSIT in April 2023 highlights the unique trajectory of quantum technology cooperation. Recognizing quantum information science and technology (QIST), the statement enunciated that this cooperation is rooted in the bilateral Scientific and Technological Cooperation Agreement, which aims to foster technological collaboration between the two countries.[40] The joint statement provides a more solid foundation for quantum cooperation compared to other areas. While the agreement broadly defined cooperation without specific initiatives, the joint statement aims to seek "collaborative and transnational efforts in research and development are important to accelerating innovation" and "the identification of overlapping interests and opportunities for future scientific cooperation."[41] The recognition of this agreement provides a robust and formal foundation and authenticates the rhetoric in the joint statement.

In particular, the 11th joint committee meeting (JCM) on science and technology, convened under the cooperation agreement, also featured a dedicated roundtable involving researchers and government officials, emphasizing the prioritization of quantum technology in collaborative research efforts.[42] The US-South Korea quantum roundtable, hosted by the US National Science Foundation (NSF) and MSIT, emphasized both nations' commitment to advancing quantum technologies through collaborative research and researcher exchange programs. With the US delegation led by US Science Envoy Prineha Narang and the participation of private sector leaders such as IBM, both countries agreed to strengthen joint efforts by exploring new research areas and opportunities for future collaboration.[43]

Akin to AI cooperation emphasizing standard-setting, the scope of bilateral technology cooperation includes standardization and technology protection. In February 2024, South Korea assumed the chair position of the ISO/IEC Joint Technical Committee on Quantum Technologies.[44] At the U.S.-Korea Standards Forum in June 2024, certain quantum technologies were prioritized due to the nascent state of quantum standards. Specifically, US and South Korean standard development organizations identified post-quantum cryptography and quantum secure communications as strategic areas for cooperation.[45]

However, exploring joint R&D opportunities remains the primary focus and produces more tangible outcomes than other types of cooperation, such as standardization. These cooperation efforts were reinforced during the inaugural U.S.-ROK Next Generation CET Dialogue.[46] One of the three initiatives highlighted in the statement involves research collaboration between the US NIST and the Korea Research Institute of Standards and Science (KRISS) on next-generation superconducting quantum computing. This collaboration is detailed in the amendment to their existing MOU, which includes projects such as the "development of advanced precision RF measurement technologies" and "qubit readout and control for scalable low-latency qubit feedback." The commitment to joint research was further supported during a July 2024 meeting between the US NSF Director and the ROK Minister of Science and ICT, where Minister Lee proposed new joint research initiatives in quantum and biological technologies.[47]

Quantum technology cooperation—similar to AI cooperation—involves initiatives beyond the state level, including third-party states and private sectors. Universities in South Korea (Yonsei University and Seoul National University), Japan (Keio University and the University of Tokyo), and the United States (University of Chicago) have formed a partnership, supported by IBM, to provide training in quantum computing for approximately 40,000 students over the next decade.[48] The trilateral education and training initiative, which aims to "train a quantum workforce and strengthen [their] collective competitiveness," was also recognized at the trilateral meeting between the three countries' national security advisors in January 2024.[49] In addition, the United States recently established the Quantum Development Group, led by Deputy Secretary of State Kurt Campbell, with eight participating countries, including South Korea, to foster "coordinated approaches" and facilitate R&D collaboration in quantum technologies.[50]

Despite active multilateral and private-sector-led initiatives, bilateral cooperation in quantum technologies between the United States and South Korea focuses predominantly on tangible research projects. This is distinct from AI cooperation, which prioritizes standardization, governance, and the

establishment of international norms. Quantum technology collaboration, on the other hand, is rooted in the foundational Scientific and Technological Cooperation Agreement, a formalized framework that enables long-term joint research initiatives. This presents a contradiction to AI cooperation in that both states prioritize the creation of new knowledge and capabilities through hands-on scientific collaboration. At the same time, this practical focus reflects the fact that quantum technologies are still in the early stages of commercialization and require significant R&D to mature. Therefore, bilateral quantum cooperation is centered on pooling resources, expertise, and infrastructure to push the boundaries of quantum research rather than on governance or standardization efforts that dominate AI discussions. This cooperative research-driven approach helps both countries build capacity in quantum technologies.

Policy Recommendations

Beyond the formality of technology cooperation, cooperation also must prioritize human researchers, as they are the driving force behind technological innovation and advancement. Securing highly skilled researchers and providing education to cultivate future talent is critical, and cooperation between the United States and South Korea is no exception in this context. For instance, in the field of quantum computing, with the top 25 percent of most cited papers, the largest number of highly cited researchers begin their education in China (22.6 percent), but a significant portion ends up employed in the United States (31.2 percent). Similarly, in machine learning, most researchers start their education in China (22.5 percent), yet the United States again leads in attracting top talent, employing 25.3 percent of researchers.[51]

This trend, consistent across various subfields of AI and quantum technologies, highlights the United States' ability to attract both domestic and international researchers, whereas China is less competitive in retaining top talent. Meanwhile, South Korea has been relatively successful in retaining researchers trained domestically, although the overall number is small, and there is minimal inflow from other countries. This analysis suggests that both the United States and South Korea can enhance their research environments by building on their respective strengths—whether it be the United States' ability to attract global talent or South Korea's effective cultivation of homegrown researchers.

Acknowledging the significant disparity in technology competencies between Washington and Seoul, which makes genuine reciprocal cooperation challenging, this article provides policy recommendations for advancing AI and quantum technology cooperation.[52] First, regarding AI, the two countries

should engage actively in initiatives and processes of the Global Partnership on Artificial Intelligence (GPAI) to foster the development of secure and reliable AI systems. In addition to leveraging existing international summits and collaborating through these venues, both countries are founding members of the GPAI. Initially established as an independent international organization, GPAI has since been incorporated under the OECD's umbrella, broadening its influence and collaborative scope. As a "unique initiative for global multi-stakeholder cooperation on AI," GPAI is committed to promoting trustworthy, human-centric AI while addressing the challenges and transformative impact of the technology.[53] Given that China and Russia are not members of GPAI (as of November 2024), US and South Korean participation is crucial for shaping global AI norms and ensuring that both countries influence the ethical, technical, and policy frameworks that govern the development and use of AI technologies.

Second, both states should actively participate in and lead dialogues, workshops, and conferences within the ISO/IEC JTC 1/SC 42, the primary forum for discussing AI technical standards. Given that the United States serves as the secretariat, the two countries' leadership is crucial to ensure that their approaches to AI development are reflected in universal standards. While serving as the secretariat may not directly enhance cooperation due to its neutral role, its responsibilities, such as circulating agendas and organizing meetings, can play a crucial role in facilitating cooperation on standards. Although the adoption of these standards is voluntary, they serve as foundational principles for guiding the development of AI technologies globally. As complementary leaders in AI, the United States and South Korea should collaborate to align their efforts, ensuring a unified approach to technical and ethical standards.

Lastly, both governments should aim for more robust governmental cooperation or elevate private-sector-led collaborations to a national level. AI cooperation between the United States and South Korea has been largely driven by private sector initiatives or by the South Korean government partnering with US companies, such as the above mentioned cases of the Korea AI and System IC Innovation Center, GITCC, or Global AI Frontier Lab. Expanding these efforts to government-level collaborations would help strengthen joint R&D programs, supporting the commercialization and practical implementation of AI technologies. Deeper cooperation would not only accelerate technological advancements but also bolster joint initiatives for AI standardization.

For quantum technologies, where both states are already engaged in collaborative research, there is potential to expand cooperation on a broader scale with like-minded partners. The Quantum Economic Development Consortium (QED-C), established under the US National Quantum Initiative Act, serves as a multi-stakeholder platform that brings together the private and public sectors. Initiatives like the Quantum Development Group, which was launched by the US Department of State, and the Entanglement Exchange, which facilitates exchanges of international researchers in quantum technologies, are instrumental in fostering deeper cooperation. Both the United States and South Korea can leverage these frameworks to enhance their collaborative efforts, broadening the scope of joint research and innovation in quantum technologies while ensuring alignment with global quantum technology developments. Expanding these partnerships will not only accelerate technological advancements but also position both nations as key players in the evolving global quantum landscape.

South Korea can also expand cooperation in quantum technologies to multilateral platforms. Following individual bilateral dialogues on emerging technologies between the United States and both South Korea and India, the three countries initiated a trilateral technology dialogue centered on complementary agendas and technical capabilities.[54] Following the launch of the Korea-US Quantum Technology Cooperation Center in Washington, DC, South Korea has chosen Brussels as the location for its second Quantum Technology Cooperation Center, focusing on partnerships with European countries.[55] With five ongoing joint projects involving Switzerland, the Netherlands, Germany, Israel, and the United Kingdom, South Korea can coordinate its research initiatives across Washington and Brussels in a manner similar to the trilateral dialogue on emerging technologies with the United States and India. This strategic alignment will facilitate the exploration and development of further opportunities in quantum research, strengthening South Korea's role in the global quantum technology ecosystem.

Conclusion

This article elucidates how Washington and Seoul cooperate on AI and quantum technologies, both recognized as critical emerging technologies essential to their national interests. Here, technology cooperation is denoted as government-to-government efforts aimed at cultivating and developing technologies, focusing on national strategies and interests rather than the profit-driven motives of the private sector. In AI, US-South Korea cooperation emphasizes the establishment of standards over direct joint research, aligning

with the common framework of data, algorithms, and computing capacity. South Korea, with demonstrated competency in AI as evidenced by various data sources, prioritizes standardization as a strategic approach alongside the United States. In contrast, South Korea's capabilities in quantum technologies are limited, with the United States and China regarded as global leaders. Bilateral cooperation in this domain focuses on joint R&D through national research institutes and participation in multilateral or international research initiatives. These efforts are supported by formal agreements on science and technology cooperation between the two nations, providing a stable and long-term foundation for collaboration in quantum technology.

The US-ROK alliance originated from the security threat posed by North Korea during the Korean War and is rooted in the Mutual Defense Treaty of 1953. However, the alliance has evolved alongside shifts in the geopolitical landscape. North Korea's development and testing of nuclear weapons, the rise of China and its challenge to US global leadership, and the ongoing war in Ukraine have all influenced the focus of the alliance. Additionally, the signing of the Korea-US Free Trade Agreement (KORUS FTA) in 2007 has strengthened economic ties, positioning the United States and South Korea among each other's top trading partners.

While security threats to South Korea remain significant, the US-ROK alliance has evolved into a broader framework that extends beyond security and economic matters to include technological cooperation based on shared norms and principles. Ideological solidarity, underpinned by democratic values and support for a market economy, has contributed to the alliance's resilience.[56] The progression of the US-ROK alliance in this direction is both natural and beneficial, as the development of advanced and sophisticated technologies is increasingly beyond the capacity of any single state alone. Autarkic policies in technological development are unlikely to succeed in the current global landscape. Fostering technological growth requires cooperation between like-minded states and collaboration with various stakeholders. As AI and quantum technologies are critical areas of focus for many countries, advancing technology cooperation is the next step for the US-ROK alliance.

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Clean Energy Pragmatism as a Spark for US-South Korea Relations

By Elan Sykes

Introduction

Climate change and threats to energy security and supply chains present global challenges that no single country can solve alone. Moreover, as US-China competition intensifies and draws in shared trading partners, policymakers and private investors around the world are struggling to adjust. Cooperation between allies like the United States and South Korea, or the Republic of Korea (ROK), can serve as an engine for progress in the face of these growing challenges.

The United States and South Korea—both early in the process of enacting meaningful domestic climate policy and committed to cooperation on climate as well as energy security and supply chain resilience—are uniquely positioned to harness their alliance capabilities and advanced industries to overcome obstacles in the clean energy transition. Clean energy pragmatism, defined here as a willingness to use a range of politically viable and flexible policy tools to drive technology deployment and encourage private innovation and investment in all potential clean energy solutions, should serve as the animating principle of US-South Korea climate cooperation.

This paper will first explore clean energy pragmatism in the bilateral context and apply its framework to three technologies: batteries, hydrogen, and nuclear power. The US-ROK alliance has successfully produced massive joint investments in the beginning and end stages of the battery supply chain. Both are members of the multilateral Minerals Security Partnership (MSP) to cooperate with resource-rich countries in supplying critical raw inputs. Additionally, joint investment between US and Korean firms in battery cell and pack assembly are larger than those of any other US ally, yet both countries will need to expand refining capacity that turns raw minerals into usable materials for batteries in the critical "midstream" step currently dominated by China. In clean hydrogen, joint research to drive innovation, push down the cost of equipment, and align accounting

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standards would help cultivate the sector into a cost-competitive climate solution and replacement for existing carbon-intensive hydrogen. Cooperation on nuclear power has been successful between the two governments but contentious in the private sector. Resolving these roadblocks and working together on expansion and exports could provide both countries with a vital source of reliable, zero-carbon electricity to fuel new load growth from electrification, new climate applications in hydrogen and direct-air capture, and rising demand for information and communication technology (ICT).

Bilateral and Multilateral Commitments to Climate Cooperation

The United States and South Korea are two of the world's largest economies, powered by energy systems releasing the second- and eleventh-most greenhouse gas (GHG) emissions in the world.[1] Their respective domestic climate and energy policies remain contested but have seen major transformation under current leadership. The US Congress passed, and President Joe Biden signed into law, the Inflation Reduction Act (IRA), which included the largest public appropriation for clean energy in US history, along with the bipartisan Infrastructure Investment and Jobs Act (IIJA) and CHIPS and Science Act, that is driving massive new investments across a wide range of technologies. Initial estimates suggest a total public investment of USD 790 billion in IRA clean energy spending and an annual emissions reduction of roughly 40 percent by 2030.[2] Those modeled emissions projections depend on an unprecedented pace of deployment, which could face constraints due to long permitting timelines and slow-moving electric grid expansion and interconnection.[3] More importantly, the fate of the entire IRA under the second Donald Trump presidency remains unclear. Nobody can predict whether private energy sector support, subsidized investments in Republican districts, or technology competition with China will win the fight to protect its core policies from factions of the Republican party that pursue energy policy through a culture war lens or represent fossil fuel producing districts.

In Korea, President Yoon Suk-yeol and the People Power Party (PPP) have retained much of Korea's long-standing climate policy regime, including topline targets for net-zero emissions by 2050, green spending plans, and the country's cap-and-trade system (Korean Emissions Trading Scheme, or KETS), while adjusting interim GHG targets and reversing a major plan from the previous Moon Jae-in administration to phase out nuclear power and rapidly deploy renewables. Both the earlier renewables-focused Ninth Basic Plan for Long-Term Electricity Supply and Demand (BPLE) and the Yoon administration's current Tenth BPLE would partially phase down coal generation by 2030.[4] Notably, the Tenth BPLE goes further in coal reduction and cuts the projected

renewable share of the 2030 generation mix, making up the difference with additional liquefied natural gas (LNG) imports and nuclear power expansion. Internationally, President Yoon has sought to recruit public-private partnerships in a new Carbon-Free Alliance, led by former Intergovernmental Panel on Climate Change (IPCC) Chair Lee Hoe-sung, to encourage the consumption of all sources of zero-carbon energy, including renewables, nuclear, and hydrogen, though only Korean firms have thus far joined.[5]

Following the PPP loss in the 2024 National Assembly elections and a Supreme Court ruling against President Yoon's interim climate targets, the foreseeable future of Korea's climate policy will require pragmatism and cooperation, not just with international partners but also with the domestic opposition. Finding ways to reduce polarization and credibly commit to the continued use of nuclear power will be necessary if Korea wishes to maintain its export-oriented industrial sectors and produce sufficient clean electricity to support them.

Neither the United States nor South Korea will be able to develop all of these technologies alone, nor could they direct all the capital necessary to deploy clean energy at the scale and pace required to meet global climate targets and mitigate the worst impacts of climate change. The IRA has unleashed huge Korean investments in US battery and electric vehicle (EV) factories, and the US-Korea free trade agreement (FTA) allows Korean products to claim higher subsidies than producers from countries without FTAs, like China or the European Union. Korea's export-oriented production of primary industrial materials, such as steel and chemicals, and heavy or advanced machinery, including ships and electronics, serves a vital role in providing like-minded democracies with alternative supply chains not controlled by China.

Presidents Biden and Yoon have met several times and affirmed their commitment to cooperation across a slew of security, economic, and technology policy areas. During bilateral state visits in May 2022 and April 2023, the two leaders have repeatedly stressed the importance of clean energy cooperation not just for decarbonization but also for economic growth, energy security, and supply chain resilience in a shifting geopolitical world. In their leaders' joint statements, both presidents have highlighted nuclear energy, critical battery materials, and clean hydrogen as areas ripe for bilateral cooperation.[6] They have also mentioned collaboration on green shipping, carbon capture, utilization, and storage (CCUS), methane mitigation from existing fossil fuels, accelerating EV deployment, and related non-energy technologies such as semiconductor manufacturing that are crucial to the sector.[7] At the ministerial level, US Secretary of Energy Jennifer Granholm has

met with officials from the ROK Ministry of Trade, Industry and Energy (MOTIE) to discuss bilateral cooperation on climate change, energy security, and research, development, and demonstration (RD&D).[8]

Cooperation between the United States and South Korea also takes place within wider international institutional efforts. Outside of global arrangements like the UN Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, the United States and South Korea frequently contribute to multilateral, regional, and subject-specific cooperative efforts. Both countries are members of the Group of 20 (G20), which hosted a summit in 2023 for climate and environment ministers that called for additional climate finance and the tripling of renewable energy deployment—though the statement is not binding.[9] Since 2010, Washington and Seoul have been members of the Clean Energy Ministerial, a voluntary body that holds annual meetings between top energy policymakers from 26 member countries, which hosts working groups to coordinate policy across the energy system, including EVs, battery storage, hydrogen, and nuclear innovation.[10] Shared regional efforts, from trilateral summits with Japan to annual meetings for Asia-Pacific Economic Cooperation (APEC) and the Indo-Pacific Economic Framework (IPEF), offer a range of interested parties—including the United States, South Korea, and many of their close neighbors and trading partners—the opportunity to deepen collaboration on core clean energy policy objectives.

APEC, a regional body with wide membership from the Indo-Pacific, includes China and Russia and thus does not constitute a climate-leading body composed of friendly democracies. Nonetheless, APEC allows for the exchange of information and policy through regular leader-level and ministerial summits, including on clean energy cooperation.[11] The 2023 APEC Summit in San Francisco adopted the theme of "Creating a Resilient and Sustainable Future for All." President Yoon used the occasion to tout Korea's support for various clean energy technologies and promoted Korea's Carbon-Free Alliance, which calls for the private sector to use carbon-free power from nuclear generators in addition to renewables.[12] The Golden Gate Declaration that resulted from the summit called for the tripling of global renewable capacity and employing similar targets for other climate mitigation technologies in line with carbon reduction goals.[13]

IPEF, on the other hand, offers more promise for tangible cooperation on climate.[14] Composed of four pillars, IPEF seeks to deepen economic cooperation across a range of policy areas—one whole pillar of which is dedicated to clean energy while the others are dedicated to trade policies,

supply chain resilience, and transparency and anti-corruption measures.[15] Negotiations for the clean economy pillar concluded in November 2023 and included an exhaustive list of shared, non-binding clean energy aspirations along with two investment funds and an initial subject-matter Cooperative Work Programme (CWP) on hydrogen policy.[16] An IPEF summit this past June announced additional CWPs for clean electricity and carbon markets along with an investment fund and a forum for public-private consultations with investors and project developers.[17] IPEF's direct investment fund for official development assistance-eligible countries, the "Catalytic Capital Fund," received USD 33 million in startup funding from the United States, South Korea, Japan, and Australia, while the first investor forum identified USD 6 billion worth of investment-ready projects and a total of USD 23 billion in potential projects for regional governments and private investors to examine.[18] Pillar II, which covers resilient supply chains, could include helpful exchanges of information for clean energy cooperation as the United States has suggested the inclusion of critical minerals, batteries, nuclear energy, hydrogen, and many other relevant energy technology supply chains on its list of covered sectors.[19] Still, stalled negotiations on the trade pillar and the flexible nature of IPEF leave its ultimate utility up to participants.

Pragmatic Clean Energy Cooperation

Despite their meaningful progress, both the United States and South Korea will need to maintain active engagement in the energy and climate policymaking process throughout the energy transition as global markets, technology development, and political priorities continue to change. Successful cooperation requires not only shared goals but also compatible domestic politics and continued attention paid to dynamic private markets. By embracing pragmatic policy tools to boost technology development and deployment in critical battery materials, clean hydrogen, and nuclear power, the United States and South Korea can grow their economies and speed up the transition not just for their own energy systems but also through exports to other climate-ambitious trading partners.

The United States and South Korea, together with the EU, Japan, and China, collectively account for 90 percent of recent clean energy patents, and OECD research suggests strong positive outcomes from international cooperation on climate technologies.[20] Solving climate change will require the adoption of a wide range of technologies in different applications across the entire economy, and some of these technologies are closer to mass production and adoption

than others. Certain technologies work as drop-in replacements for an existing process, while others will require local contextualization, which is just as important for policy design.[21]

This paper focuses on specific technologies and technology-specific policies, but several principles apply generally to pragmatic climate and energy security policies. The first is that global international agreements face serious structural limitations due to incentive misalignment. Pragmatism would not call for the UNFCCC or Paris Accord to be revoked, but coalition-based or bilateral approaches starting with a core of like-minded countries seeking to cooperate can unlock much more incentive-compatible progress than consensus-based multilateral negotiations among a larger mix of countries.[22]

Second, domestic policies should strive for technology inclusivity and wide economic coverage where possible. Broad, inclusive tax credits like the US clean energy generation tax credits will subsidize all sources of zero-carbon power generation starting in 2025 rather than vary compensation by technology type. Even better is GHG pricing with broad coverage, which rewards those who reduce emissions wherever they are economical to avoid, rewarding any investors, workers, and consumers who do so. Still, carbon pricing systems are sensitive to political pressure in the United States, and outcomes for the policy worldwide depend not just on the price but also on important implementation questions. Which sectors are covered, which entities are responsible for paying a fee or securing a permit, and how the system treats energy-intensive industries are also crucial factors.[23]

Major domestic policy shifts, though, will likely not be driven by bilateral cooperation as much as by domestic politics and the response to global dynamics.[24] Thus, the third principle requires focusing on support for politically viable technology-specific policies and forms of information exchange that unlock gains without major overhauls to US or South Korean environmental policy regimes. The latter includes ensuring the availability of reliable data, agreements on accounting standards, and exchanges of research, technical expertise, and analysis of market conditions. Aligning market and climate policy rules to ensure participation on a level playing field can help lessen the impact of fragmenting global markets and supply chains. Policy design, implementation, and analysis with shared outcomes in mind can also provide policymakers with iterative feedback from a larger set of markets and help them reach a better understanding of optimal next steps.

There are many technology-specific measures that both the United States and South Korea could take to benefit their climate progress. Energy as a sector is capital-intensive and dependent on fixed infrastructure, and because of its social and economic importance, energy technology faces a wide range of tech-specific policy and market failures that are best addressed with contextual rather than broad policy treatments.[25] Early-stage research needs public support because private researchers under-invest in areas where they will not be able to capture all the gains from their work. For nascent technologies like green hydrogen or direct-air capture, obstacles include proving the technology's basic performance and the industry's economic and political viability despite significant market and financial barriers to investment. For mostly ready technologies like EVs or solar panels, private finance and policy support are boosting uptake, but the obstacles to mass adoption include not just financial costs but also infrastructure constraints like the lack of public chargers or electric grid capacity.

Solving these innovation market failures requires cooperation among democratic countries with advanced technological-industrial ecosystems like the United States and South Korea. Battery supply chains, clean hydrogen capital equipment, and constructing new nuclear power plants all face a collection of these roadblocks. The following sections will address each, starting with respective US and Korean domestic policies, cooperative initiatives, and forward-looking policy recommendations.

Battery Supply Chains

Batteries have taken a prominent role in the energy transition toward decarbonizing transportation and energy storage. Policy tools to spur wider adoption of batteries among various end-users, like EV subsidies and grid battery procurement, have aided this process, but as demand grows, supply chains for raw materials, refining, component production, and assembly of cells and packs cannot keep up. Meanwhile, new entrants are discouraged by China's dominant market power and willingness to impose export restrictions on input minerals in short supply.

Battery supply chains start with various raw minerals that are processed down into usable refined materials, assembled into components like cathodes and anodes, and grouped together into active cells for final assembly. The term "critical minerals" is a broad term that includes minerals used not just in the energy transition but also in other advanced technology sectors like aerospace, semiconductors, and products with sensitive defense applications. The concept of "criticality" depends on context, is dynamic in the long run, and encompasses a variety of supply risks, including geopolitical, economic, and other uncertainties. Newly growing demand for battery inputs like lithium

hydroxide, graphite, and nickel, among many others, have combined with familiar commodity market boom-bust cycles and supply-side constraints to create unpredictable price fluctuations. The International Energy Agency (IEA) produces a price index for energy transition minerals that tracks battery inputs along with rare earth elements and copper, and prices through 2024 are far below the peak of March 2022.[26] Low prices benefit consumers in the short run, but their volatility does not augur well for investment in upstream production that will be necessary as consumer and policy demand grows over the coming decades. The IEA predicts that the demand for critical mineral inputs will double by 2030 under current policies.[27]

Less appreciated than mining or final battery assembly, the "midstream" step of refining raw ores into highly refined, pure, and usable products is an energy-, knowledge-, and capital-intensive process that varies by mineral type, ore source, and customer needs. China's monopolistic control over refined transition materials ranges from being in the top three of copper and nickel production to majority control (65 percent) of lithium and nearly 100 percent of the world's graphite and rare earths.[28] Neither the United States nor South Korea ranks in the top three refiners for any of the six critical mineral processing markets tracked by the IEA, and China has recently shown a willingness to exploit this vulnerability with restrictions on graphite and rare earth exports.[29]

Policy support for scaling up battery production in the United States includes demand-side measures like the IRA's enlarged EV tax credits (up to USD 7,500 per vehicle) and various policies covering the upstream supply chain from both the IRA and IIJA. US battery producers can choose between a production credit that subsidizes battery and critical mineral production or an investment credit that applies to advanced energy manufacturing facilities.[30] The US EV credit limits subsidies with components sourced from "Foreign Entities of Concern" (FEOCs), which includes China, for batteries starting this year and for mineral inputs starting in 2025. On top of changes to the tax code, new grants and loans have also started to flow to private partners in the sector. The US Department of Energy (DOE) has issued USD 2.8 billion out of USD 3 billion in funding for material processing, and its Loan Programs Office provides concessional finance for automotive factory conversion, for which USD 1.7 billion in loans were announced this past July.[31]

Korea also produces batteries domestically, hosting major global producers such as SK On, LG Energy Solutions, Samsung SDI, and EV manufacturer Hyundai.[32] Korean battery production currently constitutes 37 percent of the global market share, and battery exports totaled USD 9.7 billion in 2022, of which the United States was the top destination.[33] Korea has subsidized EV

adoption with varying direct subsidies and indirect support via charger installations since 2011. Overhauled rules in February this year reduced subsidies for cars using Lithium Iron-Phosphate (LFP) batteries, which are cheaper but lower range and mainly produced in China compared to Nickel-Manganese-Cobalt (NMC) batteries that Hyundai produces.[34] The government has also subsidized Battery Energy Storage Systems (BESS) in various forms since 2011 and has installed 1.6 GW of capacity by 2019.[35]

In RD&D, Korea's 2022 National Technology Nurture Plan ranks batteries as a top priority, and recent budget adjustments have boosted battery and EV research budgets.[36] Upstream, the Yoon government maintains a list of 33 critical minerals to watch—of which ten are designated "strategic" high priorities—with an eye toward building a global supply chain map, arranging memorandums of understanding (MOUs) with supplying partner countries, and funding domestic projects in production and recycling.[37] Additional subsidies to the supply chain that were recently announced include the Battery Alliance, a public-private partnership started in 2022 with KRW 50 trillion (USD 35 billion) of public financing over the next eight years in order to seek 40 percent of global market share by 2030, and another round of support announced in 2023 for KRW 38 trillion (USD 28.8 billion) toward investment subsidies, critical minerals, and advanced research and development.[38] Korea has also initiated bilateral agreements with a wide range of trading partners, including Kazakhstan, Uzbekistan, Turkmenistan, and Vietnam, and held a 48-country Korea-Africa Summit, which produced an agreement to cooperate on future critical mineral dialogues and a number of bilateral agreements.[39]

Internationally, the United States and South Korea have moved together and on complementary pathways to build new connections with resource-rich countries and like-minded importers concerned about energy security, environmental, social, and governance (ESG) conditions in the mining industry, and the scale of mineral demand needed for decarbonization. Batteries and critical mineral supply chains have been raised as areas of key cooperation at both US-South Korea state visits, as well as in the Phnom Penh and Camp David trilateral meetings with Japan. During President Yoon's April 2023 state visit to the United States, bilateral commitments included an MOU on battery supply chains, which was followed by Korea's announcement of USD 5.3 billion in support of Korean investment in North American battery supply chains.[40]

In addition to leader-level affirmations of cooperation, multiple ministerial dialogues and MOUs have been launched between US and Korean government agencies. An MOU between the Export-Import Bank of the United States (EXIM) and the Korea Trade Insurance Corporation (K-SURE) in 2022, an MOU

between EXIM and K-EXIM during COP28 in December 2023, and MOUs between the US DOE's Loan Program Office, K-EXIM, and K-Sure all prominently feature critical mineral and battery supply chain investment.[41] A public-private event co-hosted by the Department of State and MOTIE in November 2023 with the Carbon-Free Alliance and the US-based Clean Energy Buyers Association included several members of the Korean battery industry, and US Secretary of Commerce Gina Raimondo and ROK MOTIE Minister Ahn Duk-geun have held two joint Supply Chain and Commercial Dialogues (SCCD) and called for a staff subcommittee specifically for critical minerals.[42]

In addition to such dialogues, the two countries have also ensured conversations about battery supply chain resilience include diplomatic and security concerns. A call between the US National Security Advisory Jake Sullivan and ROK National Security Advisory Cho Tae-yong in December 2023 launched a bilateral Next Generation Critical and Emerging Technologies (CET) Dialogue covering critical mineral and battery supply chain investments, research, and cooperation, and the decade-long US-ROK Energy Security Dialogue held by the US Department of State and the ROK Ministry of Foreign Affairs now stresses the importance of cooperation on battery supply chains both bilaterally and through the MSP.[43]

The two countries have shown a willingness to maintain flexibility in their joint approach to building out the battery supply chain. Following difficulties sourcing FEOC-compliant graphite, Korean battery producers received a two-year extension from the United States in May 2024 to continue using Chinese graphite while the Korean government announced KRW 9.7 trillion (USD 7.1 billion) in support for graphite supply chains.[44] Together, battery supply chain projects announced since the passage of the IRA total USD 103 billion—Korea ranks first among all sources of post-IRA foreign investment in the United States, including nearly USD 20 billion in Korean battery firm projects.[45]

Korea is also the current and second-ever chair of the MSP, a coalition of 14 countries and the European Union, launched by the United States in 2022.[46] Together, the MSP has actively collaborated at the ministerial and working levels, including a Korea-led deep dive on graphite supply chains, establishing an MSP Finance Network that includes US EXIM, the US International Development Finance Corporation, K-EXIM, K-Sure, the Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR), and Korea Institute of Geoscience and Mineral Resources (KIGAM), and welcoming 15 resource-rich countries into a new MSP Forum.[47] The IPEF countries, whose agreements on pillars two and three cover supply chain resilience and clean energy, have called for "building a better understanding of the challenges and vulnerabilities of the region's supply chains

and securing more diversified and sustainable sources of critical inputs, including critical minerals or materials, for clean energy technologies."[48] At the inaugural IPEF Clean Energy Investors Forum mentioned above, a Malaysian battery factory was presented among the billions of dollars worth of potential investments, and the Catalytic Capital Fund, which includes both the United States and Korea as founding funders, announced its operational launch.[49]

Recommendations

As capacity investment ramps up alongside subsidies for battery production, the United States and South Korea should focus on the constrained segments of the supply chain that mine and refine critical minerals (along with recycling used batteries) to ensure sufficient inputs downstream. Public financial and regulatory support for investments in processing should serve as the primary tool for a US-Korea battery supply chain strategy. On top of direct financial subsidies, the establishment of joint trading benchmarks for minerals like graphite not yet included on major commodity exchanges would boost transparency and reduce friction for market participants, leading to greater certainty and, thus, legible risks for enticing investment.[50]

While China dominates mining and processing, the "N-1 supply chain risks" of losing access to the top supplier for most critical battery inputs would stymie deployment in the United States, South Korea, and allies like the European Union and Japan.[51] To hedge against these risks and smooth commodity price fluctuations, exploring and planning for the potential establishment of strategic stockpiles for key minerals—modeled after the US Strategic Petroleum Reserve or the IEA's oil reserve requirements—could also induce greater investments and provide security against short-term supply disruptions.[52]

Finally, the two countries should maintain subsidies for the demand side and align rules for product standards and carbon accounting. Adoption subsidies for battery applications, whether through EV tax credits or grid storage investments, will help ensure that investments along the supply chain continue to scale at a necessary pace and avoid demand slumps that render production capacity uneconomic. As batteries are made in different countries by firms using various chemistries and different charging characteristics, importing governments and users will require heightened assurance on safety issues and the climate impacts of different production methods.

The latter has become an area of intense focus in global climate policy with the EU's adoption of its Carbon Border Adjustment Mechanism (CBAM), which will initially apply to six primary industries and potentially expand in the future, and

US proposals for carbon intensity accounting through the PROVE IT Act or various carbon border fee bills. France and Korea have already entered negotiations to establish a shared accounting method for embodied carbon in Korean EVs, and policies that require supply chain measurement may become more common in the future.[53]

Batteries made in China are produced with three times the carbon intensity of US batteries, and the overall carbon intensity and lifetime "payback period" for EVs is highly dependent on the battery's embodied carbon.[54] Agreeing on carbon accounting has proven difficult—even for simple industrial products like steel and aluminum—so preparations for more complex manufactured products with global supply chains like EVs that collect and share carbon intensity and supply chain data and methodologies early in the scaling-up process can help establish a solid foundation for future cooperation.

Hydrogen

Hydrogen is the world's lightest element and a useful molecule for chemical processes such as fertilizer production and oil refinement. Hydrogen is generally made from natural gas in steam reformers, which involves two major sources of GHGs: upstream methane leaks from gas extraction and carbon dioxide released during the production process.[55] This production is carbon-intensive, so policymakers and clean industrialists hope to replace it with a combination of several decarbonized production methods, including "green" hydrogen produced by electrolyzers powered with clean electricity, "blue" hydrogen made with CCUS-equipped steam-reformers, and potentially significant geologic stores of natural hydrogen. Existing demand for hydrogen is indifferent to production methods, so replacing existing applications of this "gray" hydrogen with cost-competitive clean hydrogen would serve as an exciting carbon abatement opportunity. In the future, though, clean hydrogen may see additional applications if large volumes of clean hydrogen can be produced and utilized in energy generation, storage, transportation, buildings, and industry.

Unfortunately for hydrogen, several of these applications have seen competing technologies take off at a rapid scale. Clean hydrogen projects have been slow to deploy, and demand forecasts have been revised down because of a combination of policy obstacles and market developments, especially higher-than-expected costs.[56] Less than 1 percent of hydrogen consumed in 2022 was produced with low-carbon methods, and less than 1 percent went to new applications as opposed to existing users.[57] Policymakers have struggled to sift through existing data and modeling on the projected impact of major new electricity demand from sources like green hydrogen electrolyzers, and the

global market for hydrogen risks fragmentation along different accounting standards before it is even born. Thus, the top priorities for US-Korea clean hydrogen cooperation should include domestic policies to encourage clean hydrogen demand, investment in advanced industrial applications and long-duration energy storage, and alignment on carbon accounting.

US energy officials have been interested in hydrogen since the 1970s energy crisis, but the Biden administration's tenure marks the first period in US history of serious fiscal or regulatory investment in clean hydrogen. The IIJA included USD 8 billion in funding for regional clean hydrogen hubs, supporting seven production clusters spread across the country for geographic and technological diversification and setting aside USD 1 billion for demand-side support.[58] The IRA includes a new production tax credit for clean hydrogen production that grants a USD 3/kg subsidy for fully zero-carbon hydrogen produced through any pathway, though blue hydrogen producers will have to choose between claiming credits for the carbon captured and stored during production (45Q) or the hydrogen produced (45V).

Despite these generous subsidies, the US clean hydrogen economy has not yet taken off, as disputes during the regulatory implementation process have prevented investors from making final investment decisions. The problem stems from the scale of subsidies, the scale of electricity needed to match production, and the lack of agreement over clean electricity procurement standards.[59] Electrolyzers are expensive, energy-hungry machines that pulse electricity through water to generate hydrogen, so their scale of electricity demand is projected to have major impacts on overall electricity demand and demand for clean electricity in particular.[60] The Biden administration tried to establish rules that would require hourly matched clean electricity accounting to prevent increases in emissions, but many potential industrial hydrogen producers have argued that the US grid is unprepared to properly account for the hour-by-hour sources of electricity powering an electrolyzer connected to broader power grids.[61] All clean hydrogen projects in the United States are now effectively on hold because private capital will not commit to such policy-dependent investments without sufficient certainty regarding the eligibility rules and lack of policies to spur demand.[62]

Meanwhile, South Korea's hydrogen policies have been a major focus of the past two governments. Under President Moon, the 2019 hydrogen roadmap and an additional suite of standards, sectoral goals, infrastructure, and R&D laid out ambitious plans to use significant quantities of hydrogen for power, transport for light- and heavy-duty Fuel Cell Vehicles (FCEVs), and several pilot cities' heating needs over the next several decades.[63]

Since President Yoon's inauguration, the new government released a report identifying South Korea as the top market for growth in FCEVs, hydrogen refueling stations, and fuel cell capacity and amended the Hydrogen Act to add a Clean Hydrogen Portfolio Standard (CHPS) for major hydrogen and electricity producers and consumers and create new definitions for zero-carbon, low-carbon, and general hydrogen and derivative products.[64] The Hydrogen Economy Commission, chaired by Prime Minister Han Duk-soo, also issued a hydrogen innovation policy titled "3Up" to scale up production, build up infrastructure, and level up advanced technology for the sector and later added plans for a new clean hydrogen certification system, FCEV deployment, R&D, and the industry's needs for materials, parts, and equipment.[65] The CHPS policy phases the requirements for selling and purchasing quotas of gray and clean hydrogen over time depending on firm size, and auctions for the general market started in August 2023.[66] Korea's clean hydrogen exchange, launched in May 2024 as the first clean hydrogen bidding market in the world, should help buyers and sellers identify each other as the CHPS requirements for clean hydrogen come into force by 2027.[67]

The US and Korean governments have eagerly expressed interest in cooperating on clean hydrogen. As a land-rich renewables and natural gas producer, the United States has several major advantages in producing hydrogen if its equipment for generating, transmitting, storing, and using it can achieve workable prices. Meanwhile, South Korea has excelled at utilization policies in transportation and power and hosts major industrial firms that may be willing to operate pilot and demonstration projects for next-generation applications in hard-to-abate industries.[68] At the leader level, clean hydrogen was mentioned in joint statements from both US-Korea state visits and the Phnom Penh and Camp David trilateral statement, in addition to the Tenth Energy Security Dialogue.[69] The April 2023 state visit marked the agreement of an MOU on hydrogen between the two governments, which included private sector participants from both countries, and an additional MOU between Lawrence Livermore National Laboratory and the Korea Advanced Institute of Science and Technology (KAIST) signed in September 2024 focuses on hydrogen R&D specifically.[70]

The United States and South Korea also work together in several multilateral bodies to address hydrogen. The premier international body working on hydrogen policy is the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). It was founded in 2003 by the United States, includes Korea as a member, and hosts regular meetings on exchange policy and industry updates from member countries.[71] Since 2018, the IPHE has been working to develop methodologies for hydrogen carbon accounting in both the production and transport phases.[72]

IPEF has also established a regional hydrogen initiative as its first CWP and, as of March 2024, has begun sharing information and methodologies on carbon intensity at the ministerial and working levels.[73] The Clean Energy Ministerial also hosts a working group for hydrogen policy, which includes an initiative on international hydrogen trade in which both the United States and Korea participate with a group of global ports including Ulsan and Houston.[74] As members of the Global Methane Pledge and the DOE's international methane monitoring working group, both countries have committed to rapid reductions of methane emissions and, while not the focus of this paper, could use the Pledge and working group's progress to align members on blue hydrogen GHG intensity accounting.[75]

Recommendations

Discussions about aligning standards are not guaranteed to reach alignment itself. In order for clean hydrogen to succeed as a climate solution, the industry and concerned governments like the United States and South Korea must not only align on accounting standards and definitions but also work to reduce capital costs, increase clean electricity generation to meet growing demand, and incentivize the purchase of clean hydrogen despite price premiums.

The two countries could greatly benefit from the clean hydrogen industry's eventual success if the technology and costs improve or if new applications for decarbonization become cost-competitive. Joint support for RD&D projects could help both countries make additional progress in these areas. RD&D should focus on the scale and cost of production for equipment and materials including electrolyzers and their components, storage tanks, and distribution networks along with end-use capital equipment that use hydrogen for applications in industry, heavy transportation, and other sectors.

For hydrogen as a molecule, the optimal approach would combine innovation policies to lower the cost of low-carbon hydrogen and fiscal incentives to drive adoption among current hydrogen users. For hydrogen as an energy carrier, the most promising avenue for further RD&D would be spurring demand through support for new pilot and demonstration projects to help reduce costs and de-risk investment in hydrogen utilization projects for sectors with few replacement options. These include high-heat industrial processes and long-duration, inter-seasonal storage for which substitutions are either infeasible (e.g., inter-seasonal battery storage) or unsuited to further expansion (geographic constraints on pumped hydropower storage).[76]

Whether FCEVs take off as a competitor to EVs or high-temperature industrial firms develop hydrogen pathways over electrified or heat-battery-based production will ultimately depend on technological advancement. Thus, investment in R&D at all stages of the production and consumption process would assure US-Korea readiness without committing wholeheartedly to a particular end-use or production pathway. Either way, the rise of an international clean hydrogen market requires alignment on carbon accounting. Uncertainty and investment delays in the United States demonstrate its importance, but agreeing on a methodology for green hydrogen has proven difficult, even within the United States—to say nothing of the rest of the world with its wildly different electricity systems and data quality. For two early adopters, though, a shared carbon intensity methodology and research agenda would shape the United States and South Korea into formidable players in the market as the world starts to turn policy roadmaps into real volumes of clean hydrogen over the coming decades.

Nuclear Power

Civilian nuclear power is an extremely energy-dense, long-lasting, and controversial electricity source. Nuclear power plants do not emit carbon dioxide, but accidents like Chernobyl, Three Mile Island, or Fukushima raise the salience of radiation risk, leading to a lack of consensus on the value of nuclear energy within the climate community. But for steady, large, and predictable energy users like heavy industries, import-dependent countries operating fossil plants, and land-constrained electricity grids with few places to expand solar, wind, geothermal, or hydropower, nuclear plants offer an extremely compelling combination of values: efficient land-use footprint, zero emissions, constant production, and inertia to connected grids. Technological innovation requires abundant energy, especially in the age of energy-specific innovations like clean hydrogen, which will require vast quantities of electricity, and newly energy-hungry end-users like data center operators. For these reasons, the UNFCCC parties decided at COP28 to commit to tripling global nuclear power capacity by 2050.[77]

The US electricity grids and energy use profiles vary widely by region and operator, but many states use nuclear power as their primary power source, and a variety of new policy tools hope to spur growth in the industry after decades of stagnation, cost overruns, and delay.[78] South Korea, on the other hand, operates a much smaller set of grids as a geographically isolated country dependent on fossil imports to power an economy built around energy-intensive export industries. After periods of decline, both countries appear on the cusp of finally unleashing a new generation of high-density, extremely safe

reactor designs—if only the two countries could resolve private-sector IP disputes, align export rules, and enact policies designed to ensure industry certainty of buildout at scale.

The US nuclear energy policy is driven by the DOE and Nuclear Regulatory Commission, which are responsible for broader program implementation in the energy system and for reactor design, safety, and permits, respectively. After three decades without a new nuclear reactor built in the United States, Southern Company's Vogtle Reactors 3 and 4 opened in 2023 and 2024, and new momentum from the IIJA and IRA has created limited optimism in the US industry.[79] The IIJA included a USD 6 billion appropriation for Civil Nuclear Credits (CNCs) for plants at risk of retirement due to market conditions in recognition of the value older nuclear plants have in providing zero-carbon energy and appropriated USD 2.4 billion in grants for the Advanced Reactor Demonstration Program, which funds next-generation reactor designs, construction cost-sharing, and risk-reduction research, in addition to several smaller infrastructure and site survey programs.[80] The IRA's tech-neutral clean electricity tax credits apply to new nuclear plants, which can claim either an investment credit of 30 percent or a USD 25/MWh production credit, along with a USD 15/MWh credit for existing plants to complement the IIJA CNC funding.[81] Additionally, the IRA included USD 700 million in funding for domestic High-Assay, Low-Enriched Uranium (HALEU) supply chains, which should provide a much-needed boost to advanced reactor designs requiring fuel that can no longer be sourced from Russia.[82]

Domestic nuclear deployment has also struggled under what industry associations and independent analysts argue is an unnecessarily long and expensive approval process for new reactor permits that does not effectively assure safety, given newer designs and outdated requirements.[83] Several nuclear-specific legislative attempts to rectify these delays have passed in Congress on a bipartisan basis.[84] As the US nuclear industry plans for expansion and extends the maintenance of the existing fleet, questions remain over the cost of building new nuclear capacity in the coming years, safety and waste disposal concerns, and the effective implementation of NRC reforms.

South Korea's nuclear policies have undergone a more intense political fight than in the United States. Nuclear power is the single largest source of electricity consumed in the country as of 2023.[85] Following the Fukushima nuclear disaster in Japan and safety scandals at KEPCO's Kori plant in 2013, the popularity of nuclear power dropped—by 2019, President Moon planned a nuclear phase-out policy to shut down the fleet over 45 years in conjunction with a plan to expand

renewables.[86] Safety concerns are understandable, and goals for expanding renewable generation are commendable. But South Koreans should look to the United States and Japan as examples. Microsoft recently announced an agreement to restart the Three-Mile Island reactor, and Japan has restarted 12 reactors since 2015 after the shutdown that followed Fukushima.[87] A policy to phase out a grid's largest source of carbon-free power at a time of global disruptions in the energy market while also affirming ambitious commitments to drive down carbon emissions in a country as geographically constrained as Korea would risk significantly impeding the country's energy transition and energy-intensive export industries. Without additional clean firm generation and advanced grid technologies, Korea's grid lacks sufficient inertial resources to add renewables—especially at the pace and scale President Moon had envisioned—while still providing the frequency support and other ancillary services crucial to the operational function of electricity grids.[88]

Since his term began, President Yoon has reversed the phase-out policy. The Tenth BPLE called for an increase in nuclear generation up to 231 TWh, or 35 percent of power, by 2036, along with a still-ambitious renewables target of 31 percent.[89] Shin Hanul Reactor units 3 and 4, previously stalled under President Moon, received construction permits this September.[90] While the Moon administration did not actively plan to end civilian nuclear exports, Korea had not produced any reactors for export since 2009. Under the current administration, President Yoon has actively pursued new markets and deeper cooperation with the United States on exporting reactors.

For US and South Korean public officials, cooperation on nuclear exports is a shared priority with a deep history. Korea's first reactor was provided by the United States under the 1962 "Atoms for Peace" initiative, and Kori-1, the first commercial-scale reactor, was built with designs by the US-based Westinghouse.[91] In 2015, the two countries renewed their 1970s-era agreement on civilian nuclear power to increase cooperation on design and marginally lessen restrictions on fuel enrichment and reprocessing in Korea—which were related to concerns over Korea's potential nuclear weapons proliferation rather than civilian safety—while establishing a High-Level Bilateral Commission to cover fuel supply, enrichment, reprocessing, and private sector collaboration.[92] Since Presidents Biden and Yoon have been in office, the two leaders have worked closely on nuclear power expansion. In their May 2022 joint statement, the two presidents committed to "greater nuclear energy collaboration and accelerating the development and global deployment of advanced reactors and small modular reactors by jointly using export promotion and capacity building tools, and building a more resilient nuclear supply chain," and they

jointly announced South Korea's decision to join the US coalition for global small modular reactors (SMR) deployment, "FIRST."[93] Their April 2023 leader-level statement and the Phnom Penh statement with Japan also call for greater civilian nuclear cooperation.[94]

While government progress is welcome, cooperation in the private sector between US and Korean firms has encountered obstacles. A successful bid by Korea Hydro & Nuclear Power (KHNP) to build reactors for Czechia over Westinghouse (and French nuclear developer EDF) is stuck in a legal challenge regarding KHNP's right to license shared technology for export.[95] President Yoon visited Czechia for a summit in September 2024 to finalize the reactor deal, but Westinghouse and KHNP have not resolved their dispute.[96] Westinghouse and KHNP both contributed to the design of the APR-1000 reactor, based on an original AP-1000 design by Westinghouse, and signed a nongovernmental MOU in 2016 to "promote technological exchange," but this has not allayed the IP dispute.[97] KHNP recently received a favorable ruling in a US federal district court that will certainly be appealed by Westinghouse, and a Czech appeal by Westinghouse and EDF was preliminarily rejected by competition authorities.[98] Bilateral government discussions between the US DOE and Department of State and South Korean MOTIE and MOFA have engaged in the issue since August and announced a provisional MOU on November 1, 2024 that includes reference to exports without concrete details available to the public.[99]

Recommendations

The dispute is between two private firms, so all policymakers can do is attempt to resolve the KHNP-Westinghouse situation amicably. Policymakers should, however, try to work with the private sector to smooth over such disputes with persuasion where possible and establish trusted, shared forums for dispute resolution as well as forward-looking policies to plan for future joint exports.

Market and political shifts left nuclear power stagnant for decades in the United States and for years in Korea. Investors, future nuclear engineers and other expert workers in the supply chain, and major power consumers will not plan to count on expanded nuclear reactor fleets if policies change rapidly and introduce massive risks to such a long-lived asset class. The scale of future electricity demand due to the electrification of transportation and heating and new sources

of demand like clean hydrogen mean that all sources of zero-carbon energy will likely be needed over the coming decades. While the United States and South Korea could both stand to expand renewables, both would benefit from public policies that commit to long-term buildout of not just one-off reactors but an entirely new fleet that can reliably procure equipment, inputs, and workers.

Research and demonstration projects in the advanced nuclear sub-sector are also crucial. Small Modular Reactors (SMRs), many of which plan to use prefabricated replicable designs, may help bring the cost curve down faster than larger and relatively more bespoke plants. Advanced reactors, both large and small, add many new built-in safety advantages compared to older, conventional reactor designs, and advances in fuel variety, production, reprocessing, and permanent storage would aid the whole supply chain and lifecycle to ensure continued access to domestic or trusted sources of supply and end-of-life management.

Conclusion

Clean energy pragmatism can help guide the United States and South Korea on a path of cooperation toward prosperous and decarbonized world leadership. With a suite of democratically driven and market-informed policy tools to unlock advances in critical mineral processing and battery production, clean hydrogen accounting and equipment manufacturing, and new nuclear power plant construction, these two countries can live up to joint commitments made by the respective leaders and officials to invent the growing green energy systems of the future.

Policy design and implementation are never complete unless a problem is entirely solved, and climate change is not a problem that can be solved over a single presidential term. Political shifts, such as the results of the 2022 US congressional midterms or 2024 Korean National Assembly elections that brought opposition legislators into the majority of both countries and the aftermath of Trump's victory in the 2024 US presidential election, hold the potential to either undo progress or help spur new action. Attention to the dynamic challenges of climate politics, policy implementation, and collaboration with the private sector and shared global allies will help ensure continued leadership for the United States and South Korea through their current presidential terms and beyond, through the entire energy transition.

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A Bio-Future for the US-South Korea Strategic Alliance

By Zeena Nisar

Technology is reshaping the security landscape of the 21st century. The nation that fully harnesses emerging technologies, such as artificial intelligence (AI) and biotechnology, will capture critical military, economic, and cultural advantages. China's national policies reveal an acute awareness of the importance of scientific and technological innovation in its pursuit of global competitive leadership. In the past decades, China has laid out national plans to harness emerging technologies, including biotechnology, as key enablers of industrial productivity, economic development, and geostrategic influence. These national plans include China's National Medium- to Long-Term Plan for Science and Technology Development (2006-2020), the 13th Five-Year Plan for Science and Technology Innovation (2016-2020), and the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035 (2021-2025), all of which point to advanced technologies, including biotechnology, as a critical component for China's pursuit of global strategic leadership.[1]

The United States has similarly become attuned to the importance of establishing leadership in world-defining technologies. In its National Security Strategy released in 2022, the Joe Biden administration specifically outlined the importance of technological leadership in this century and that the "competition to develop and deploy foundational technologies that will transform our security and economy is intensifying."[2] In a 2022 speech at the Special Competitive Studies Project Summit, National Security Advisor Jake Sullivan articulated the United States' new perception of technological leadership, one in which a "relative" advantage is no longer sufficient against (or vis-à-vis) rising competitors like China and in which the United States has to maintain "as large of a lead as possible."[3]

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As strategic competition between the United States and China intensifies, like-minded allies and partners are aligning and deepening cooperation in critical new fora related to technology protection, economic statecraft, and supply chain security. With China ambitiously pursuing state-driven innovation in emerging technologies to secure its position as a global superpower and reshape global norms, the United States and its democratic allies and partners are finding themselves moving quickly and defensively in line to out-compete and out-maneuver China. Now, the United States seeks to realign, redefine, and strengthen its bilateral and multilateral relationships with like-minded partners in Europe and the Indo-Pacific region to pursue mutual aims in economic competitiveness and technology security. Efforts such as the US-EU Trade and Technology Council and the US-South Korea-India Trilateral Technology Dialogue in recent years highlight the growing importance and urgency of aligning international efforts to scale and secure emerging technologies amidst global disruptions, as well as a shared desire across many nations to promote domestic economic interests for more reliable and resilient technology supply chains.

The bilateral relationship between the United States and South Korea, or the Republic of Korea (ROK), has historically been characterized by a robust and long-standing military alliance. Against the backdrop of a rising China, the US-ROK alliance has responded by deepening cooperation beyond its traditional military scope to better encapsulate new security concerns tied to technology, supply chains, and economic vulnerabilities. What Presidents Biden and Yoon Suk-yeol call a "global comprehensive strategic alliance" between the United States and South Korea is a figurative moat to China's technology-based threat to the global order, in which cooperation in emerging biotechnology will allow for this technology to develop within and reinforce a rules-based international order.

As an emerging technology sector, biotechnology is a critical component of this new global comprehensive strategic alliance. Emerging biotechnologies and biomanufacturing will provide strategic and economic advantages unseen before in this new century. Simply put, biotechnology is the manipulation of biological processes to develop certain products and technologies. Examples of biotechnology include bioengineered crops, medical vaccines, and even industrial materials such as bio-based cement.[4] As a foundational and emerging technology, biotechnologies can be deployed across sectors to improve the manufacturing of existing products, develop new medical therapies, generate more efficient and productive agricultural products, and much more. Biomanufacturing, a form of production that uses biological processes and biotechnologies to develop clinical and commercial products, holds immense

potential for onshoring critical supply chains for materials and medicines, a paramount issue within the US-China strategic competition. Moreover, these emerging capabilities to produce alternative and new products via biotechnology translate to strategic advantages on the battlefield, with recent innovations in shelf-stable blood and on-site drug manufacturing providing critical logistical agility for military operations.[5]

Biotechnology and biomanufacturing are intertwined with the larger priorities of the US-South Korea bilateral relationship, namely supply chain security and the securitization of technology development. For both nations, de-risking supply chains and maintaining technological leadership are critical in their approach to China's rise. Both the United States and South Korea have critical dependencies in China, and China has historically shown a willingness to leverage supply chain vulnerabilities to geopolitically retaliate and economically coerce other states.[6] With supply chain dependencies on China for active pharmaceutical ingredients and biomanufacturing, the United States and South Korea are urgently seeking to onshore these critical needs away from China. Moreover, as an emerging technology, biotechnology will contribute to economic, strategic, and military advantages that, if leveraged by China, threaten Indo-Pacific security.

This paper seeks to characterize the bilateral relationship with respect to biotechnology and outline the contours of possibility and pessimism for the future of the technology partnership between the United States and South Korea. First, the author outlines national, industry, and research commitments on biotechnology-related cooperation between the two countries and tracks the outcome of these commitments within the larger technology partnership. Then, the author outlines the opportunities and challenges that lie ahead for deepening US-South Korea cooperation in biotechnology and biomanufacturing. This paper will ultimately provide both policy and industry leaders with an understanding of the different facets of biotechnology and the different areas of cooperation within the US-ROK alliance.

US-ROK Commitments in Biotechnology

Deepened commitments from political, military, research, and commercial leaders in biotechnology and biomanufacturing signal resilient and robust new ties between the United States and South Korea in this space. These commitments are often tied to broader, bilateral priorities for supply chain resiliency, technology innovation, and the securitization of technological development between the two countries. As China's state-driven policies seek

to obtain data, manufacturing, and know-how in this sector, the United States and South Korea have made commitments at all levels of society to leverage their respective leadership and strengths in biotechnology innovation to compete with China. Moreover, global disruptions to supply chains, such as the COVID-19 pandemic, have reaffirmed the urgent need for the United States and South Korea to strengthen international cooperation in order to generate resiliency in advanced technology supply chains.

At the national level, the United States and South Korea have publicly aligned policies to enhance alliance cooperation and leverage the respective strengths of both nations to maintain technological competitiveness against a rising China. Both nations possess strong innovation metrics with respect to research activity, human talent, investments, knowledge transfer, commercial innovation, and patent applications.[7] These strengths feature prominently in leader-level commitments between the United States and South Korea on technology cooperation and, more specifically, biotechnology. These bilateral commitments also overlap with the increasingly defensive nature of economic statecraft and technology protection controls implemented by both nations. Recent national and military commitments to deepen US-ROK alliance cooperation, specifically in biotechnology, are outlined below:

May 22, 2022: US-ROK Leaders' Joint Statement

On May 22, 2022, President Biden made his first state visit to South Korea since President Yoon's inauguration. During their first summit meeting, the two leaders highlighted a new shift in the traditional and long-standing alliance. The resulting joint statement began by reaffirming the deep security ties between the two nations, the US extended deterrence commitment to South Korea, and the shared goal for the complete denuclearization of the Korean Peninsula. The two leaders then outlined new parameters in the bilateral relationship in response to the evolving security landscape to include economic security and technology cooperation. This new forum of collaboration specifically outlined biotechnology and biomanufacturing, along with advanced semiconductors, quantum technology, AI, EV batteries, and autonomous robots, as critical and emerging technologies for enhanced public-private cooperation between the two nations. Presidents Biden and Yoon also highlighted resilient supply chains as foundational to these bilateral efforts in advancing critical technologies and affirmed deepened cooperation to address potential supply chain disruptions and prevent the adversarial use of these technologies in ways that undermine "national and economic security."[8]

June 9, 2022: The US Department of Defense Deepens Collaboration with South Korea

On the heels of President Biden's state visit to South Korea, the US Department of Defense identified five key technology areas for further cooperation and development with South Korea. These identified technologies included AI, communications technologies, quantum computing, biotechnology, and renewable energy generation and storage. These technologies are not only identified as critical for the defense partnership between the United States and South Korea but also serve bilateral efforts in fostering supply chain security.[9]

December 13, 2022: The United States and South Korea Reaffirm Commitment to Deepen Economic Partnership at the Seventh Senior Economic Dialogue

In December 2022, US Under Secretary of State for Economic Growth, Energy, and the Environment Jose Fernandez and ROK Second Vice Minister of Foreign Affairs Lee Dohoon convened the Seventh US-ROK Senior Economic Dialogue (SED). Under Secretary Fernandez and Vice Minister Lee reviewed the progress made after May 2022, underscoring the deepening economic and technology cooperation between the two countries. With regards to biotechnology, the United States and South Korea committed to strengthening cooperation in supply chain resiliency for health-related supplies, advancing health security efforts, including the Korea-US (KORUS) Global Vaccine Partnership, and enhancing bilateral collaboration on research and development (R&D) in critical and emerging technologies.[10]

April 26, 2023: Leaders' Joint Statement in Commemoration of the 70th Anniversary of the US-ROK Alliance

In April 2023, on the 70th anniversary of the US-ROK alliance, President Yoon met with President Biden in Washington, DC, for an official state visit. In the joint statement, the two presidents reaffirmed bilateral cooperation in economic security and critical and emerging technologies, including biotechnology, and established the Next Generation Critical and Emerging Technologies (CET) Dialogue.[11]

December 8, 2023: The US-ROK Next Generation CET Dialogue

In late 2023, US National Security Advisor Jake Sullivan and ROK National Security Advisor Cho Tae-yong convened for the inaugural US-ROK Next Generation CET Dialogue. Biotechnology was outlined as one of the six strategic technological areas most consequential to economic prosperity,

supply chain security, and the two countries' competitive advantages. As such, the United States and South Korea proposed new collaborations across industry, government, and academia. These collaborations included new bioeconomy research collaborations between the US National Science Foundation and the ROK Ministry of Science and ICT (MSIT), the launch of a track 1.5 dialogue in 2024 to accelerate bilateral R&D, identify active pharmaceutical ingredients, and build resilience in biopharmaceutical supply chains, and the expansion of ongoing collaboration between the US National Institutes of Health and the ROK Ministry of Health and Welfare to include talent exchange programs and research cooperation.[12]

The bilateral commitments in biotechnology are bolstered by other multilateral agreements with like-minded, democratic nations. Following the US-ROK Next Generational CET Dialogue in December 2023 and the US-India initiative on Critical and Emerging Technology (iCET) in January 2023, the United States, South Korea, and India convened a trilateral technology dialogue in Seoul in March 2024. The three nations reaffirmed commitments to deepen cooperation in critical technology sectors, align economic and national security interests in the development of these technologies, and build more resilient technology supply chains. In this trilateral dialogue, the three countries outlined opportunities for deepened cooperation in biotechnology and active pharmaceutical supply chains, along with other critical technology sectors such as semiconductors, telecommunications, and quantum technology.[13] Moreover, the August 2023 Camp David Summit between Biden, Yoon, and Japanese Prime Minister Kishida Fumio stressed the shared objectives in supply chain resiliency and technology security for critical and emerging technologies, including biotechnology.[14]

Beyond national-level commitments, US-South Korea cooperation in biotechnology is reinforced by commitments from industry and commercial stakeholders. In April 2023, on the sidelines of President Yoon's state visit, the Korea Biotechnology Industry Organization signed an MOU with the US Biotechnology Innovation Organization to strengthen ties in the bioeconomy, ranging from R&D cooperation to supply chain management. US and South Korean organizations represent approximately 12,000 and 6,000 firms, respectively, in the biotechnology industry.[15] The alignment of industry and commercial stakeholders in biotechnology signals that these bilateral commitments will be robust and resilient.

Moreover, the US and South Korean research and innovation ecosystems are deepening ties to align with the overarching national priorities of both governments. In May 2024, the ROK Ministry of Trade, Industry and Energy

(MOTIE) selected Johns Hopkins University to anchor a Global Industrial Technology Cooperation Center (GITCC), collaborating on R&D efforts in pharmaceuticals, medical devices, biomanufacturing, AI research in healthcare, and biomaterials.[16] This commitment deepens cooperation in biotechnology research and innovation between the United States and South Korea through growing ties in bilateral research collaborations and technology transfer.

The bilateral commitments are substantially bolstered by all levels of society, including political, research, industry, and military sectors. The holistic alignment of biotechnology innovation, development, and policy signals a robust future for bilateral cooperation in biotechnology.

Charting Progress in the US-ROK Strategic Alliance

The strategic alliance has led to material progress in the integration and collaboration between the US and South Korean biotechnology ecosystems. In recent years, South Korean biotech entities have made significant inroads in the United States, with many establishing subsidiaries, headquarters, and investment funds in the United States.[17] The increase in bilateral research and innovation activity is in part due to ambitious South Korean initiatives to expand global R&D collaborations. In November 2023, MSIT released an R&D innovation plan for emerging technologies, increasing its budget for global R&D collaboration from KRW 500 billion in 2023 to KRW 1.8 trillion (approximately USD 1.3 billion) in 2024.[18] The South Korean government has also announced the expansion of the country's biotechnology R&D budget by 12 percent in 2024.[19] The United States has also taken measures to strengthen its leadership and outputs in biotechnology and biomanufacturing, most notably the 2022 Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy.[20] These unilateral and bilateral commitments have converged the two countries' biotechnology ecosystems.

In research, there has been an uptick in new collaboration between the United States and South Korea. As outlined earlier, MOTIE's establishment of a GITCC at Johns Hopkins University will foster bilateral R&D collaborations in pharmaceuticals, biomaterials, and biomanufacturing and further integrate the biotechnology ecosystems of the respective organizations. Moreover, this collaborative initiative has also drawn interest from the Korean private sector, given the strong demand for international research and technology transfer.[21] MSIT has also announced the establishment of the Boston-Korea Project to strengthen cooperation in biotechnology.[22]

Investment ties between the two countries have also grown in recent years. Overall, foreign direct investment (FDI) from South Korea to the United States has grown substantially over the past two decades, with FDI stock totaling USD 76.7 billion in 2023.[23] Moreover, in 2023, outbound South Korean capital to the United States reached a record high, more than any other country and usurping Taiwan as the largest investor in the US economy.[24] Although US FDI to South Korea has been trending upward to reach USD 35.6 billion in 2023, a 7.7 percent increase from 2022, it remains slightly below rates seen in recent years.[25] Nevertheless, for biotechnology specifically, two-way investment flows are supporting the integration of the US and South Korean innovation ecosystems by leveraging the respective strengths of the two nations in biotechnology and biomanufacturing.

South Korea has set national, strategic goals to become a "global vaccine hub," and the United States is at the forefront of basic and clinical research in vaccine development.[26] It is, thus, unsurprising that this symbiotic space has seen an uptick in two-way investments. For example, South Korea-based SK Bioscience announced in 2024 that it would invest USD 2 million into US-based Sunflower Therapeutics to bolster SK Bioscience's vaccine development and manufacturing capabilities with Sunflower Therapeutics' yeast-based biomanufacturing technologies.[27] In addition, MOTIE has been reported to be in talks with US-based Thermo Fisher Scientific to outline potential US investments in production facilities in South Korea.[28] South Korean pharmaceutical firms have also increased efforts to expand their market presence in the United States through mergers and acquisitions of US firms.[29] In 2023, South Korea-based OSR Holdings, a healthcare holding company, merged with US-based Bellevue Life Sciences Acquisition Corporation with the aim of bringing the holding company onto the Nasdaq stock exchange.[30]

In venture capital, the connective tissue between the US and South Korean biotechnology innovation ecosystems is also rapidly growing. In 2022, US-based Orange Grove Bio and South Korea-based SV Investment established a new partnership for joint biotech collaboration in sourcing and developing therapeutics.[31] A few years later, Mirae Asset Financial Group, a South Korean investment firm, launched its first US fund focused on life science and biotechnology.[32]

As both the United States and South Korea seek to diversify supply chains and market dependencies away from China, there is a growing trend of new corporate collaborations that support South Korean firms entering the United

States and US firms entering South Korea. In 2024, US-based Radyus Research and South Korea-based Dt&CRO announced a strategic partnership to provide Radyus with testing services for Asia-based clients and provide support for Dt&CRO's clients entering the US market.[33]

For biotechnology and biomanufacturing, the United States and South Korea have made material progress in expanding corporate ties, increasing trade and investment flows, and strengthening market integration. Given that the majority of biotechnology R&D is done in the commercial sector, the increasing integration of the two countries' biotechnology ecosystems is evidence that strong and successful demand signals are being sent to the commercial sector to align with the aims of the US-ROK alliance. This expansion of alliance cooperation in biotechnology will support the goal of both countries to diversify supply chains away from China and support the secure development of this critical and emerging technology sector alongside allies and partners.

Future Opportunities for Strengthened Cooperation

Although the United States and South Korea have made considerable progress in developing and strengthening alliance cooperation in biotechnology and biomanufacturing, there remain future considerations and opportunities for the two nations to achieve shared aims in building supply chain resiliency, economic security, and the secure development of this critical sector amidst rising tensions with China. Most notably, there are opportunities for the two countries to expand alliance cooperation in biotechnology to achieve mutually beneficial aims to reduce supply chain vulnerabilities in active pharmaceutical ingredients (APIs) and biomanufacturing, alleviate barriers to market entry, and build multilateral coalitions for technology protection and supply chain security. All of these objectives will be critical to the national and economic security of both countries amidst geopolitical disruptions and increasing Chinese economic coercion.

Building More Resilient Supply Chains in Biotechnology and Biomanufacturing

Both the United States and South Korea share key vulnerabilities in biotech supply chains. In the Biden administration's 100-day review of critical supply chains, APIs were a primary focus, alongside semiconductors, large-capacity batteries, and critical minerals. Given that generic drug shortages have been occurring in the United States for years, it is unsurprising that the review found that 87 percent of generic API production occurs overseas, estimating that China and India control substantial parts of the supply chain.[34] Similarly, South Korea is also reliant on China for API production, more so than India. In 2022,

South Korea imported USD 916.9 million in drug substances from China and USD 303.3 million from India.[35] To complicate things further, although there are leading API manufacturers in India, the nation also relies on China for three-quarters of its APIs used in drug production.[36] South Korea's direct and indirect reliance on China for APIs correlate to high risks to the nation's drug supply in the event of geopolitical disruptions. This was most evident during the COVID-19 pandemic when South Korea experienced acute shortages of acetaminophen, or paracetamol, a generic pain medicine that consists of APIs largely produced and exported by China.[37]

Given the shared interest of both the United States and South Korea in building more resilient API supply chains and finding alternative production capacity outside of China, there is an opportunity to deepen alliance cooperation and achieve mutually beneficial outcomes for the security of both nations. Currently, the most feasible alternative to China's API production capacity is India. The triangulation of interests between the United States, South Korea, and India in establishing more resilient API production has already emerged in the 2024 trilateral technology dialogue, where the three nations discussed opportunities to cooperate in active pharmaceutical supply chains. Moreover, both the United States and South Korea are setting targets to develop a domestic capacity for API production.[38] Building on this momentum, the two countries should continue to develop this area of alliance cooperation to secure more reliable drug supply chains.

There is also an overlap of interests in supply chain security between the United States and South Korea with regard to biomanufacturing. In September 2024, the US House of Representatives passed the BIOSECURE Act with bipartisan support. The legislation prohibits federal agencies from procuring, purchasing, or contracting biotechnology equipment or services from a foreign adversarial biotechnology company, explicitly naming Chinese companies such as the BGI Group, WuXi AppTec, and WuXi Biologics.[39] As a contract development and manufacturing organization (CDMO), WuXu AppTec's US operations brought in USD 3.6 billion in 2023, approximately 65 percent of the company's total revenue.[40] Given that the US biotechnology industry is entangled with Chinese CDMOs, the passage of the BIOSECURE Act into law will lead to a high demand for alternative CDMO services.[41]

The scaling and development of South Korean CDMO capacity offers a promising pathway to deepen US-South Korea cooperation in biomanufacturing amidst a seismic restructuring of supply chains. As part of its plan to become one of the top CDMOs in the world, South Korea-based Lotte Biologics recently

broke ground on its Songdo Bio Campus in 2024 as a part of the company's larger effort to expand its manufacturing capacity.[42] Other South Korean companies, such as Samsung Biologics and Celltrion, are also positioning themselves to capture key market demand for CDMOs from US biotechnology firms if the BIOSECURE Act is passed into law.[43] The future success of South Korean CDMOs integrating with the US biotechnology industry will require deliberate guidance and bilateral cooperation between the two allies to ensure biomanufacturing supply chains are resilient in the long term.

Strengthening Bilateral Ties in Agricultural Biotechnology

There are opportunities for the United States and South Korea to strengthen bilateral ties in agricultural biotechnology to support mutual aims in food and economic security. Although the implementation of the Korea-US Free Trade Agreement (KORUS FTA) in 2012 has allowed for the development of robust investment and trade relations, there remain opportunities to smooth out certain regulatory barriers to market access for biotechnology between the two countries.

South Korea is the sixth-largest export market for US agricultural products. Robust agricultural ties between the two countries have flourished under the KORUS FTA, especially given that South Korea granted duty-free status to two-thirds of US agricultural products.[44] However, in agriculture, South Korea's regulatory system for genetically engineered crops is a barrier to the export of US agricultural biotechnology. According to the US trade representative, the approval process for new biotechnology products in South Korea is drawn out and inefficient, with five different agencies managing the process and data requests. This approval process is mandated by South Korea's Living Modified Organisms (LMO) Act.[45]

Fortunately, MOTIE recently proposed draft changes to the LMO Act that would introduce a policy for innovative biotechnologies and establish a pre-review system to exempt certain products from a full review. The United States engaged with MOTIE in the development of these draft amendments and continues to engage with the Korean government to streamline the regulatory process for agricultural biotechnology.[46] Looking forward, it would be highly beneficial for both nations to articulate the importance of agricultural biotechnology within the US-ROK strategic alliance as a driver of food, economic, and national security and continue efforts in streamlining and establishing regulatory transparency.

Multilateral Engagements and Cooperation

Beyond the US-ROK strategic alliance, the two nations have converging interests in supply chain security and technology protection that could be leveraged within larger multilateral forums. As highlighted previously, trilateral engagements between the United States and South Korea with other like-minded partners, such as the US-South Korea-India technology dialogue, offer an opportunity for the United States and South Korea to leverage the capabilities and resources afforded by like-minded partners to achieve mutual security aims. For example, India possesses considerable API production capacity that could support US and South Korean aims to develop more resilient biotechnology supply chains. Moreover, within the recently established Bio-5 Coalition, the United States and South Korea are working alongside other like-minded nations, including Japan, India, and EU countries, to address global drug shortage issues and generate more resilient supply chains for health security.[47] Finally, there is a critical opportunity for the United States and South Korea to achieve mutual security aims in strategic economic competitiveness within the Indo-Pacific Economic Framework's recently established pillar on supply chain resiliency. With 14 founding member nations, this framework has four pillars: trade, supply chains, green energy, and tax and anti-corruption.[48] Within these larger multilateral frameworks and cooperative measures, there are considerable opportunities for the United States and South Korea to achieve shared aims in developing strategic economic and technological competitiveness while protecting critical technology sectors and vulnerable supply chains alongside like-minded allies and partners.

Challenges for the US-ROK Strategic Alliance

Although the United States and South Korea have made material progress in deepening bilateral cooperation in biotechnology and biomanufacturing, certain obstacles remain to the US-ROK strategic alliance. Ambitious bilateral efforts to secure strategic supply chains and protect critical and emerging technologies can, at times, conflict with the political and economic realities facing both nations. These challenges include political shifts due to elections, the triangular relationship between the United States, South Korea, and China, and domestic economic constraints.

Political Shifts and Elections

During South Korea's National Assembly election in April 2024, the opposition Democratic Party (DP) secured 175 seats, while the ruling People Power Party (PPP) only secured 108 seats. Given that President Yoon is a part of the PPP

and has three years remaining in his five-year term, South Korea will face political gridlock as the DP retains its legislative majority, which will most likely clash with President Yoon's agenda.[49] If South Korea aims to spur technological leadership and economic competitiveness in biotechnology, political consensus will be critical to create conducive policies for research, innovation, and cooperation in this industry, and recent bipartisan legislation from the National Assembly suggests this is possible.[50] The DP and PPP will have to find common ground in framing the economic and national security rationale for supporting technological leadership and strategic cooperation in biotechnology and biomanufacturing.

On the other side of the Pacific, there is some clarity insofar as the United States has elected former President Donald Trump. Yet, there remains a large degree of uncertainty regarding the resiliency of this new area of alliance cooperation in biotechnology. Across both the Biden and Trump administrations, there has been some consistency in utilizing economic statecraft and technology protection controls to counter China's economic and technological threat to the rules-based international order. For example, the first Trump administration severed US ties to Huawei, a Chinese telecommunications company, and the Biden administration upheld many of these Huawei-related restrictions and went further to tighten restrictions on the sales of semiconductors for 5G devices.[51] Given that the United States has frequently outlined the importance of biotechnology as a critical and strategic sector for economic competitiveness and national security, there can be some certainty that biotechnology will remain a strategic priority for the United States moving forward.[52] Whether this domestic focus on establishing global leadership in biotechnology translates to bilateral cooperation, however, is less certain.

Differing Perspectives and Vulnerabilities Surrounding China

Although both the United States and South Korea share similar concerns over China's threat to the rules-based international order, the two nations diverge in their approaches and capabilities in countering this threat. The United States currently perceives China as the "only competitor with both the intent to reshape the international order and, increasingly, the economic, diplomatic, military, and technological power to do it." The 2022 National Security Strategy highlighted a three-fold approach to the US strategic competition with China: investing in domestic capabilities, aligning efforts with allies and partners, and competing responsibly with China.[53] US strategies to de-risk from China are well-known, ranging from the recent tariffs placed on imports of Chinese electric vehicles to the October 7 export controls placed on advanced

semiconductors, and are increasingly defensive and protective of emerging critical technology sectors.[54] It is indisputable that the United States and China are deeply entrenched in a great power competition.

On the other hand, South Korea is in a more precarious position within the larger US-China strategic competition. From the US perspective, South Korea is a "linchpin for peace and prosperity" and a strong ally in the Indo-Pacific.[55] From the Chinese perspective, South Korea is critically important to its regional strategy by influencing the geopolitics of the Korean Peninsula and creating a more malleable Indo-Pacific region for its interests.[56] As tensions rise between the United States and China, South Korea is increasingly becoming a key middle power in the region and, along with it, becoming increasingly exposed to the economic and geopolitical risks of being caught in the middle of two competing powers. With South Korea increasingly aligning with the United States in bilateral and multilateral efforts, China has responded harshly in expressing its disapproval, with China's Ambassador to South Korea Xing Haiming going so far as to threaten that "those who bet on China's loss will surely regret their decision in the future."[57] This threat is not without weight, especially given that when South Korea installed a US THAAD system in 2017, China responded with retaliatory economic coercion.[58] Looking forward, South Korea must carefully navigate a precarious minefield of geopolitical, economic, and technology strategies—all while pursuing domestic interests amidst internal political gridlock.

Economic Realities

The economic realities of South Korea present significant challenges to the full and whole-hearted embrace of bilateral technological and economic cooperation with the United States. For the past decade, the Chinese and South Korean economies have been highly integrated. China is a significant trading partner of South Korea, with China being the top destination for South Korean exports and imports.[59] Only recently has this economic reality begun to shift, with South Korean exports to the United States surpassing China in 2023.[60] Nevertheless, South Korea's economic dependence on China will constrain its foreign policy. For example, China's economic pressure in 2017 included retaliatory actions against South Korean consumer products, automobile sales, and companies.[61] Should South Korea align more closely with the United States in critical and emerging technology sectors, such as biotechnology, there is a high risk that China will retaliate with economic pressure in these sectors.

Domestic economic realities in South Korea may also constrain the nation's foreign policy and engagement in the US-ROK strategic alliance. Demographic shifts due to South Korea's aging population and low birth rate may begin to restrain the nation's economic growth. South Korea's long-term economic growth rate is predicted to be 1.9 percent from 2023 to 2030, 1.3 percent from 2031 to 2040, and drop to 0.7 percent from 2041 to 2050.[62] These predictions signal potentially stagnant economic growth for South Korea. Domestic considerations for an aging population and stagnant economic outlook will inform South Korea's technological and foreign policymaking in the next decade and beyond. For example, the potential for biotechnology to address critical medical needs of a population may be a higher priority for policymakers than the technology's potential for novel industrial manufacturing. As a critical technology sector and a component of the US-ROK alliance, South Korean commitments and investments in biotechnology may pressurize these economic and demographic constraints if the long-term benefits are not realized in time.

Reconciling US Economic Statecraft with Allies and Partners

There lies an inherent mismatch between the United States' aims for economic statecraft and technology security vis-à-vis China and its bilateral and multilateral commitments to allies and partners that may eventually come to challenge the evolving strategic alliance between the United States and South Korea. As was outlined before, the national-level bilateral and multilateral commitments between the United States, South Korea, and other like-minded nations on critical and emerging technologies often stress the importance of these technologies to economic and supply chain security and technology protection. As these national-level commitments progress in biotechnology, they may soon encounter friction between shared concerns for economic and technology security and the domestic tools of economic statecraft.

Recent US controls on advanced semiconductors have illuminated the complications between domestic tools of economic statecraft and technology security and its profound implications for foreign policy. When the United States implemented sweeping new measures for export controls on advanced semiconductors in October 2022, it did so unilaterally. This unilateral move to use export controls was done so, reportedly, after inconclusive conversations with US allies earlier that year.[63] These export controls were met with concern from South Korea, given that South Korean companies such as Samsung and SK Hynix possess NAND and DRAM manufacturing plants in China.[64] These

firms would eventually go on to receive indefinite licensing waivers from the United States in an effort to smooth over concerns regarding semiconductor technology controls.[65]

Nevertheless, this fundamental divide between the domestic policy levers for technology and economic security and foreign policy has yet to be resolved. Looking at other emerging technology sectors, such as biotechnology, there is reason to believe that future unilateral measures from either the United States or South Korea will potentially come in conflict with the mutual aims outlined within this new global comprehensive strategic alliance.

Conclusion

The biotechnology sector holds immense potential for the United States and South Korea to expand bilateral cooperation and the strategic alliance into new avenues for securing economic and technological competitiveness in the 21st century. Amidst rising tensions with China, there is a convergence of mutual aims between the two countries in strengthening and securing biotechnology and biomanufacturing as a critical and emerging sector for economic competitiveness and technological leadership.

Bilateral commitments have consistently included biotechnology as a critical technology for economic and national security, and working-level commitments between the two nations have shown participation from all levels of society in strengthening cooperation in this sector. Moreover, there remain opportunities to continue strengthening bilateral cooperation in biotechnology, given shared interests in de-risking biotechnology supply chains, increasing trade in agricultural biotechnology, and working toward mutually beneficial aims within larger multilateral fora.

However, there is some uncertainty in the current and future geopolitical landscape that may test the future of US-South Korea cooperation in biotechnology. Political changes due to elections, the triangular relationship between the United States, South Korea, and China, and domestic economic realities may constrain bilateral cooperation in biotechnology. To alleviate these constraints and ensure the future success of the US-ROK strategic alliance, US policymakers will have to reaffirm their commitment to the alliance, avoid positioning South Korea in direct conflict with China, and develop conducive messaging and policies that link domestic economic needs with larger security interests.

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Section 2

New & Evolving Cooporation in Security & Defense

US-South Korea Relations in Space: A New Era for Partnership

By Katherine Melbourne and Sam Wilson

Introduction

Reaching its 70th anniversary in 2023, the alliance between the United States and South Korea, or the Republic of Korea (ROK), has entailed extensive military and defense collaboration. Such collaboration, however, has not typically extended to outer space. Policy restrictions have complicated projects between the two countries, which resulted in South Korea turning to other nations to partner with in space. Historically, this included Russia, which launched many South Korean satellites and assisted with developing South Korean space-launch vehicles in the 2000s and 2010s.

The limited nature of US-South Korea space collaboration seems to be changing, including for defense and security applications. Recent diplomatic and official engagements between the two countries reflect a heightened focus on US-South Korea relations in space. US President Joe Biden and South Korean President Yoon Suk-yeol issued a joint statement in May 2022 outlining the goals and commitments of the bilateral "Strategic Economic and Technology Partnership."[1] The presidents emphasized the exchange of expertise across many research areas with an explicit call to strengthen cooperation in space.

Also, in the spring of 2022, representatives of the US National Aeronautics and Space Administration (NASA) and the ROK Ministry of Science and ICT (MSIT) signed a Joint Statement of Intent for Cooperation on Space Exploration and Science.[2] The statement was followed by the MSIT vice minister's visit to NASA in January 2024 and the NASA deputy administrator's visit to Korea six months later.[3] Military space cooperation is also a growing focus. Notably, the US Space Force established a field component in South Korea (SPACEFOR-KOR) in 2022, and the commander of the US Space Command (USSPACECOM) visited South Korea to discuss US-South Korea space and missile defense in April 2024.[4]

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These engagements build upon South Korea's ambitious pursuit of a space program and the accumulation of successful efforts in space in recent decades. Despite getting a later start than other, more established space powers, the country has achieved a myriad of important milestones in space since it entered the field in the late 1980s with the establishment of a national aerospace research institute.[5] In 1992, the first South Korean satellite began operations, launching with the French company Arianespace. Three decades later, South Korea became one of a limited number of nations with indigenous orbital launch capabilities after its launch and deployment of a satellite from its Nuri rocket, also known as Korean Space Launch Vehicle-II (KSLV-II). Making strides toward deep space exploration, South Korea designed and built Danuri, a lunar orbiter mission on orbit since December 2022.[6] Additionally, with the launch of two reconnaissance satellites in December 2023 and April 2024, respectively, South Korea is challenging North Korea by demonstrating its ability to become a regional watchdog in space.[7]

Despite limited space collaboration between the two countries in the past, the future of US-South Korea space relations is ripe with potential for mutually beneficial collaboration, accompanied by some challenges that, if properly understood, are surmountable. This paper will assess such opportunities in detail by examining the history of space cooperation between the two countries, South Korea's policy objectives in space, areas of current and potential future cooperation, and extant challenges to the US-South Korea partnership in space.

Historical Context of the US-South Korea Space Cooperation

Cultivating US-South Korea space cooperation requires understanding the foundation of the bilateral relationship in space over the past few decades. Due to ties between missile technology and space-launch capabilities, South Korea's development of space capabilities had a slow start, constrained by international regulations and policies. Starting in the 1970s, the United States and South Korea entered into an agreement that authorized exchanging details on US missile technology while restricting the range and payloads authorized for South Korean missile launches.[8] Although the primary motivation of these restrictions was to limit the range and destructiveness of South Korea's missile strike systems to prevent crisis escalation, it also had the effect of restricting South Korea's space launch technology development, including preventing the use of solid fuels in rockets.[9]

More than two decades later, South Korea joined the international Missile Technology Control Regime (MTCR) in 2001, spurring the United States and South Korea to revisit and revise their original agreement on missile technology exchange.[10] South Korea's expanding ambitions in space remained hindered by the revised missile control agreement, however, as the United States was restricted from helping South Korea develop space-launch capabilities. South Korea instead turned to Russia to develop a joint orbital launch vehicle, Naro-1, that made a successful mission in 2013.[11] In 2021, just before President Yoon took office, the United States and South Korea once again revised their agreement on sharing missile technology, allowing for technology exchange between the two countries to include assistance on launch-vehicle development.[12] South Korea then became one of the few states with independent launch capabilities when its Nuri rocket launched a satellite into orbit in June 2022.[13] The revisions also allowed South Korea to develop rockets with ranges far exceeding the Korean Peninsula, and some experts suggest that the scrapping of the guidelines was also motivated by US-China strategic competition and an increasing focus on defense-industrial cooperation between the United States and its allies.[14] The shifting political and regulatory environment is creating more opportunities for US-South Korea space collaboration. The United States is continuing to authorize more security-related exports by changing historically strict policies. This includes a policy change in 2023 that allowed for increased satellite technology sharing with MTCR members.[15]

South Korea's Policy Objectives in Space

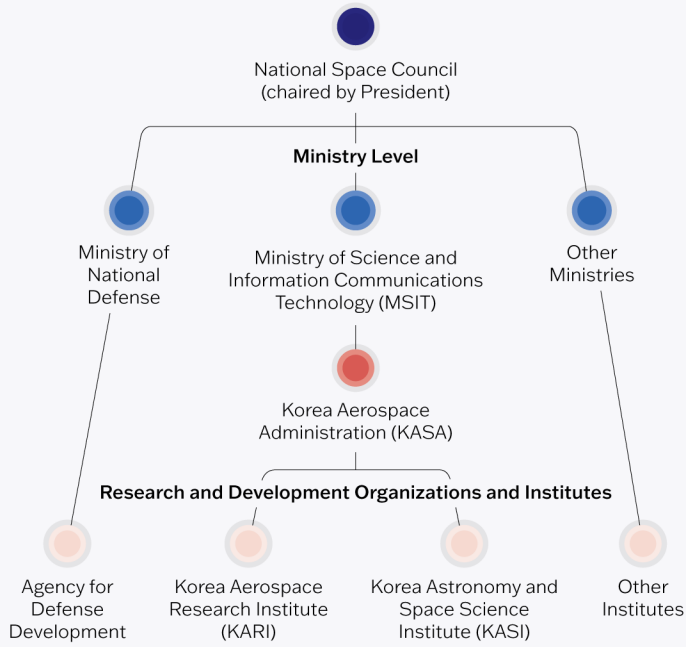
After taking office in 2022, President Yoon laid out a clear vision for the South Korean space industry and issued the country's fourth Space Development Promotion Basic Plan, approved in December 2022. Previous basic plans were issued in 2007, 2012, and 2018 and include national strategies for space that extend far beyond any one presidential administration. The first two plans focused on satellite technology development and creating national launch services, with the goal of building the foundation for future space exploration and the cultivation of a globally competitive national space industry.[16] With increasing experience and growing expertise, the country was able to expand to more specific and ambitious

objectives in its third basic plan, which guided South Korea to its first successful indigenous space launch. This plan also allowed the country to make progress on longer-term goals such as lunar exploration and the development of a navigation satellite constellation.[17] The fourth basic plan is based on the same foundational theme that space provides national economic benefits and presents an opportunity for South Korea to participate in space on a global stage. It also includes initiatives started in past plans—in particular, a growing investment in the Korean Positioning System (KPS), which underwent initial studies as part of the third basic plan and has nearly doubled its share of the total South Korean space budget from 2022 to 2024.[18]

However, the fourth basic plan is uniquely bold in its stated goals. South Korea aims to become a globally recognized space power, and the country is demonstrating its commitment to missions that will require significant technological advancements, a restructuring of the organization of its space and science agencies, and increased spending to foster growth in the space sector compared to past basic plans. Specific targets include a robotic landing on the Moon in 2032 and on Mars in 2045, a doubling of the government's space investments by 2027 (up to KRW 1.5 trillion, or about USD 1.1 billion), and focusing on private space industry growth. Regarding the latter, the fourth basic plan aims for South Korea's share of the total global space revenue to grow to 10 percent by 2045.[19]

The most notable policy change is the establishment of the Korean AeroSpace Agency (KASA), which is charged with managing the national civil, commercial, and military strategies for space and helping align research and development (R&D) efforts with the nation's long-term goals in space. KASA will oversee the existing Korea Aerospace Research Institute (KARI) and the Korea Astronomy and Space Science Institute (KASI), and MSIT will oversee KASA at the ministry level. The National Space Council, which has purview over the space portfolios of the various ministries, is chaired by President Yoon to ensure that the highest level of South Korean leadership is involved in space policy decisions. The structure of the government's space organizations is shown in Figure 1.

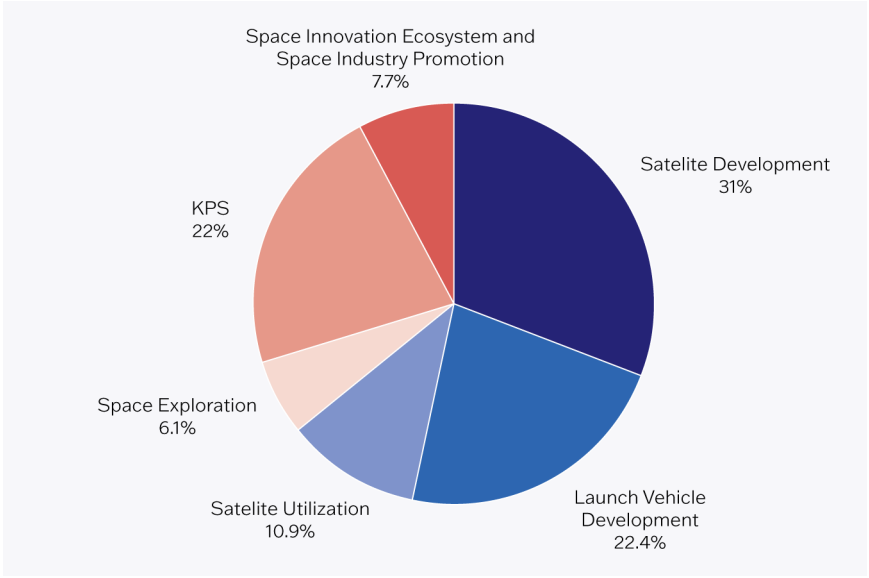
Figure 1. Space Organizations within the South Korean Government



Source: Analysis from The Aerospace Corporation (2024)
Notes:
National Space Council: Writes the national space development roadmap
Ministry of National Defense: Oversees military space activity
MSIT: Sets national science and technology policy and funds R&D and commercial
Agency for Defense Development: Conducts R&D in defense space technology
KARI: Conducts R&D for satelites and space launch vehicles
KASI: Conducts R&D for governmental astronomy and telescopic projects

Since the fourth basic plan was announced, the South Korean space budget climbed 19 percent from 2022 to 2023 and grew an additional 13.5 percent in 2024.[20] There are no signs of this investment slowing down. The ambitions for a thriving South Korean space economy are included in other national plans, in particular the New Growth Strategy 4.0 issued by the Ministry of Economy and Finance. Space is seen as a promising sector for growing the per capita gross national income.[21] Most of the space budget is spent on expanding the domestic market for space capabilities across various sectors of the industry. The breakdown is shown in Figure 2.

Figure 2. South Korea's 2024 Space Budget



Cultivation of Domestic Private Space Industry

Nearly a quarter of South Korea's space budget is spent on developing launch vehicles, for which the government is starting to turn toward the industry. While some of these funds are going toward the initial design of the KSLV-III, the third-generation South Korean launch vehicle that will take their lunar lander to the Moon by 2032, some funds are going toward ongoing launch technology transfer efforts.[22] Nuri, South Korea's second-generation orbital-launch vehicle, launched successfully for the first time in October 2021. Shortly before, the South Korean government announced its intention to transfer the system's technology to commercial partners.[23] Hanwha Aerospace was selected to receive support from KARI as part of the Korea Space Launch Vehicle Advance Project, which leads planned Nuri launches from 2022 to 2027.[24] The private industry, including Hanwha Aerospace, has been involved in South Korean space ventures from the beginning; the original construction of the Nuri rocket was made possible by the contributions of many commercial partners.[25] The South Korean government will continue to set targets for the industry to achieve—the most recent being the development of a reusable rocket that can send one-kilogram payloads to low Earth orbit (LEO) for USD 1000 per kilogram by the mid-2030s.[26] Having the industry take the reins of the overall launch effort—from researching launch technologies to managing launches—is motivated by the desire to increase the reliability of launches while decreasing their cost.

South Korea has actively worked to transfer payload technology to commercial partners as well. KARI has traditionally led the design and manufacturing of 500kg, medium-sized satellites, but Korean Aerospace Industries (KAI) has been chosen to take over.[27] The selection of KAI means more progress toward South Korea's goal of exporting space capabilities, as the states importing South Korean airplanes from KAI are also interested in acquiring satellites and available space data.[28] Hanwha Aerospace is also part of the payload technology transfer and is interested in inter-satellite-link technology, like that used in Starlink, for its 2000-satellite LEO constellation planned for 2030.[29]

The transfer of satellite technology in recent years has been led by the government-sponsored Korea Advanced Institute of Science and Technology (KAIST) and is just one example of the shift from relying on state-funded facilities for R&D to establishing joint facilities with academia and industry. President Yoon initiated the "Triangular Cluster" concept in March 2024, promising government support for space facilities by private industries throughout the country.[30] The cluster is intended to help achieve President Yoon's goal of having KRW 100 trillion (around USD 74.7 billion) in private investments in the South Korean space industry and the creation of 250,000 space-related jobs by 2045. Encompassing different geographic hubs for various sectors of the space industry, the triangular cluster consists of Daejeon leading space R&D efforts, South Jeolla Province leading launches, and South Gyeongsang Province leading manufacturing and testing.[31] The cluster concept has been used to support the commercial growth of other South Korean sectors of strategic interest, including the semiconductor industry, and demonstrates the country's commitment to its stated national goals.[32]

Restructured Civil Space Research Authorities

Keeping with the goal of growing South Korea's role as a major global actor in space, the establishment of KASA will contribute significantly to US-South Korea relations in space. After several years of preparations, KASA became the newest organization within the South Korean space governance structure in May 2024. Responsible for fostering the commercial space industry and developing and executing national space security strategies, including the

fourth basic plan, KASA will function as the "control tower of national space affairs and international cooperation."[33] KASA will be the umbrella organization for KARI and KASI, developing policies that directly inform the R&D choices made by the two space research institutions. The vision of KASA is to guide South Korea to "becoming the top five spacefaring nations in the world and making aerospace sector a national main industry" through expanding domestic investment in space and raising the profile of South Korean commercial companies to a global stage.[34] This includes moving from limited participation in international cooperative space efforts to assuming greater leadership in these efforts.

The establishment of KASA is crucial to growing the US-South Korea relationship in space. KASA is modeled after NASA, and the first KASA administrator, Yoon Young-bin, is a former NASA executive.[35] These connections could lead to close ties between the two agencies as they look forward to future collaborations. Additionally, KASA's positioning within South Korea's space governance provides clarity when communicating with international space partners by housing policy and strategy within one organization. South Korea's adaptation of a whole-of-government approach to space was recommended in previous analyses of the US-South Korea space relationship, and KASA has fulfilled that need.[36] With the lines of communication open between the United States and South Korea—and now NASA and KASA—the two countries can focus on the areas of space in which a bilateral partnership would be most impactful for both states.

Promising Areas for Continued and Future Partnership

The United States and South Korea each offer unique strengths in technology development and space capabilities. The opportunities for mutually beneficial partnerships in space include civil and military programs and span goals that can be achieved at any time between the next few years and the next few decades. These opportunities could take the form of diplomatic efforts, information sharing, commercial partnerships, and combined capabilities. Additionally, a summary of the working groups, agreements, and joint statements relevant to space mentioned in this paper is shown in Table 1.

Table 1: US-South Korea Working Groups, Agreements, and Joint Statements Relevant to Space

Agreement, Statement, or Working Group	Date of Establishment	Main Purpose	Agencies, Leaders, and Organizations Involved
Scientist-in-residence personnel exchange	2009	Space Science	• US National Oceanic and Atmospheric Association (NOAA) • Korean Space Weather Center (KSWC)
Memorandum of Understanding (MOU) on sharing space situational awareness data	September 5, 2014	Security	• US Department of Defense • ROK Ministry of National Defense
South Korea signs the Artemis Accords	May 24, 2021	Space Exploration	• NASA • ROK Ministry of Science and ICT
Joint statement on civil global navigation satellite systems cooperation	May 26, 2021	Security and Civil	• US Department of State • US National Coordination Office for Space-Based PNT • ROK Ministry of Science and ICT • ROK Ministry of Foreign Affairs
MOU on forming a joint space policy consultative body	August 27, 2021	Security	• US Space Force • ROK Air Force
US-ROK Leaders' Joint Statement on Strategic Economic and Technology Partnership	May 21, 2022	Governance	• US President Joe Biden • South Korean President Yoon Suk-yeol

GPS-KPS Technical Working Group	March 20, 2023	Security, Civil, and Commercial	• US Department of State • US Department of Commerce • US Space Force • US Coast Gaurd • ROK Ministry of Science and ICT • ROK Ministry of Foreign Affairs
Joint Statement of Intent for Cooperation on Space Exploration and Science	January 29, 2024	Space Exploration	• NASA • ROK Ministry of Science and ICT
Joint Project Agreement Ocean Research Panel Workshop	June 2024	Environmental Science Research (using satellite data)	• Various US and South Korean academic institutions • NOAA • Korea institute for Ocean Science and Technology
Joint Statement to Advance Aerospace Cooperation	September 22, 2024	Space Exploration	• NASA • KASA

Security and Civil Partnership Opportunities

Space situational awareness (SSA) is a capability that contributes to space security, and there has been explicit US-South Korea information sharing of SSA for a decade. A 2014 agreement between the US Department of Defense (DOD) and the ROK Ministry of National Defense (MND) called for exchanging "higher-quality and more timely space information" from the United States for satellite positioning and radio-frequency emission information from South Korea.[37] Space surveillance capabilities were also a key focus of the 2021 space security agreement between the US Space Force and the ROK Air Force.[38] This joint effort was put into action later that year with a bilateral drill designed to test SSA information-sharing pathways. The US-South Korea commitment to joint SSA is strong, but developing independent SSA capabilities remains a

priority for South Korea. KASA's space policy strategy includes the development of the Korean Integrated Space Situational Awareness System (K-SSA) for managing both public and military assets.[39] This builds off the satellite monitoring unit set up by the ROK Air Force in 2021 with the goal of developing ground-based lasers for a robust space tracking system by 2030.[40] With the United States' demonstrated commitment to space security through cooperation with South Korea, the US-ROK alliance can leverage US leadership and expertise in SSA to continue building South Korea's independent capabilities. Additionally, the growing emphasis on cislunar SSA provides another prime opportunity for US-South Korea collaboration that will help both countries achieve their goals of expansion toward the Moon.

Position, navigation, and timing (PNT) capabilities are essential not only for civilian and military global location services but also for technologies under development, including the rapidly expanding industry around autonomous vehicles. South Korea first established a steering committee to determine the requirements and scope of its KPS under the third basic plan for space in 2018.[41] Since then, the country has approved a proposed KRW 3.72 trillion (about USD 3.3 billion) for a project to design, launch, and operate eight satellites in geostationary orbit (GEO) by 2035.[42] The first launch is expected to take place in 2027 after completing the development of the satellite structure system in 2025. Notably, KPS made up about 12 percent of South Korea's space budget in 2022 and comprise about 22 percent in 2024.

KPS will have far-reaching impacts on South Korea and can greatly improve US Global Positioning System (GPS) services as well. In addition to cultivating commercial capabilities by contracting with South Korean companies for KPS satellite design, the infrastructure needed to operate, communicate with, and receive signals from KPS, as well as the accelerated technology development that will happen when KPS comes online, will help accelerate the growth of the private space industry in South Korea.[43] Although the motivation for KPS is largely domestic, South Korea is intentionally designing KPS to be interoperable with GPS capabilities to augment existing services and provide redundancy in the region.[44] South Korea is receiving US support to develop KPS in exchange for the country's participation in the Artemis Accords.[45] In March 2023, a GPS-KPS Technical Working Group was established and held its first meeting to discuss compatibility and interoperability between the two services.[46] This working group follows the commitments made in the 2022 joint statement between Presidents Biden and Yoon to support KPS development.[47] While there are several options for making GPS and KPS interoperable, the accuracy of both systems would be improved if used together.[48]

Hosting payloads could be an intriguing opportunity for US-South Korea defense space collaboration. In 2024, US commercial rockets launched a Norwegian spacecraft, which hosted US military satellite communication payloads.[49] This was the first time that a foreign spacecraft had active operational payloads from the US Department of Defense (DOD). The United States is also partnering with Japan, which will launch navigation satellites that will also host US national security payloads. Importantly, the DOD is transitioning to more proliferated satellite networks for missions, including missile warning and tracking. These proliferated assets typically comprise smaller and less expensive satellites. By moving from low numbers of expensive satellites for a mission to large numbers of cheaper satellites, DOD will have more opportunities to partner on shared capabilities with close allies and partners. The push toward proliferation may also make the department more willing to partner on shared capabilities because individual satellites will be less critical to the mission in a proliferated network than in a small constellation of satellites. South Korean spacecraft hosting US national security payloads should be an option that the United States and South Korea consider, including for missions of mutual interest such as missile warning and positioning, navigation, and timing.

Science Research and Space Exploration Collaboration

Protecting space assets through accurate space weather forecasting is another critical aspect of SSA, and the Korean Space Weather Center (KSWC) serves that purpose. Established in 2011 and now under the purview of KASA, the KSWC develops modeling capabilities and provides space weather-related warnings to satellite operators. South Korea has invested in its own space weather satellites, contracting with a domestic private company to launch a forecasting system focused on protecting South Korean military assets in space.[50] The KSWC director has emphasized the center's goal of strengthening their international partnerships.[51] To that end, South Korea is already a member of the International Space Environment Service (ISES), dedicated to international coordination of space weather data and warnings.[52] US-South Korea bilateral partnership includes KSWC scientists using data from US space weather satellites, particularly the Geostationary Operational Environment Satellite controlled by the National Oceanic and Atmospheric Association (NOAA).[53] Additionally, in 2009, NOAA and KWSC participated in a personnel exchange in which four South Korean scientists were scientists-in-residents at NOAA.[54] Both countries recognize the need for comprehensive space weather disaster management and issued updated national response plans in 2023.[55] Adequate preparation relies on quality research and data, and there is an opportunity to build on past space weather agreements and encourage more space weather expert exchanges between the two countries.

The United States and South Korea have the chance to strengthen their cooperation in space through environmental monitoring and forecasting as well. The desire to be an independent provider of Earth observation satellite-based forecasting spurred South Korea's entry into GEO in 2010 with the first launch of its Communication, Ocean, and Meteorological Satellite (COMS). Also known as the "Chollian" series of satellites, the follow-on payloads are designed to provide neighborhood-level weather monitoring services and help detect extreme weather-related events, including flooding and fires.[56] The United States and South Korea both have robust forecasting capabilities and recognize that exchanging ideas between scientists analyzing meteorological data is valuable for both countries. A recent example of such exchange took place in June 2024 when Seoul National University hosted a series of technical workshops for US and South Korean scientists to discuss techniques for extreme weather forecasting using satellite data.[57] Additionally, organizations from both countries are members of the Coordination Group of Meteorological Satellites (CGMS). Global users of CGMS data receive standardized, high-quality data, and members of CGMS are committed to helping each other if a member loses access to one of their satellite assets or data.[58] CGMS is now adding greenhouse gas monitoring to the organization's priorities, presenting an opportunity for the United States and South Korea to collaborate and take the lead in collecting and analyzing climate change data from space-based assets, building on a history of climate change cooperation between the two countries.[59]

Another category of observation satellites hosts synthetic aperture radar (SAR) systems to produce fine-resolution images of the Earth's surface. Launched in 2013, the Fifth Korea Multipurpose Satellite (KOMPSAT-5) is South Korea's first all-weather SAR satellite, used for mapping, predicting and tracking natural disasters, and managing resources.[60] The all-day, all-weather SAR technology is appealing to the military as well. The second of the five-satellite South Korean reconnaissance constellation, which launched in April 2024, used a combination of electro-optical/infrared (EO/IR) and SAR sensors.[61] Despite new advances in SAR, some South Korean scholars have noted that the country lags when it comes to EO/IR and SAR data-fusion technologies, advocating for South Korea to establish an "international technical cooperation system" to help fill technology gaps.[62] As the global research community tackles the challenges of SAR and EO/IR data-fusion processes, the US-South Korea scientific partnership could help accelerate progress. Paired with the increasing demand for high-resolution Earth observations—and, by extension, a growing market for this data—there is potential for enhancing US-South Korea commercial partnerships on SAR technology development and deployment.[63] Finally, South Korea could consider joining the International Coordination Group for Synthetic Aperture Radar

Missions (ICGS-SAR). NASA is a member, and South Korea's participation would further the country's global representation as an emerging expert on this essential space technology.[64]

Space exploration is another opportunity for South Korean global engagement. With a signatory status on the Artemis Accords, which details guidelines and principles for lunar and deep space exploration, South Korea is already working closely with the United States on international norms development. The fourth basic plan includes the envisioned dates of 2032 for a South Korean robotic lunar lander and 2045 for a Mars robotic lander. Both projects would offer plentiful opportunities for the United States to support South Korea's development of these capabilities. The United States has already participated in South Korean-led space exploration with the launch and commissioning of the Korea Pathfinder Lunar Orbiter (KPLO) in 2022, which carried a US-built instrument to the Moon.[65] US scientists will also have the opportunity to learn from data gathered by novel space missions led by South Korea. One example is the planned South Korean solar observer mission to the Sun-Earth Lagrange point L4, which would allow a unique vantage point of the heliosphere and improve understanding of solar activity.[66] The United States has proposed a similar mission to L4 to study solar wind.[67] In the Sun-Earth system, Lagrange points are areas where gravity is balanced between the Earth and the Sun. While there are no missions currently at L4, the fact that both countries have proposed missions to L4 means there are significant opportunities to collaborate for the betterment of both programs.[68] In September 2024, NASA and KASA signed a joint statement that mentioned their intention to explore L4 as well as providing some details on KASA's continued involvement in the Artemis program.[69]

Support for International Space Governance

With the US legacy of global leadership in space and South Korea's emergence as an international space leader, the next decade offers plentiful opportunities for joint space leadership on the world stage, particularly through the support of UN initiatives. Dedicated to ensuring continued access to space for all, the United States was a founding member of the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS), which develops space governance under the auspices of the UN Office of Outer Space Affairs (UNOOSA).[70] Being a relative latecomer to the space sector has not prevented South Korea from being an active member in shaping the future of international space governance. Like the United States, South Korea has ratified the four main UN space treaties: the Outer Space Treaty, the Rescue Agreement, the Liability Convention, and the Registration Convention. As a fellow member of

UNCOPUOS, South Korea shares the US desire for free access to space, particularly for developing countries and emerging space-faring nations. South Korea actively supports these states by offering an International Space Training Program through KARI.[71] Part of the UN's Space 2030 Agenda encompasses encouraging the participation of women in space, and South Korea is supporting Space 2030 by leading UNOOSA's Space4Women three-year study to assess women's engagement in the global space industry.[72]

The United States and South Korea have similar overarching goals for the global space industry and are extensively involved in international space initiatives. Therefore, maintaining an open dialogue between the United States and South Korea on how the two countries envision future economic, scientific, and strategic success in space will ensure their work on international initiatives is aligned to enhance the global platform of both states.

Challenges to Partnership

While the opportunities for collaboration are promising, there are several challenges the United States and South Korea will have to consider—both individually and as allies—when furthering their space partnership. Some analysts suggest the US-South Korea space alliance would benefit most from a "train the trainer" model, where the United States is not focused on heavy-handed space capacity building in South Korea but rather empowers South Korea's independence in space through the exchange of technical expertise.[73] This aligns with South Korea's goals from its fourth basic plan. Additionally, there may be areas of space technology development in which South Korea would be well-suited to take the lead in the bilateral alliance. Given South Korea's expertise in 5G services and focus on expansion to 6G, the United States has an opportunity to partner with South Korea in terms of mobility, autonomy, and communication for space exploration.[74] As identified in the MSIT visit to NASA in January 2024, these technologies would be particularly useful for lunar rovers and communications, in addition to potential space traffic management applications.[75] The challenge is that South Korea must be able to build an adequate domestic market to achieve its targeted space milestones and maintain its indigenous space capabilities before the country can take on more responsibility in its partnership with the United States.[76]

South Korean leaders have espoused bold goals in space for the next two decades and are actively pursuing ventures that will help the country achieve those goals. However, investment and infrastructure alone are not the only problems to solve when building a thriving domestic space market. The government remains the primary customer of South Korean satellites and

space equipment, and it remains to be seen if government investment will be sufficient to sustain these bold directives for the industry. One example is the difficulty of getting competitive bids for space programs. For the development of KSLV-III, only one bidder participated and was ultimately chosen after a second bidder dropped out.[77] Additionally, South Korea still relies on foreign launch capabilities to achieve some of its goals in space. The South Korean reconnaissance satellite launched in December 2023 was brought to orbit by a SpaceX rocket rather than the domestic Nuri rocket, as SpaceX was more economical and reliable given the criticality of the satellite system to national security.[78] While the transition to having more domestic competition and using domestic providers for space services will take time, South Korea can continue to accelerate progress by instituting a policy to perform technology demonstrations on US missions to help test industry-made satellite components and help South Korean development processes remain agile.

South Korea's financial resources will be put to the test in the long term as well. Despite significant growth in their space budget as stipulated by the fourth basic plan, the South Korean space budget is less than one-fifth of Japan's space budget, a country with similarly ambitious goals in the industry.[79] Looking at relative spending compared to gross domestic product (GDP), South Korea's national spending on space is only 0.034 percent of its GDP, compared to the US space budget at 0.243 percent of the country's GDP.[80] Even if the rate of funding is sufficient to achieve national goals in space, experts warn that nurturing a growing space industry could give rise to similar challenges to those experienced at the start of the aviation industry in South Korea, where investments must be made years before profits can be expected.[81] A key part of the fourth basic plan is the economic benefit of space, which includes the domestic jobs the burgeoning industry will create. The creation of 500,000 space industry jobs is one of the country's many targets for 2045.[82] Aiming to make a 5000 percent increase in the number of employees in the domestic space industry—even over a 20-year period—would be a significant undertaking that the whole of the South Korean government should consider.[83]

Partnerships and Geopolitical Competition

Growing US-South Korea space cooperation is particularly important given the development of space coalitions or collaboration among competitor nations. After Russia invaded Ukraine, South Korea canceled satellite missions with Russia.[84] Moscow has now turned toward potentially supporting North Korea in its satellite technology development.[85] Around the same time as South Korea's successful reconnaissance satellite deployment in late 2023, North Korea launched its own reconnaissance satellite, possibly with help

from Russia, a move that the United States publicly condemned as a violation of UN restrictions on North Korean launch capabilities.[86] North Korea has also advanced its missile capabilities. Over the last ten years, China and Russia have also expanded their collaboration on space issues, including PNT and deep space.[87] Space security concerns also extend to Iran, with USSPACECOM warning of the bond between China, Iran, Russia, and North Korea in space.[88]

In addition to bilateral technology exchange between the United States and South Korea, the strong US-Japan alliance can be used as a foundation for a stronger US-South Korea-Japan trilateral relationship that includes a focus on space. An August 2023 meeting between the leaders of the United States, South Korea, and Japan named space as a key area of emphasis for this relationship. Japan has strong individual space capabilities and a history of partnering with the United States in space, with a particular focus on SSA.[89] With SSA being a focus for all three countries, South Korea and Japan would benefit from more direct information sharing. Historical tension between South Korea and Japan creates obstacles, but especially with the United States involved as a third partner, space offers a promising cooperative front to boost all three countries' individual capabilities and collective security.[90]

While the strength of the US-South Korea-Japan partnership should not be taken for granted, the expansion of this trilateral cooperation into space will be essential for Indo-Pacific regional security. In fact, missile-warning systems are a crucial area for US-South Korea-Japan trilateral cooperation in space, and the three countries should continue defining how information sharing can be more efficient and effective to ensure regional security.[91] In 2022, the three countries conducted a missile-defense exercise after holding a joint ministerial meeting, and at the end of 2023, a missile-warning data-sharing mechanism between the three countries was brought online.[92] As noted, deeper partnerships in this area could be particularly viable given that the United States is transitioning to large numbers of proliferated spacecraft for missile warning and tracking. For example, this could take the form of South Korea or Japan building their own satellites and hosting the US Space Development Agency's missile warning and tracking payloads. More broadly, as South Korea and Japan both have a deep bilateral alliance with the United States, the United States is in a unique position to continue encouraging dialogue and supporting a stronger bilateral relationship between South Korea and Japan. If South Korea fully embraces what President Yoon calls a "future-oriented" view of South Korea-Japan relations, both countries will be better protected from potential regional conflict.[93]

Nonetheless, tightening such cooperation—and the perception or reality of a US-led regional missile defense architecture—will undoubtedly result in strong pushback from Beijing, Pyongyang, and Moscow. In the context of increased

geopolitical competition and fault lines in the Indo-Pacific, policymakers in Washington, Seoul, and Tokyo will need to make sure their strategic communication about increased space cooperation is cohesive and convincingly responds to Chinese, North Korean, and Russian counter-narratives.

Looking to the Future

The mutual benefits of partnership, in addition to the vulnerabilities and values shared by the United States and South Korea, outweigh the risks posed by the challenges of cooperating in critical areas, including space.[94] The United States and South Korea have been key allies, but this partnership has not historically extended to space. This, however, is changing. South Korea aims to establish itself as a global space power by restructuring its space governance schema, promoting domestic commercial space capabilities, and laying the groundwork for ambitious space exploration goals. Meanwhile, the United States and South Korea have been leaning on their alliance legacy to ensure regional security by advancing space capabilities. The US-South Korea relationship in space is gaining momentum due to South Korea's renewed enthusiasm for space and recent space information-sharing agreements, military exercises, and bilateral scientific cooperation. Further, the US push toward proliferated space assets could create more opportunities for shared capabilities among allies and partners. Despite the challenges that lay ahead for South Korea's national space goals and international challenges that could arise, a strong US-South Korea space partnership would be mutually beneficial, and there is a plethora of cooperative avenues to pursue. There is no doubt that the next decade will be pivotal for defining the scope of US-South Korean partnerships in space.

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US-South Korea Cyber Cooperation: Towards the Higher-Hanging Fruits

By Dr. Jenny Jun and Dr. So Jeong Kim

Introduction

The range of cyber threats facing the United States and South Korea, or the Republic of Korea (ROK), over the next decade will not be the same as that of the past decade. In the past, the United States and South Korea jointly faced a relatively narrow set of challenges in cyberspace, mainly limited to North Korea's cybercrime and its funding of the country's nuclear and missile program. However, the geopolitical situation surrounding the Korean Peninsula is rapidly changing, and these changes will trickle down to the cyber domain as well. North Korea is increasing military ties with Russia and has entered the war in Ukraine. US-China strategic competition is intensifying, which has resulted in Chinese cyber intrusions to overseas US military bases in the Indo-Pacific. A second Donald Trump administration will also intensify trade tensions with China, increase volatility in US alliances in the region, and result in potential changes to the United States' North Korea policy.

Under these circumstances, cyber threats will also diversify. In the future, the two countries will have to worry about more than North Korea's cybercrime. For instance, there may be more disruptive or destructive cyberattacks beyond crime or espionage targeting South Korean public and private sectors, especially to coerce or influence South Korea's Ukraine policy. Pro-Russian hacktivists have already launched a distributed denial-of-service (DDoS) campaign against South Korean government agency websites.[1] We may see Chinese cyber intrusions similar to Volt Typhoon in 2023 and 2024, where the suspected goal was to maintain access and persistence on systems connected to US military bases to create effects in the event of a crisis in the Indo-Pacific. The Korean Peninsula is again caught in competition among superpowers, and this is no exception for the cyber domain. The stakes are getting higher, and there is going to be less room for error in order to minimize accidents and manage escalation.

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Therefore, now is the time to reach for the higher-hanging fruits in US-South Korea cyber cooperation. Over the past two years, the two countries have made a dramatic shift toward fostering greater cooperation on cyber issues and have made some significant progress in regularizing workshops and expanding cooperation to trilateral and multilateral settings. Much of the content of such meetings concerned jointly combatting North Korea's cybercrime, which is appropriate given that it is the modal threat and there is little disagreement as to a need to respond. Going forward, now that the basic structure of the dialogues has been established, it is time to touch on the more difficult questions.

Much of these more difficult conversations come down to coming to a consensus at the strategic level as to whether and what range of cyber threats jointly concerning the two countries need to be deterred versus mitigated through active defense measures and how responsibilities and authorities will be divided up for such operations, if any. South Korea's new national cybersecurity strategy that introduces the concept of "offensive cyber defense" needs to be further refined, and policymakers need to have more discussions on how such a strategy will work in tandem with the US cyber strategy of Defend Forward and Hunt Forward missions.[2] Jointly thinking through these questions in advance will help clarify responsibilities and improve readiness ahead of future cyber incidents on the Korean peninsula.

In this paper, we provide an overview of the range of cyber threats facing the United States and South Korea and analyze the progress made so far in the past two years of cyber cooperation between the two countries. We then highlight the remaining challenges and suggest topics for further discussion by policymakers in both countries.

The Evolving Cyber Threat Landscape

North Korea

Currently, the modal cyber threat jointly facing the United States and South Korea is undeniably coming from North Korea. North Korea's cyber operations have become more brazen, sophisticated, and diversified throughout the past decade. Most importantly, North Korea has significantly expanded its cybercrime enterprise to fund its nuclear and missile program, creating a gaping loophole in the international sanctions regime. North Korea has engaged in fraudulent SWIFT transactions targeting banks, fraudulent ATM cashouts, and ransomware, as well as cryptocurrency heists against exchanges and gaming platforms.[3] North Korean IT workers have also sought jobs at foreign companies under false identities, generating revenue for the regime while also laying the grounds for further exploitation.[4]

Among these, the most important category of illicit revenue from North Korea's cybercrime activities is the theft of virtual assets, including cryptocurrencies. Virtual assets are highly attractive targets for North Korea due to the large sums of money that can be stolen at once and the relatively low-security protections on targets compared to traditional financial institutions. Although exact estimates are difficult, the UN Panel of Experts on North Korea reported that they are investigating 97 suspected cases between 2017 and 2024, valued at USD 3.6 billion.[5] Industry analysis also assesses that North Korea was responsible for almost a third of all cryptocurrency heists in 2023.[6] A single heist can range in the hundreds of millions of dollars worth of virtual assets, such as the 2022 hack of Axie Infinity's Ronin Bridge in which North Korean hackers stole about USD 620 million worth of Ethereum.[7] Comparing this amount to North Korea's legitimate sources of foreign cash provides a sense of how much the regime relies on illicit money flows. In 2022, North Korea's total exports were a meager USD 160 million, where 96.7 percent were exported to China, and minerals accounted for 41.3 percent of total exports.[8] The revenue from such heists is thus a lifeline for the cash-strapped regime.

North Korea having such a lucrative outside option further dilutes the power of sanctions as a policy lever in slowing down North Korea's weapons program and pressuring the regime to change its calculus. About half of North Korea's missile program is funded by cybercrime, according to a 2023 assessment by US Deputy National Security Advisor for Cyber and Emerging Technology Anne Neuberger.[9] Furthermore, effective sanctions enforcement is likely to be undermined even more with the dismantling of the UN Panel of Experts that has served as the primary monitoring body for UN sanctions vis-a-vis North Korea in early 2024. This is why the North Korean cybercrime issue is no longer a technical issue dealt with at the working level but integral to the US and South Korea's overall North Korea policy.

In addition to cybercrime, North Korea also conducts extensive industrial espionage to obtain sensitive information on areas such as nuclear facilities, unmanned weapons systems, satellite technologies, and radar systems, often targeting foreign critical infrastructure in the process.[10] North Korean hackers have also targeted researchers and experts focusing on the Korean Peninsula, directly obtaining strategic analysis and compromising their accounts to further exploit other researchers in the network.[11] These activities are likely to continue, and responding to North Korea's cybercrime and espionage will remain a major pillar of US-South Korea cyber cooperation, as they have been for the past two years.

Future Threats

Beyond these threats, however, lie other categories of cyber threats that the United States and South Korea should have a clear playbook for. South Korea also faces cyberattacks intended to have disruptive and/or destructive effects beyond financial crime or espionage. The actors are also more diverse than just North Korea; South Korea has been targeted by state and non-state actors from Russia and China. While these may occur with less frequency, they may have a higher impact and entail different geopolitical risks beyond the narrowly defined North Korean threat. With escalating tensions in Northeast Asia amid increasing Russia-North Korea ties and US-China competition, these types of threats may also occur more frequently in the future.

First, South Korea may see more disruptive and/or destructive cyberattacks going forward. These may be a response to protest certain South Korean policies, or they may be accompanied by a coercive threat. For example, after South Korea announced that it may review its previous policy against directly supplying arms to Ukraine in response to North Korean troops joining the war in Ukraine, pro-Russian hackers have launched DDoS attacks against South Korean government agency websites.[12] While DDoS attacks themselves have had a minimal disruptive impact, this incident shows that South Korea's cyber threat landscape will diversify because of the war. Though less frequent in recent years, South Korea has experienced major cyberattacks, such as the disruption of the 2018 Pyeongchang Winter Olympics opening ceremony by Russian state actors.[13] It has also faced coercive threats such as the attack on Korea Hydro and Nuclear Power (KHNP) in 2014, where the hackers demanded that South Korea shut down three of its civilian nuclear reactors by Christmas and released stolen blueprints and employee information as part of the threat.[14] These less frequent, but high impact threat scenarios require more coherent thought leadership at the strategic level and a clear playbook at the operational level.

Second, South Korea's growing role as an arms exporter and its increasing role in the global supply chain for critical goods may increase cyber threats to the private sector, affecting US security interests as well. For example, Hanwha Ocean won a contract earlier this year to perform maintenance, repair, and overhaul (MRO) for the US Navy, as the United States increasingly seeks to reduce downtime of its ships through utilizing international shipyards.[15] Because South Korea's shipbuilding industry is already frequently targeted by cyber actors, increasing cooperation between the US military and South Korean shipbuilding companies poses new supply chain risks.[16] South Korea is also becoming a major arms exporter to Western Europe and the Middle East, making such South Korean companies a prime target for cyber espionage and

supply chain compromise by adversaries of the weapons importers, not just North Korea. These are also a different category of threats than disruptive and/or destructive cyberattacks and thus require a separate discussion for appropriately defending against such threats.

Third, as a major treaty ally of the United States in the Indo-Pacific, South Korea is not immune from campaigns such as Volt Typhoon as the strategic competition between the United States and China intensifies. Volt Typhoon was a Chinese campaign that sought access and persistence on US critical infrastructure, including communications, energy, transportation, and wastewater systems, and it was believed to cause disruptive effects in the event of a crisis or a conflict.[17] Targets of this campaign included infrastructure serving US military bases in Guam.[18] Such efforts to retain the capacity to cause friction on US military forces stationed in the Indo-Pacific may also extend to the Korean Peninsula. These intrusions may not directly target US forces but target South Korean civilian infrastructure that serves such bases, and detection of such intrusions may also, in part, depend on the private sector. Such scenarios highlight a need for close coordination on cyber issues between the US and South Korea and with the private sector.

The State of US-South Korea Cyber Cooperation

Despite the growing significance and impact of the North Korean cyber threat over the past decade, US-South Korean cooperation on the issue has been mostly sporadic until 2022. On many occasions, the United States independently responded to North Korea's cybercrime and espionage activities through its own security and law enforcement agencies and in cooperation with the private sector. The South Korean government's response to the North Korean cyber threat has oscillated between administrations, depending on their broader policy on inter-Korean relations and perception of the North Korean threat. For instance, South Korea's 2019 National Cybersecurity Strategy did not mention North Korea as the country's main threat. During the Moon Jae-in administration, existing US-ROK dialogues, such as the bilateral cyber cooperation working group, stopped convening, and mentions of cyber cooperation in high-level joint statements were limited to the context of ASEAN and domestic abuse, without mentioning the North Korean cyber threat.[19] In many ways, the United States and South Korea did not see eye to eye on the level of threat posed by North Korea's cyber operations, much less an articulation of a shared vision for how the two countries would manage security issues in the cyber domain.

In 2022, the conservative Yoon Suk-yeol administration came into power in South Korea, shifting the government's North Korea policy to a more hawkish posture compared to the previous Moon administration. This extended to the cyber domain as well. The word "cyber" appeared 10 times in the 2022 joint statement between President Yoon and US President Joe Biden, with an explicit statement on responding to North Korean cyber threats and a full paragraph that enumerated specific areas of cooperation. The statement specified "cooperation on deterring cyber adversaries, cybersecurity of critical infrastructure, combating cybercrime and associated money laundering, securing cryptocurrency and blockchain applications, capacity building, cyber exercises, information sharing, military-to-military cyber cooperation, and other international security issues in cyberspace."[20] This signaled a willingness to significantly deepen and broaden bilateral cooperation on cyber issues. Not only were issues related to the North Korean cyber threat listed with specificity, but they also hinted that South Korea was willing to look beyond just the North Korean issue to seek strategic cyber cooperation with the broader regional and international security context in mind.

Over the next two years, the United States and South Korea had a dizzying number of diplomatic and working-level engagements on cyber issues. Many of the dialogues have become frequent and regularized, providing a stable platform at the working level. The newly created US-ROK working group on the North Korean cyber threat met seven times. Other similar bilateral fora were convened, including the US-ROK Cyber Policy Consultations, the US-ROK Cybersecurity Senior Steering Group, and the US-ROK Joint Symposium on countering DPRK Cyber Threats to Cryptocurrency Exchanges. The United States and South Korea also issued several joint sanctions and threat advisories on the North Korean cyber threat, signaling that the two countries are aligned on the issue. In 2023, Presidents Biden and Yoon signed the Strategic Cybersecurity Cooperation Framework following their summit, expanding on many of the items discussed in the previous year.[21] The two countries also engaged in military-to-military cyber dialogues and held a joint cybersecurity drill in early 2024.

The United States and South Korea also broadened their cyber cooperation to multilateral and international fora. One of the most notable developments was the expansion of the conversation to a US-South Korea-Japan trilateral setting. After a trilateral summit at Camp David in August 2023, the three countries launched a US-ROK-Japan Trilateral Diplomatic Working Group on North Korea's Cyber Activities in December of that year. In addition, the three countries conducted FREEDOM EDGE, a multi-domain joint military exercise

that included cyber. In 2022, South Korea also became the first Asian country to formally join the NATO Cooperative Cyber Defence Centre of Excellence (NATO CCD COE) as a contributing participant.[22] A list of publicly reported meetings and joint actions between 2022 and 2024 is in Appendix A.

At the same time, the midterm report card is less clear on whether this newfound energy on bilateral cooperation has translated into effective curbing of problems such as North Korea's cryptocurrency theft and money laundering. North Korea continues to steal and launder large amounts of cryptocurrency despite bilateral and international efforts to increase friction on its illicit money flows. It is also difficult to delineate the extent to which progress is still largely a function of preexisting independent intelligence activity and law enforcement actions by the US government and the extent to which cooperation with South Korean counterparts has yielded additional gains. On the military front, mil-to-mil dialogues and joint exercises are welcome developments. At the same time, South Korea's new cyber strategy leaves room for further conceptual clarification and thinking through how it will work in tandem with US cyber operations to send the right signals and manage miscalculation risks. Cooperation on related topics such as misinformation and artificial intelligence is beginning to occur, though their progress remains to be seen. These are all promising areas for further discussion as the initial excitement of the first few years hopefully matures into a more routine working relationship.

Progress in Countering North Korea's Cyber Crime

Because of this issue's connection to North Korea's nuclear and missile threat, the US government has taken North Korea's cybercrime enterprise seriously. Over the past few years, the United States has been ramping up efforts to use a variety of means at their disposal to impose friction. The main approach has been to intervene in the intermediary steps between the moment funds are stolen and the point where they end up in North Korean-controlled accounts, mainly done through existing authorities in the Department of Treasury, Department of Justice, and FBI. This includes various indictments of hackers and money-laundering intermediaries, some of which have led to arrests and sentences.[23] They were also able to directly seize parts of the stolen funds in cooperation with the private sector and foreign governments—for example, USD 30 million out of about USD 600 million stolen in the Axie Infinity heist were recovered.[24] They have also sanctioned crypto mixers that facilitate money laundering, such as Tornado Cash and Sinbad.io.[25] The founders of Tornado Cash have also been indicted for money laundering and sanctions violations.[26] Many of these efforts have been conducted independently by the US government outside of the context of US-South Korea cyber cooperation.

South Korea has demonstrated solidarity with the United States by following suit with independent and joint sanctions as well as threat advisories on multiple occasions.[27] In 2023, the South Korean government issued its first-ever sanctions related to North Korea's cyber threat, designating seven entities and four individuals.[28] Although some of these entities and individuals had already been sanctioned by the US government, new names were also added. In turn, they have been subsequently sanctioned by the United States.[29] This is an instance of the value-add from closer working-level cooperation between the United States and South Korea.

On the illicit IT workers issue, the United States and South Korea have issued separate and joint advisories to raise awareness of the methods used by these individuals in an effort to disrupt their activities. US law enforcement officials have also arrested intermediaries that facilitate such operations, such as a Nashville resident who operated "laptop farms" for North Korean IT workers.[30] Although general awareness of this issue has increased over the past few years, North Korean workers continue to successfully secure jobs by creating new identities that leverage AI deepfakes or exploiting third parties to obtain contracts.[31]

These are certainly promising signs of progress. At the same time, there is room for further cooperation as the relationship matures. Even after both countries' earnest efforts, North Korea continues to steal and launder large sums of money and shows no signs of slowing down. There are important limits to how much sanctions and threat advisories can effectively curb the illicit money flow. North Korean hackers find alternative mixers and laundering schemes with relative ease, and effectively enforcing sanctions remains difficult as some entities, such as the Russia-based Garantex exchange, continue to operate despite being sanctioned and allow transactions from North Korean heists.[32] Slightly more effective are interventions that indict and arrest money-laundering intermediaries and those that directly seize parts of the stolen funds. Such measures, however, require close law enforcement cooperation with not just South Korea and Japan but with a variety of international partners due to the global nature of North Korea's illicit networks. Similarly, greater regulation of virtual assets generally requires extensive discussion and buy-in at the international level. These efforts to build a broad global consensus on virtual asset regulation, however, will be further delayed as a crypto-friendly second Trump administration moves to deregulate the industry in the United States.

While the United States and South Korea have closely coordinated on the IT workers issue, they also face some challenges ahead as this becomes a cat-and-mouse game. There is a growing trend of North Korean IT personnel

relocating to Southeast Asian countries as they face difficulties in securing work. This complicates direct sanctions against them. In such cases, additional measures may be required, such as restricting access to IT infrastructure, limiting their activities, or expelling them through cooperation with the respective countries. There is also a concern of displacement, specifically that North Korean IT personnel who fail to meet their assigned revenue quotas may become further involved in more explicitly malicious activities, such as being hackers-for-hire in greater numbers. This could lead to their operations becoming more malicious and covert, which makes complete eradication a challenging task.[33] Strengthening relationships and enhancing cooperation with countries where North Korean IT personnel operate freely is necessary to address this issue. Like the virtual assets issue, combatting this issue requires buy-in from key third-party states, and thus, issue-based diplomatic coordination is key.

This means that the United States and South Korea should increase diplomatic coordination to convince third parties to cooperate on this issue. This is a difficult task as further efforts are needed to build a consensus on the importance of virtual asset theft as a national security issue. In particular, states such as Russia are actively trying to downplay the threat by characterizing this issue as a mere crime that does not merit discussion in international organizations. While the UN Open-ended Working Group (OEWG) listed virtual asset theft as a major threat for the first time in its third Annual Progress Report (APR), Russia and other states have argued that ransomware and virtual asset theft are merely cybercrimes and should not be dealt with by the OEWG. If virtual asset theft is treated solely as a crime, it could undermine current actions taken from a national security perspective, including sanctions and countermeasures. This year, Russia also vetoed extending the mandate of the UN Panel of Experts, the key body that monitored UN member states' enforcement of the international sanctions regime against North Korea.[34] Although the United States launched an alternative 11-state multilateral monitoring body called the Multilateral Sanctions Monitoring Team (MSMT), details are currently sparse, and there is uncertainty on whether this body will have the authority and capacity to monitor sanctions pertaining to UN Security Council resolutions.

Considering the closer relationship between North Korea and Russia through the signing of the Treaty on Comprehensive Strategic Partnership, the United States and South Korea can expect an actively contested arena for agenda setting and norms development on combating cybercrime. At the same time, it also means that the United States should work with close allies such as South

Korea and Japan to shape the debate and increase buy-in from third-party states. North Korea targets globally and has stolen hundreds of millions of dollars from victims around the world, so treating the issue similarly to ransomware may help increase buy-in from states that are otherwise geopolitically disinterested in North Korea. Raising the profile of the issue, such as the debate held at the UN Security Council in June 2024, is a start.[35]

Maturing South Korea's Cyber Strategy

Another important aspect of US-South Korea cyber cooperation is in the military domain, forming a coherent strategy and accompanying operational capacity to effectively manage threats in the cyber domain. In this regard, South Korea made significant changes to its own national cyber strategy that show a desire to align more closely with the US cyber strategy of Defend Forward. In 2024, South Korea published its National Cybersecurity Strategy and the National Cybersecurity Basic Plan, an implementation roadmap for the strategy.[36] These two documents represent a major departure from the 2019 National Cybersecurity Strategy, which focused more on defensive measures at home.[37]

Most notably, one of the key aspects of the strategy is a new posture called "offensive cyber defense (공세적 사이버 방어)."[38] Although a clear articulation of the fine-print strategic logic behind the phrase remains murky, and it is still unclear how it will be operationalized and implemented by individual agencies, the spirit of this posture is likely the South Korean government's desire to align its cybersecurity strategy with the US cyber strategy of Persistent Engagement and Defend Forward.[39] Other pillars of South Korea's strategy stress greater diplomatic engagement with the international community on cyber issues, critical infrastructure resilience at home, and securing competitiveness around critical and emerging technologies. The strategy and the accompanying basic plan also make important updates to the bureaucratic chain of command, delegate tasks to individual agencies, and advocate for updating legal and regulatory frameworks.

However, South Korea's current articulation of the strategy, especially the key phrase of "offensive cyber defense," needs further refinement in its strategic logic. This is a prerequisite that should precede further discussions regarding the capabilities needed to achieve such ends, which agencies will have authority and autonomy in operational decision-making, and how these capabilities will create synergistic effects with existing US cyber operational concepts.

The phrase "offensive cyber defense" is the first pillar and appears 11 times in South Korea's new national cybersecurity strategy. The importance of the phrase has been further echoed by President Yoon in key government-organized conferences such as the Cyber Summit Korea 2024, during which he stated that "attack is the best defense."[40] On the surface, this looks like a pivot toward Defend Forward because it starts from the same realization that passive defense at home is not enough to stop cyberattacks or intrusions from occurring. Upon a closer look, however, South Korea's conceptualization is quite different from that of the US strategy.

Where the two states diverge is in their thinking on the best approach for achieving deterrence in cyberspace. South Korea's strategy indicates a focus on acquiring offensive capabilities as a response to cyberattacks to achieve deterrence by punishment through attribution and subsequent retaliation. This is seen in language such as "The Republic of Korea must shift the paradigm to offensive responses to threats, including those from North Korea."[41] This focus on deterrence by punishment becomes clearer further down the document, where it states that South Korea will acquire capabilities to "identify perpetrators of cyber attacks," "enhance response capabilities…by advancing systems for identifying attack origins," "identify the entities behind cyber attacks…and impose corresponding accountability," and "develop deterrence strategies against national security threats in cyberspace."[42] However, the same section also "task[s] intelligence agencies and the military with…preparing for anticipated attacks to preemptively and offensively respond to threats"—language that is quite different from deterrence by punishment.[43] Similarly, the Basic Plan also focuses on attribution and identifying "attack origins."[44] The Yoon administration's strategic thinking reflecting a reliance on deterrence by punishment is also not unique to cyberspace and is echoed in other domains as well.[45]

In cyberspace, the United States moved away from this kind of thinking in 2018. The motivation for the pivot was the realization that deterrence by punishment in cyberspace is hard to achieve, especially against routine attacks and intrusions that occur at the threshold below armed conflict.[46] Instead, the US approach turned to Persistent Engagement—the idea that in a domain characterized by constant contact, actors constantly maneuver to compete for limited advantages. The strategy born from that conceptualization of the domain was Defend Forward, which aims to "disrupt or halt malicious cyber activity at its source" in order to "stop threats before they reach our targets."[47] The desired end state is not necessarily malicious cyber actors being deterred as a result of Defend Forward operations but competition at a manageable level.

Knocking the knife out of the attacker's hand before an attack versus acquiring a knife oneself to slash back, such that the attacker does not think about attacking again, are very different strategic concepts and, accordingly, require very different operational capabilities. For example, acquiring capabilities for attribution and the identification of an attack's origin are more important for the latter. South Korea's first mission should be to clarify the meaning of "offensive cyber defense" and whether they really want to achieve cyber deterrence and examine whether there is a disconnect between the means and the end. If they instead meant to emphasize active defense, South Korea's second mission should be to clarify what kind of active defense they plan to adopt. Not all active defense is equal—some states, such as the United Kingdom, prefer to conduct active defense mostly in blue space, while the United States conducts operations in gray and red space in third-party and adversary-controlled systems.[48] This will determine the necessary authorities and capabilities. South Korea should also discuss the degree to which agencies will have autonomy in planning and executing such offensive cyber operations and how oversight will work. It will also inform how South Korea's operations will work alongside US initiatives, such as Hunt Forward missions.

Furthermore, South Korea should think about the signaling effects of its posture beyond the North Korean threat. South Korea is targeted not just by North Korea but also by other states such as China and Russia. This is where language around offensive cyber operations should be calibrated closely so as to minimize misperception and miscalculation. This is especially relevant as US-South Korea cyber cooperation expands to include Japan, multi-domain joint military exercises are held with the broader Indo-Pacific geopolitical context in mind, and South Korea joins organizations such as NATO CCD COE. How to engage Chinese and Russian cyber activity targeting South Korea is a sensitive discussion that requires close coordination with US counterparts. Sharing a similar strategic vision is important, but that does not always mean that South Korea must acquire the same capabilities as the United States to carry out its independent operations. Just like how European allies rarely conduct offensive cyber operations on their own but still work with the United States to dismantle servers and expose adversary toolkits, it is important to assess how South Korea's capabilities can complement and augment existing US capabilities and missions.

The Harder Questions of US-South Korea Cyber Cooperation

The deepening and broadening of cyber cooperation and proactive engagement over the past two years is commendable. The United States and South Korea are coordinating on a variety of fronts, including the North Korean cyber threat,

military-to-military dialogues and exercises, and US-South Korea-Japan trilateral dialogues. Conversations are happening at both the working level and the diplomatic level, embedded in multilateral and international fora. Efforts are also being made to update national strategies to better align with one another. At the same time, real challenges remain as the initial flurry of establishing workshop series and consultative meetings transition to mature working relationships. Soon, there will also be a need to assess the practical impact of such discussions and initiatives.

Of course, the most immediate challenge for both countries is to effectively curb North Korea's revenue generation through cyber means. In some ways, a full report card on the impact of bilateral cooperation on this issue is premature, as initiatives are just starting to kick off. In the short term, there are instances where cooperation has concrete synergy, such as identifying entities and individuals to be sanctioned. In some cases, such as the issue of illicit IT workers, issuing joint threat advisories helps raise public awareness about the problem in both countries. At the same time, there are limits to how much sanctions designations and joint advisories can directly stop the flow of money to the North Korean regime. Interventions, such as directly seizing stolen virtual assets and increasing regulatory oversight on virtual asset transactions, are promising, though they require partnerships with key third-party states. In a crypto-friendly second Trump administration, it remains to be seen whether virtual asset theft will be seen as a threat to the industry to be cracked down on or overlooked in the push to deregulate the industry.

Locking in the initial enthusiasm into long-term, regularized cooperation also remains uncertain. Historically, enthusiasm for cooperation on cyber issues has waxed and waned in South Korea depending on the administration in power and their perception of the North Korean threat, the US-ROK alliance, and close cooperation with Japan. Navigating South Korea's bureaucracy and streamlining efforts is also another challenge. There is also a risk of duplicating efforts, with cooperation on the same topic taking place through both working-level partnerships and diplomatic channels. Strengthening policy expertise within South Korea's Ministry of Foreign Affairs and enhancing the professional capacity of relevant departments is also necessary. The ROK National Security Office's support capabilities should be bolstered to provide more realistic oversight and coordination. On the US side, a second Trump administration is likely to result in severe budget cuts to key federal agencies, increase uncertainty in the alliance, and undermine multilateralism. Keeping up the momentum of the past two years will be challenging on both sides.

Finally, there are harder questions that need to be asked beyond the narrowly defined issue of North Korean cybercrime. The core of the bilateral relationship is the US-ROK military alliance, and increasing geopolitical tensions surrounding the Korean Peninsula also raise stakes in the cyber domain as well. Increasing Russia-North Korea ties and South Korea's growing role as an arms exporter and an integral part of the global supply chain entangle South Korea in affairs beyond Northeast Asia to a greater extent, increasing the possibility that South Korea's public and private sector will become more frequent targets of disruptive cyberattacks, espionage, and supply chain compromise, by state and non-state cyber actors other than North Korea. Certain South Korean civilian critical infrastructure may be targeted as a way to maintain persistence in the event of a crisis in the Indo-Pacific. While they may not be the current modal threat, they will have greater impact and risk miscalculation and escalation when they do occur.

The US-ROK alliance needs a joint vision and strategic clarity on cyberspace and needs a playbook for responding to varying scenarios of intrusion campaigns and disruptive cyberattacks. First, to perform any joint actions responding to a cyber incident, the two countries need to come to a consensus as to whether the goal of performing such an action is to achieve deterrence of further similar incidents or denial and for which types of cyber incidents. To be fair, the US cyber strategy has also not completely resolved similar tensions between active defense and deterrence.[49] This tension, however, is much more pronounced in South Korea's current cyber strategy under the concept of "offensive cyber defense." Coming to such a shared vision is especially important given the recent confirmation by Secretary Blinken that the scope of the US-ROK Mutual Defense Treaty extends to space and cyber domains.[50] Perhaps there is a small range of destructive cyberattacks on critical infrastructure that rise to the level of armed attack, but the vast majority of cyber intrusions and attacks do not rise to this level of intensity. How the two countries will coordinate response, if at all, to this latter category of cyber threats is the more important and thorny question.

Whether South Korea decides to deal with cyber threats that fall below the level of armed attack through active defense or deterrence by punishment will have important implications for what practical capabilities and authorities are needed to implement such a goal. If South Korea wants to move towards active defense, this means that the main agency tasked with such operations will need augmented intelligence capabilities to "detect threats before they reach the target," which may be in gray and red space. This generally goes beyond what is

currently listed in the South Korean strategy of "identifying attack origins," which makes more sense for retaliatory measures. This increases the mission scope of that agency. This then brings up questions of nuances in oversight and operational autonomy as to what extent that agency can perform cyber operations beyond intelligence gathering in gray and red space without prior authorization from the National Security Council, where expediency is key in active defense. Also related to this question is the extent to which acquiring independent operational capabilities makes sense in relation to an already global reach of US Defend Forward and Hunt Forward missions. The United States, on the other hand, needs to think about managing possible miscalculations and escalation on the Korean Peninsula arising from such exchanges.

Major breakthroughs in US-South Korea cyber cooperation come at a time of intensifying geopolitical competition in the Indo-Pacific region. Over the past two years, the focus has been on the most immediate threat from North Korea. In some ways, however, responding to North Korea's cybercrime is not necessarily a strategic challenge but a question of implementing an existing playbook with a menu of options. On the other hand, thinking about how cyber cooperation works in the military domain in the alliance context is uncharted territory and requires careful strategic thinking, coordination on joint operations and areas of delegation, and long-term concerted development of corresponding operational capabilities. In many ways, the conversation has only just begun.

Appendix A: List of Publicly Reported Instances of US-South Korea Cyber Cooperation, 2022-2024[51]

Date	Title	Meeting Type
5/21/2022	United States-Republic of Korea Leaders' Joint Statement	Joint Statement
8/10/2022	Outcome of the First ROK-U.S. Working Group Meeting on the DPRK Cyber Threat	NK Working Group Meeting
11/16/2022	Second U.S.-ROK Working Group Meeting on the DPRK Cyber Threat	NK Working Group Meeting
11/17/2022	U.S.-ROK Joint Symposium on Countering DPRK Cyber Threats to Cryptocurrency Exchanges	Cyber Consultation
12/16/2022	The Sixth ROK-U.S. Cyber Consultation	Cyber Consultation
2/9/2023	#StopRansomware: Ransomware Attacks on Critical Infrastructure Fund DPRK Malicious Cyber Activities	Joint Advisory
3/9/2023	The Third U.S.-ROK Working Group Meeting on the DPRK Cyber Threat	NK Working Group Meeting
4/20/2023	Strategic Cybersecurity Cooperation Framework Between the Republic of Korea and the United States	Joint Statement
4/26/2023	Leaders' Joint Statement in Commemoration of the 70th Anniversary of the Alliance between the United States of America and the Republic of Korea	Joint Statement
5/23/2023	Treasury Targets DPRK Malicious Cyber and Illicit IT Worker Activities	Joint Sanction
6/1/2023	U.S., ROK Agencies Alert: DPRK Cyber Actors Impersonating Targets to Collect Intelligence	Joint Advisory
6/23/2023	First ROK-U.S. Cybersecurity Senior Steering Group	Cyber Consultation
7/26/2023	Fourth U.S.-ROK Working Group Meeting on the DPRK Cyber Threat	NK Working Group Meeting

8/11/2023	The Spirit of Camp David: Joint Statement of Japan, the Republic of Korea, and the United States	Joint Statement
8/31/2023	Treasury Targets Individuals and Entity Supporting the Democratic People's Republic of Korea's Weapons of Mass Destruction Program	Joint Sanction
10/18/2023	Additional Guidance on the Democratic People's Republic of Korea Information Technology Workers	Joint Advisory
11/1/2023	Second ROK-U.K. Cybersecurity Senior Steering Group	Cyber Consultation
11/7/2023	Fifth United States-Republic of Korea Working Group Meeting on Democratic People's Republic of Korea Cyber Threats	NK Working Group Meeting
11/9/2023	CISA Signs Memorandum of Understanding with the Republic of Korea to Share Cyber Threat Information and Cybersecurity Best Practices	Joint Advisory
11/30/2023	Treasury Targets DPRK's International Agents and Illicit Cyber Intrusion Group	Joint Sanction
12/7/2023	Inaugural United States-Japan-ROK Trilateral Diplomatic Working Group Meeting on DPRK Cyber Activities	US-ROK-Japan Meeting on Cyber
12/9/2023	U.S.-ROK Next Generation Critical and Emerging Technologies (CET) Dialogue	Joint Statement
1/24/2024	Seventh U.S.-ROK Cyber Policy Consultations	Cyber Consultation
1/26/2024	S. Korea, U.S. Hold 1st Joint Cyber Security Drill	Joint Cyber Military Exercise
3/27/2024	Treasury Sanctions Actors Financing the North Korean Weapons of Mass Destruction Program	Joint Sanction
3/28/2024	Sixth United States-Republic of Korea Working Group Meeting on Democratic People's Republic of Korea Cyber Threats	NK Working Group Meeting

3/29/2024	Second United States-Japan-Republic of Korea Trilateral Diplomatic Working Group Meeting on Democratic People's Republic of Korea Cyber Activities	US-ROK-Japan Meeting on Cyber
5/12/2024	Third ROK-U.S. Cybersecurity Senior Steering Group Held	Cyber Consultation
6/28/2024	First Execution of Multi-Domain Japan-ROK-U.S. Exercise FREEDOM EDGE	Joint Cyber Military Exercise
7/25/2024	FBI, CISA, and Partners Release Advisory Highlighting North Korean Cyber Espionage Activity	Joint Advisory
7/25/2024	North Korea Cyber Group Conducts Global Espionage Campaign to Advance Regime's Military and Nuclear Programs	Joint Advisory
8/27/2024	Joint U.S.-ROK Symposium on Protecting the Virtual Asset Industry from DPRK Exploitation and Disrupting DPRK Revenue Generation	Cyber Consultation
9/5/2024	Seventh United States-Republic of Korea Working Group to Counter Cyber Threats Posed by the Democratic People's Republic of Korea	NK Working Group Meeting

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US-South Korea Defense Industrial Cooperation: Drivers, Developments, and Tasks Ahead

By Dr. Bo Ram Kwon

The 2024 US presidential election ended in a convincing win for former President Donald Trump, which reflects a strong desire for US renewal. However, the trajectory of US foreign policy is characterized by several underlying trends, regardless of who occupies the White House. These include an increasingly nationalistic approach to foreign policy, a strong military marked by the strengthening and modernization of its nuclear capabilities, and intense strategic competition with China. Although there are key differences between the Republican and Democratic parties, there is bipartisan emphasis on optimizing US defense capabilities and integrating with allies' capabilities and resources to enhance deterrence against adversaries. As a result, the US global alliance strategy has called for allies to do more burden- and role-sharing to minimize costs, reduce the risk of US entrapment, and contribute to winning the strategic competition with China. The desire to enhance economic security adds to these demands. US lawmakers see China as a revisionist, pacing threat that has taken advantage of the rules-based international order at its expense. The American people support this notion and anticipate policies to correct this trend and address their daily economic woes. Hence, US leaders champion fair trade and reciprocity and offer protectionist economic policies that prioritize the betterment of its domestic economy before the advancement of a free and open global economy. In sum, the United States places its interests first as it optimizes both military capabilities and economic resources to compete from a position of strength.

In this context, the United States has prioritized allied cooperation and also tapped into the appreciable national capacities and defense industrial bases of its allies and partners. Yet, the United States and South Korea have nuanced approaches to allied cooperation regarding the defense industry and related technology. For the United States, pursuing cooperation with South Korea as well as increasing cooperation among allies is important as a *means* to realize its global strategy and win in strategic competition with adversaries. Washington is far superior in defense,

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science, and technology, but its allies have a comparative advantage in certain areas. So, faced with multi-domain challenges to its national security, it desires efficiently resourced power through its network of allies and partners. From a South Korean perspective, enhancing defense industrial cooperation with the United States is not only a means to deepen the alliance relationship but also an *end* in itself. Namely, Seoul seeks ways to enhance its defense capabilities and competence in totality. These include opportunities to overcome problems in its own defense industrial base, as well as to more efficiently obtain advanced technologies and operation skills and access the US market.

This paper examines how defense-industrial cooperation has evolved between South Korea and the United States with a focus on the Yoon and Biden administrations. First, it aims to understand what defense industrial cooperation entails as its components range from US global strategy and integrated deterrence to the industrial policy of both countries. Second, it examines cooperation trends that can offer insights into defense industrial cooperation under the Yoon and the incoming Trump administration. The analysis centers on the US National Defense Industrial Base Strategy (NDIS) of 2024, especially the context in which it was announced, and its implications for Seoul. The paper draws on historical background, joint government statements, and recent efforts at policy implementation. As a preliminary study, the paper deserves deeper exploration in future work.

Drivers of US-South Korea Defense Industrial Cooperation

Coupled with structural geopolitical factors, South Korea's advanced defense industry and strategic alignment have served as key drivers of defense industrial cooperation with the United States.

South Korea's Defense Industry: From Client to Global Exporter

South Korea's defense industry has grown significantly from its humble beginnings, mainly due to external security threats and the strong government support. After the Korean War, the government prioritized both national security and economic recovery, building a defense-industrial foundation alongside multi-year economic development plans. External shocks such as the Nixon Doctrine and the subsequent reductions in the US troop presence highlighted South Korea's need for greater self-reliance within the US-ROK alliance. This motivated Seoul to pursue "cooperative self-reliant defense" aimed at building a domestic defense sector that would strengthen its military while maintaining strong ties with Washington.[1]

South Korea developed its defense industrial capabilities with substantial security and technological assistance from the United States. Through military assistance and foreign military sales (FMS), along with regularized joint military training and exercises, the United States provided arms, technology, and expertise that bolstered South Korea's defense capabilities. Despite the United States being its largest weapons supplier, South Korea was dedicated to producing much of its defense equipment locally, aiming to reduce dependence on its ally and achieve greater autonomy within the alliance. As a result, its defense industry evolved from simple assembly of parts to indigenous production. Government initiatives supported this growth by protecting local defense firms, mostly large conglomerates or chaebols, through guaranteed sales, loans, and tax incentives. The defense sector also benefited from the expansion of heavy industries and a push to integrate civil and military sectors, which bolstered research and development (R&D) in technology.[2]

By the 1980s, South Korea met its domestic defense needs and began seeking international buyers for its excess production. Since the mid-2000s, the government has implemented export-oriented strategies, transforming the industry from domestically focused to globally competitive. The defense industry is still subsidized by the government, but high levels of defense R&D, advanced defense technology, and a vibrant domestic market have catalyzed the expansion of arms exports.[3] Today, companies like Hanwha Aerospace and Hyundai Rotem export advanced military technologies, marking South Korea as a significant player in the global defense industry. In 2023, arms exports to Poland included the K2 Black Panther battle tank, K9 Thunder self-propelled howitzer, K-239 Chunmoo rocket artillery system, and FA-50 light combat aircraft.[4]

South Korea's Strategic Alignment and Proactive Defense

In previous years, South Korea was perceived to be hedging between the United States and China as it invoked strategic ambiguity and attempted to balance between the two countries. Since President Yoon Suk-yeol came into office in 2022, however, South Korea began to demonstrate more strategic clarity and facilitate US coalition-building and power projection in the Indo-Pacific region. The Yoon government envisioned South Korea as a "global pivotal state" that plays a larger role in regional and global affairs. Presidents Biden and Yoon elevated the US-ROK alliance to a global comprehensive strategic alliance, and South Korea published its own Indo-Pacific Strategy in late 2022, adopting a more US-aligned regional framework that the previous administration had studiously avoided.[5]

The main differences between progressive and conservative governments of South Korea include their perception of the North Korean nuclear threat, desired solutions and policy processes, and the anticipated role of China in resolving the North Korean conundrum. Nevertheless, South Korea's defense policy has been consistently grounded in proactive deterrence against North Korean aggression through allied defense. South Korea recognizes that conventional weapons are powerful against a nuclear arsenal with the advantage of higher credibility and technological advances that enable a prompt response.[6] The Ministry of National Defense (MND) continues to develop and refine the "Three Axis system," including the Korean Air and Missile Defense, the Kill Chain, and the Korean Massive Punishment and Retaliation plan.[7] The revision of the bilateral US-ROK missile guidelines in 2021 led to rapid advancements in precision-strike capabilities.[8] In this light, building a self-reliant defense industrial base has received bipartisan support in South Korea. As evidenced by its growing arms exports worldwide, South Korea is in a good position to enhance interoperability with like-minded states. It is a reliable partner with a range of high technology, development, and manufacturing capabilities. Recognizing that its own industrial growth would not have been possible without external assistance, Seoul is willing to transfer technologies as offsets.

US National Defense Industrial Strategy

Intensifying strategic competition between the United States and China, supply chain challenges during the COVID-19 pandemic, and lessons from the protracted war in Ukraine have mobilized the United States to overhaul its defense industrial base structure and bolster cooperation with allies and partners. Overall, the United States appears intent on keeping its hegemonic status as the most formidable military power but realizes that commanding primacy in all theaters and sectors is near impossible. Thus, in addition to enhancing its absolute power, it seeks to harness coalitional power through a lattice-like network of security and industrial partnerships. In fact, the strategic intent to strengthen its control and influence over existing alliances and new partnerships is the driving force behind moving from the traditional hub-and-spokes model to a production web-like model. Building overlapping linkages in production and development would ultimately project a strong signal of resolve.

In particular, with the outbreak of the war in Ukraine, the DOD realized that its "industrial ecosystem needs to be ready to provide the capabilities at speed, at scale and at cost that the department needs."[9] The unexpected setbacks faced by the Russian armed forces during combat showcased the primacy of logistics over strategy.[10] The United States quickly learned that providing everything

from simple conventional ammunition to high-technology missile defense weapons systems on the battlefield was extremely difficult. Current capacities could not satisfy immediate needs. Recognizing the importance of rapidly producing and seamlessly providing a range of interoperable, multi-domain capabilities propelled the United States to review past practices of defense industrial base cooperation and reform. As it rebuilt a defense industrial base for Ukraine, it resolved to strengthen diverse modes of cooperation with allies and partners through the co-development of new technologies, co-production of existing weapons, and shared sustainment.[11]

Against this background, the United States published its first National Defense Industrial Strategy (NDIS) in 2024. The NDIS is ambitious as it presents a strategic vision of modernizing the defense industry ecosystem that aligns with the 2022 US National Defense Strategy (NDS). At the core of the NDIS is the realization that national military power depends on economic and industrial capacity. It aims to revive the defense ecosystem so that it can produce arms rapidly and sufficiently by strengthening cooperation across all US agencies—alongside the private industry—and with allies and partners. The ultimate goal is to build an integrated deterrence capability by creating a "robust, resilient, and dynamic" industrial ecosystem with a sustainable competitive advantage over adversaries.[12]

The NDIS articulates four priorities, although this paper focuses on the first: resilient supply chains.[13] The NDIS envisions a defense ecosystem that can produce the weapons systems, components, services, and technologies needed now and in the future by strengthening the resilience of existing supply chains. Eight actions to achieve resilient supply chains are identified, with illustrative outcomes as indicators of progress. In particular, the strategy calls for "engaging with allies and partners to expand global defense production and increase supply chain resilience." The global network of US alliances and partnerships is the cornerstone of integrated deterrence.[14] The war in Ukraine uncovered numerous sub-tier vulnerabilities in the US and global defense industrial base and found that defense material production could not be scaled as needed. Hence, the DOD resolved to develop a networked cooperation framework to de-risk supply chains from adversaries and advance its ability to engage in co-sustainment and maintenance, repair, and overhaul (MRO) with like-minded states.

In this vein, the NDIS will expand defense industrial production capacity to solve supply shortage problems related to ammunition and missiles. The US government plans to play a substantive role by increasing federal and private investment, providing incentives, revising laws and regulations, enriching stockpiles of strategic items, strengthening linkages with private companies, and expanding global

production with all government agencies and friendly partners. Specifically, it will invest in excess capacity, provide multiple suppliers, and offer sourcing for licenses and contracts. Moreover, the government will strengthen inventory management efficiency, enhance supply chain risk identification and visibility through data analysis, diversify the supply base, strengthen industrial security, expand production facilities, simplify production methods, increase investment in process automation, modernize existing military depots, and actively improve the FMS system by reflecting the needs of friendly countries (Table 1).

Table 1. Actions to Achieve a Resilient Supply Chain[15]

	Actions	Contents	Illustrative Outcomes
(1)	Incentivize industries to improve resilience by investing in extra capacity.	Establish public-private partnerships and shape legislation to plan and deliver increased DIB capacity.	Increase spare production capacity.
(2)	Manage inventory and stockpile planning to decrease near-term risk.	Increase stockpiles of strategic and critical systems and increase the effectiveness of ad hoc working groups that are tasked with this job.	Increase the replenishment rate of critical systems in response to the war in Ukraine.
(3)	Continue and expand support for domestic production.	Foster innovation through accelerator programs.	Pass legislation to solve domestic challenges.
(4)	Diversify supplier base and invest in new production methods.	Expand relationships with firms and industries not included in the DIB to promote investment in advanced manufacturing automation.	Increase the number of new suppliers working with the DOD.
(5)	Leverage data analytics to improve sub-tier visibility by identifying and minimizing strategic supply chain risks and to manage disruptions proactively.	Increase supply chain visibility in the sub-tier to mitigate risk.	Identify more bottlenecks.

(6)	Engage allies and partners to expand global defense production and increase supply chain resilience.	Strengthen global defense production relationships and build production strengths through various international collaboration mechanisms such as NATO, Ukraine Defense Contact Group's National Armaments Directors, the National Technology and Industrial Base, and AUKUS.	Increase the number of purchases made through bilateral and multilateral agreements (i.e., security of supply arrangements) to boost defense production, innovation, and overall capability.
(7)	Improve the FMS process.	Enable FMS to drive commercial sustainability, working with the US Department of Commerce and Department of State.	Increase FMS.
(8)	Enhance industrial cybersecurity.	Improve capacity to deal with evolving cyber threats.	Reduce cybersecurity incidents targeting DIB partners.

Similar to all national strategies, experts continue to debate the practicality of the NDIS and the balance between means and ends. Nonetheless, the first interim implementation report of the NDIS released last June claimed that substantial funding had been secured and laid out the following details. Funding for the Defense Production Act (DPA) increased significantly from an average of USD 84 million per year (2013-2019) to USD 774.5 million per year (2020-2023). Funding was also provided by the 2021-2023 Ukraine supplemental appropriations, the Inflation Reduction Act of 2022, and the FY2024 national security supplemental appropriations. The FY2024 supplemental and base defense appropriations combined will allocate USD 74.6 billion toward defense industrial base (DIB) investments, including the modernization of the submarine industrial base and replenishment of arms sent to Ukraine, Israel, and Taiwan. To bolster resilient supply chains, the implementation report claimed that DOD has prioritized growing domestic sources of critical materials needed to reduce lead times for defense systems, investment in munitions production, and diversification of the supplier base.[16] Direct investments were made in domestic production facilities, and a Defense Industrial Base Cybersecurity Strategy was released.[17]

At the Shangri-La Dialogue in June, US Secretary of Defense Lloyd Austin talked about a deliberate and purposeful "new convergence in the Indo-Pacific" that would create a more resilient and capable network of partnerships.[18] The NDIS is bolstered by the Partnership for Indo-Pacific Industrial Resilience (PIPIR), which is a multilateral forum aimed at strengthening defense industrial resilience to promote continued defense security, economic security, and prosperity in the region. It aims to accelerate DIB cooperation by reducing production barriers, creating new sustainment hubs, and dealing with supply chain restraints. The Statement of Principles for Indo-Pacific Defense Industrial Base Collaboration emphasized the importance of shared defense industrial resilience, set out the requirements and standards, and identified relevant stakeholders. This was endorsed by 13 nations, including the United States, with Taiwan playing an advisory role.[19]

Implications for South Korea

The NDIS ultimately aims to deepen integration across domains, within US forces, and with allies and partners. Hence, it is expected to have a significant impact on future defense and acquisition policy, as well as institutional arrangements in Seoul. South Korea has a comparative advantage in expanding production capacity for ammunition, shells, missiles, and ships. It not only has leading manufacturing capacity but also maintains sufficient levels of strategic stockpiles that guarantee readiness. These features make South Korea an attractive partner for the United States and will incentivize more integration between industries and defense companies. However, South Korea also desires to gain from such cooperation, such as increasing access to the US market, reforming some of its own defense industry base practices, and lifting existing caps on methods of defense cooperation.

First, South Korea's dependence on US FMS is high—the total volume of weapons acquired through foreign purchases from 2017 to 2021 was USD 13 billion, and more than half was acquired through FMS programs valued at USD 6.7 billion.[20] If the FMS system is improved under the NDIS to better reflect the opinion of partners, South Korea can anticipate innovation in rapidly supplying arms, efficient follow-up of military support, and co-development and co-production through trade-offs. This could boost the entry of South Korean defense companies into the US defense market. The acquisition of US robotics and IT firms by South Korean defense companies is underway and could expand.[21] Building on these transactions, South Korean companies, research institutes, and universities with advanced technologies such as artificial intelligence, semiconductors, and batteries could expand joint ventures in the United States.

Second, there are internal demands to diversify the acquisition system and innovate contracting methods. South Korea's Defense Acquisition Act was partially revised in 2023 to adopt a "rapid" acquisition system in 2024. The anticipated change is that a weapons system that applies vetted technologies from the private sector or core technologies from the government can now be adopted by the military within five years. This allows for timely technology adoption and project implementation as it can sidestep various verification stages once acquisition is determined by the ROK Joint Chiefs of Staff.[22] However, the nimbleness of the rapid system is still limited compared to the United States and needs to be improved. One could envision the establishment of a Korean version of the US Defense Innovation Unit and the adoption of a rapid acquisition process for both defense software and hardware. In regards to contracting, the majority of South Korean arms contracts are signed via the lowest-cost bidding method. Choosing the bidder this way is straightforward and draws few complaints, but it could be harmful to the industry as a whole. The lowest-cost bidder is not always the one investing the most in resilience or contributing to building a robust industrial foundation for the future.[23] An alternative contracting method could be formulated alongside changes emanating from the NDIS.

Meanwhile, the self-diagnosing strategies of the NDIS are applicable to South Korea and could help identify and remedy its weaknesses. The identification of vulnerabilities in the supply chain can be directly applied. A preliminary joint study conducted by the Korea Institute of Materials Science and Technology (KIMS) and the Korea Institute for Industrial Economics and Trade (KIET) finds that South Korea is highly dependent on imports for core defense materials.[24] As of 2022, South Korea imports 78.9 percent of its ten major defense materials. Among these, 80.4 percent are metal, and 47.5 percent are non-metal. Both types of material are critical to the production of parts as well as whole products. Domestically, it procures steel, copper, nickel, cobalt, and aluminum alloys. Meanwhile, it procures core materials from a set number of countries, including the United States, Japan, Germany, and China. For instance, South Korea is highly dependent on the United States for heat-resistant alloys and titanium alloys, with no domestic alternatives. It is highly dependent on Japan for ceramics and moderately dependent on compound material, both of which South Korea can procure from within. South Korea is moderately reliant on China for compound material, ceramics, and copper and has alternative sources (See further details in Table 2). Although this is only one example of measuring vulnerability, it demonstrates that without significant external support, South Korea's defense supply chain would suffer. The lesson is that Seoul should conduct a more rigorous review of its core material procurement status and use a range of platforms, such as the Minerals Security Partnership (MSP), to enact initiatives that strengthen its supply chain with like-minded states.[25]

Table 2. South Korea's Imports of Core Defense Materials (2022)[26]

	Material	Proportion of Procurement (%)					
		Domestic	Foreign Imports				
			United States	Japan	Germany	China	Other
Metal	Steel	84.3	14.5	-	-	-	1.3
	Heat-resistant alloys	-	90.0	5.0	-	-	5.0
	Aluminum alloys	48.0	34.3	0	9.1	0.9	7.7
	Titanium alloys	-	95.0	2.5	-	-	2.5
	Copper	63.3	-	-	-	10.0	26.7
	Nickel/ Cobalt	50.0	7.5	-	15.0	2.5	25.0
	Others	-	100.0	-	-	-	-
	Total	53.1	30.1	0.3	5.3	1.7	9.5
Non-metal	Compound material	8.3	36.7	15.8	3.3	26.7	9.2
	Ceramics	20.0	-	60.0	6.7	13.3	-
	Other	25.0	75.0	-	-	-	-
	Total	16.2	40.0	21.2	3.1	15.4	4.2

In the end, South Korea could draw up its own Defense Industrial Strategy to effectively manage defense resources like the European Union, which published its own European Defense Industrial Strategy (EDIS).[27] However aspirational strategies may be, it is important to incorporate government-led defense businesses and civilian-led defense *industries* under a comprehensive strategy that emphasizes a whole-of-society approach to defense *industry* development. The recent surge in South Korean arms exports is positive, but a sustainable strategy that balances arms exports with meeting domestic demand, strategically prioritizing the production and procurement of certain weapons systems over others, is needed to build on the current level of success.

Challenges to Cooperation

Despite the urgent need to restructure the defense ecosystem so that cooperation between the United States and its allies is enhanced, there are some pre-existing, structural constraints that may hinder the process. For one, there are external factors. Since the mid-1980s, Western industrialized states have been keen to take advantage of globalization while guarding against proliferation risks.[28] Recognizing that integrating power mattered significantly more than being able to produce lower-tier parts and equipment, the United States has long been a proponent of globalization in the defense industry. It has utilized its dominant market power and technological prowess to either directly pursue its foreign policy goals or indirectly shape buyers' policy preferences, notably through the sales of F-35 fighters that are in high demand.[29]

With the end of the Cold War and after the first Gulf War, the United States began to reduce its defense spending. It sought to manage the defense industry with smaller defense budgets and encouraged mergers and acquisitions of defense firms to reduce overcapacity and administrative maintenance overhead. As a result, the US defense market was restructured to include a handful of major defense firms or prime contracting firms, including Lockheed Martin, Boeing, General Dynamics, Northrop Grumman, and Raytheon. The focus on these primes made it more difficult for foreign firms to penetrate the market.[30]

Meanwhile, the United States has concentrated investment in R&D and the procurement of next-generation weapons systems to sustain its military advantage and influence, as well as deter challenges from strategic competitors. Its emphasis on military technological development and defense production interdependence signifies the traditional approach to excel on its own. The United States has always been highly guarded about transferring technologies

with potential dual-use applications. Although research shows joint development partners who participate from the outset of the project are less likely to face hurdles in high technology transfers, such as the International Traffic in Arms Regulations (ITAR), co-development standards remain high and accompanied by many restraints.[31] These structural barriers make it difficult to cooperate with allies on advanced technology. South Korea expects to move up the production ladder and develop more sophisticated weaponry with advanced technology, preferably obtained from the United States.

Thus far, the United States has enacted various policies and laws to harness resilience in the supply chain.[32] Both the Trump and Biden administrations actively utilized executive orders to reinforce the Buy American Act (BAA) of 1933.[33] Although President Biden repealed several BAA executive orders issued by his predecessor, he maintained Executive Order 13881 and the new Final Rule.[34] Whether or not the United States has a distinct industrial policy is debatable, but the Biden administration has emphasized building and manufacturing in the United States through legislation much more than the Trump administration's emphasis on increasing tariffs and exports.[35]

Meanwhile, South Korea's defense ecosystem has been criticized for lacking opportunities for private technology companies, government-funded research institutions, private research institutes, and universities to collaborate and create synergetic effects. The number of South Korea's designated defense firms peaked at 101 in 2016 and 2017, then fell to 92 in 2018 and 83 in 2023.[36] More can often be better. To streamline defense technology R&D and the defense industry under the leadership of the ROK Ministry of National Defense (MND), a reformative plan to place the Agency for Defense Development (ADD) under the auspices of the MND is underway.[37] The defense technology protection agency and eight defense R&D-related units within the Defense Acquisition Program Administration (DAPA) will also be transferred to MND.[38] An office for the second vice minister of the MND is expected to be established to oversee these agencies, which will determine the procurement priorities of each service and notify DAPA and ADD.

Recent Developments

The US DOD and ROK MND held the 25th Korea-U.S. Integrated Defense Dialogue (KIDD) in September 2024.[39] The discussion focused on the three pillars of the Defense Vision of the US-ROK Alliance released in November 2023: enhancing extended deterrence efforts against North Korea; modernizing alliance capabilities based on science and technology cooperation; and

strengthening solidarity and regional security cooperation with like-minded partners. The two sides pledged "to continue expanding cooperative measures to enhance the defense industrial base and interoperability."[40] They agreed that the DOD's Regional Sustainment Framework (RSF), which aims to ensure that "the Joint Force is supported by sustainment strategies that are responsive, resilient, and ready to deliver in a contested logistics environment," would strengthen the posture and capabilities of the US-ROK alliance.[41]

The RSF aims to utilize allies and their defense industries proximate to a US deployment area to create a virtuous cycle, where reduced maintenance needs through nearby support lead to shorter maintenance periods, higher utilization rates and combat readiness, and the formation of a collaborative US-allied sustainment system.[42] MRO initiatives under the RSF will include increases in maintenance facilities investment. South Korea's leading shipbuilders have already signed a Master Ship Repair Agreement (MSRA) with the US Navy's Naval Supply Systems Command.[43] At this year's KIDD, South Korea's participation in the MRO pilot project for the Air Force's aviation maintenance was recognized, and the allies pledged to continue discussions on expanding cooperation with the Army's aviation and naval vessels. They also noted the recent contract between the US Navy and South Korean shipyards for the MRO of US vessels. The need to provide reciprocal market access to deepen defense cooperation, enhance supply chain resiliency, and advance progress on a Reciprocal Defense Procurement Agreement (RDP-A) was also recognized.[44]

On November 16, 2023, US Under Secretary of Defense for Acquisition and Sustainment William LaPlante and ROK Minister of DAPA Eom Dong-hwan signed the Security of Supply Arrangement (SOSA). This was previously discussed at the 48th Defense Technological Industrial Cooperation Committee (DTICC), which was held in July 2023 for the first time since 2018 and during which the allies decided to sign the agreement as soon as the administrative process was finalized. As a result, South Korea became the 16th SOSA partner of the United States.[45] SOSA allows for the prompt supply of industrial support between allies. DOD and foreign partners can request priority delivery for critical defense components from each other's respective industrial bases, which promotes government-to-government industrial cooperation and collaboration. This means that when South Korea makes a priority request to the United States, it can receive its defense supply order first. As a result, South Korean domestic weapons systems can be deployed on time, increasing their rate of operation. SOSA is also expected to facilitate the entrance of South Korean defense firms into the US market.[46]

The DTICC also created space to discuss the MRO of ships and the management of materials and parts in the supply chain. In August 2024, Hanwha Ocean entered a contract to overhaul a 40,000-ton US Navy dry cargo and ammunition ship at its Geoje shipyard. It is the first South Korean shipyard to secure a ship MRO contract with the US Navy, and Hanwha Ocean will conduct maintenance and inspections on all logistics support ships from the US Navy that dock there. This entry into the US Navy's MRO market is estimated to be worth about USD 20 trillion annually.[47] Last June, Hanwha Systems and Hanwha Ocean acquired the Philly Shipyard from Norwegian energy firm Aker ASA.[48] And, in April, HD Hyundai Heavy Industries signed a separate MOU with Philly Shipyard to cooperate on various construction and MRO projects.[49] From 2005 to 2017, HD Hyundai partnered with Philly Shipyard for design and procurement support during the construction of 22 commercial product tankers. The shipbuilders also plan to extend their collaboration to vessels and government ships for the US Navy and Coast Guard.[50]

The delegations at the 48th DTICC also discussed the RDP-A, which allows allies to access each other's defense markets and build sustainable cooperative mechanisms. The signing of the RDP-A was emphasized at the US-South Korea summit in April 2023 and reiterated at the 24th and 25th KIDD in 2024. As early as October 2022, the DAPA and MND established a whole-of-government task force for realizing the RDP-A. In February 2024, the DOD began its internal process to enter into the agreement, which was supported by legislators such as Representative Michelle Steel (R-CA). In April 2023, the US National Security Council had held its first defense industry export strategy meeting and made clear its commitment to realize the RDP-A to suit South Korean national interests. This point was raised because some advisors to the RDP-A task force questioned whether the deal would remove all such barriers as expected.[51] In reality, South Korean defense firms had limited experience in making business-to-government deals with Washington, so they could not confirm whether signing an RDP-A would be beneficial for those that lagged behind US firms in defense technology.[52] Nevertheless, an audit by the US Government Accountability Office (GAO) is anticipated to slow down negotiations on the RDP-A.[53]

What was agreed to at the 56th Security Consultative Meeting (SCM) held in October creates further momentum for US-ROK defense industrial cooperation.[54] Secretary Austin and ROK Minister of National Defense Kim Yong-hyun agreed to modernize alliance capabilities and strengthen regional security cooperation. On the former, they agreed to expand science and technology cooperation through the establishment of the Defense Science and

Technology Executive Committee (DSTEC) at the vice-minister level. They committed to deepening industrial base collaboration and supply chain resilience through the PIPIR and MRO. For the latter, they launched the Regional Cooperation Framework for US-ROK Alliance Contributions to Security in the Indo-Pacific.[55] They emphasized working together on issues of mutual interest, such as securing supply chains, enhancing technology security, and sharing best practices on export controls and foreign direct investment.

Conclusion

South Korea's dependence on the United States as its security guarantor as well as its main provider of advanced defense technology will continue to be vital to the development of its defense industry. However, it is less clear what defense industrial cooperation between the allies will look like as the United States continues to adjust its global and alliance strategy with an inward-looking leadership vision while optimizing its national resources to compete and win against China. Experts that recommend a strategy of overmatch, namely combining capabilities in sufficient scale to ensure lopsided victories over the adversary in combat, or a regional division of labor between the Indo-Pacific and European theaters underline that US hegemony is under strain, US relative power has declined, and that prioritization of resources is critical.[56] Although US grand strategy of primacy or unrivaled hegemony was largely maintained throughout the first Trump administration, it remains to be seen how the next four years will unfold.[57]

US bilateral security assistance to Ukraine and the rallying of global support for the Ukraine War in the name of value-based foreign policy underlines US reluctance toward direct military intervention. The motivation behind rebuilding Ukraine's defense industrial base and manufacturing capacity is to enhance its ability to sustain itself in the long haul, should support from the West wane. Increasing logistical self-sufficiency will make Ukraine less dependent on foreign support while its accession to the European Union and NATO remains far from guaranteed. This implies that more will be asked of allies and partners and that the integration of industries provides a strong basis. The risk of entrapment and abandonment in the traditional alliance framework may be too simplistic to characterize what dilemmas lie ahead in a multi-layered, web-like network of states, industries, and firms.

Against this background, South Korea's defense industry serves multiple purposes. It certainly helps to create a more responsive global defense ecosystem as a US ally. However, its primary aim is to support its own armed

forces in deterring North Korea, grow its self-reliant defense industry, and expand its arms export portfolio into advanced technologies. Despite positive developments, the desire to work more closely with the United States on advanced defense technology and to create inroads into the US defense market may not be readily fulfilled. As competition in the global defense market intensifies, mini- and multilateral platforms such as NATO, AUKUS, and the QUAD are being mobilized for defense industry cooperation. With the publication of the EDIS, the EU aims to "reindustrialize" its defense industry and impose quotas for arms procurement from within. Going forward, non-members such as South Korea may face various entry barriers unless they fail to act proactively. Already, there is an existing hierarchy among US allies where regulations are discriminately applied. Priority begins with the most trusted partners that belong to the US National Technology and Industrial Base (NTIB), including Canada, the United Kingdom, and Australia. Next are the allies that have RDP arrangements with the United States, such as NATO members, Israel, and Japan. Lastly, there are allies who are largely treated as non-allies.[58] In reality, South Korea has long belonged to this group, despite the US-ROK alliance being hailed as the "linchpin of peace" for the region and the world.

Some important tasks lay ahead. South Korea does not have a strategy as comprehensive as the NDIS, and instead relies on a five-year Defense Industry Development Master Plan. While the NDIS is national security-oriented and emphasizes economic deterrence, this is lacking in South Korea's plans which remains alliance focused. As Seoul grows into a mature arms exporter and continues to diversify its security relationships with non-US partners, it needs to think more strategically. For instance, it will need to strengthen economic security agreements with its buyers. The United States does not offer offsets that may affect its defense technology advantage. South Korea may need to learn from this, creating a separate agency that reviews offsets. More importantly, it will need to invest substantially in the R&D of high-technology weapons systems and parts. A fair proportion of the core technologies that make up South Korea's weapons systems are of foreign origin.[59]

That said, much hinges on the incoming Trump administration. Either the upward trajectory of South Korea's arms exports will continue due to enhanced defense industrial cooperation with the United States, or this may falter due to US pressures to increase South Korea's burden-sharing, which may affect substantive investment in defense R&D. In the meantime, acquiring advanced technology will not get any easier if a "high fence, small yard" policy continues. The potential for reductions in US security assistance to Ukraine may negatively

impact global demand for arms, and a relaxation of US export controls toward the Middle East might spark market competition between US and South Korean defense firms. Nevertheless, since precision has proliferated in modern warfare with the use of cheaply made commercial drones, the United States and South Korea should explore creative options like co-developing collaborative combat aircraft (CCA) under the Replicator initiative.[60]

In the meantime, a prudent conclusion of the RDP-A is needed, and cooperative efforts to ensure a stable global supply of critical materials should be strengthened with diverse partners. Since the RDP-A pertains to opening up the US defense market as well as South Korea's, there are concerns that Seoul may confront more aggressive negotiations with the United States next year. There may be some changes in MRO and shipbuilding cooperation, especially given the fact that President-elect Trump directly mentioned the importance of cooperation on shipbuilding between the allies.[61] The emphasis on tariffs and "buy American" could weaken MRO cooperation in favor of shipbuilding in US shipyards, which will require massive investment from South Korea defense firms. Maintaining current levels of defense industrial cooperation is important for the US-ROK alliance and their respective strategic needs. In all, it is important to keep close communication between US and South Korean government officials, industries, and researchers to find ways to harmonize the security logic of the alliance with the economic incentives of the defense industry and market.

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Knocking at the Door: South Korea's Potential Participation in AUKUS Pillar Two

By Dr. Wade Huntley and Yosep Kim

Introduction

On September 15, 2021, Australia, the United Kingdom, and the United States announced the formation of AUKUS, "an enhanced trilateral security partnership" intended to "strengthen the ability of each [country] to support our security and defense interests, building on our longstanding and ongoing bilateral ties."[1] The primary initiative under the new AUKUS partnership made global news: the United States and the United Kingdom would support Australia's acquisition of nuclear-powered submarines for the Royal Australian Navy. The joint development program to provide this capability would "focus on interoperability, commonality, and mutual benefit," leveraging existing US and UK capabilities and expertise to "bring an Australian capability into service at the earliest achievable date."

The statement indicated the three countries would take 18 months to generate detailed plans for the initiative. As planned, on March 13, 2023, the three countries announced plans for the SSN-AUKUS, a trilaterally developed nuclear-powered submarine based on a UK design and including US technologies that Australia and the United Kingdom would jointly build and incorporate into their respective navies. The plans anticipated delivery of the SSN-AUKUS for deployment by the late 2030s. Meanwhile, the United States would sell Australia between three and five Virginia-class nuclear-powered submarines throughout the decade to replace its current fleet of diesel-electric submarines as part of an array of efforts to "systematically grow Australia's sovereign SSN capability and support capacity."[2]

Implicitly recognizing the nuclear proliferation concerns that this initiative would generate, the joint leaders statement in September 2021 reaffirmed Australia's commitment to "all of its obligations as a non-nuclear weapons state" and all three countries' sustained "leadership on global nonproliferation."[3] The joint leaders statement in March 2023 restated the three countries'

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commitment to, leadership in, and respect for the global nonproliferation regime while additionally maintaining that the consortium is engaging the International Atomic Energy Agency (IAEA) "to develop a non-proliferation approach that sets the strongest precedent for the acquisition of a nuclear-powered submarine capability."[4]

A less widely recognized component of the initial AUKUS statement was the announcement of intentions for the three countries to "embark on further trilateral collaboration under AUKUS to enhance our joint capabilities and interoperability," including other undersea capabilities, cyber capabilities, artificial intelligence (AI), and quantum technologies.[5] The announcement continued:

> We will promote deeper information and technology sharing. We will foster deeper integration of security and defense-related science, technology, industrial bases, and supply chains. And in particular, we will significantly deepen cooperation on a range of security and defense capabilities.[6]

The following spring, the three countries issued an update on AUKUS that noted progress on "advanced capabilities" collaboration, including the announcement of four additional areas: hypersonic and counter-hypersonic capabilities, electronic warfare, innovation, and information sharing.[7] Concurrently, providing nuclear-powered submarines to Australia has become known as Pillar One of the AUKUS partnership, with Pillar Two referring to other initiatives for advanced capabilities collaboration. Pillar Two activities take place under the auspices of working groups (or workstreams) established by the governments to coordinate efforts in each of these areas.[8]

Notably, the White House's fact sheet on AUKUS in April 2022 stated, "As we mature trilateral lines of effort within these and other critical defense and security capabilities, *we will seek to engage allies and close partners as appropriate*."[9] Thus, at the outset, the AUKUS partnership explicitly included a door within Pillar Two through which other countries may be brought into collaborative development of advanced capabilities, either within existing initiatives or through new areas specific to a given partnership.[10]

A number of countries have expressed interest, for various reasons, in joining AUKUS Pillar Two activities. This paper focuses on South Korea, or the Republic of Korea (ROK), and its interests and capacities for collaborating under AUKUS Pillar Two on advanced capabilities development. The following section briefly reviews South Korea's range of reactions to the overall emergence of the AUKUS partnership. The paper then delves more deeply into the interests of,

opportunities for, and limitations facing South Korea in collaborating with each of the eight Pillar Two areas. The paper concludes with a brief discussion of how South Korean engagement with AUKUS in some form may impact the country's conceptions of its core interests, the US-ROK alliance, and other security relationships in the Indo-Pacific region overall.

South Korean Reactions to AUKUS

The announcement of the AUKUS partnership touched on many elements of South Korea's security concerns and circumstances. Accordingly, the news elicited a range of reactions among subject matter experts and policy advocates, often tracking with the existing spectrum of viewpoints in South Korea on key security issues but, in some respects, fostering new perspectives.

South Korea has had a longstanding interest in acquiring nuclear-powered submarines of its own. Debate within South Korea over this possibility addresses a range of issues, including basic costs, the feasibility of developing the requisite nuclear infrastructure, and the need to fit this initiative within the US-ROK alliance. Many observers have considered the idea fanciful, at best symbolic, and at worst a drain on resources better directed to other defense needs. Probably the most important issue has been the efficacy of nuclear-powered submarines in achieving South Korea's core security interests, which spotlights more fundamental debates over defining these core security interests. While advocates of South Korea's acquisition of nuclear-powered submarines tout their utility in tracking and countering North Korea's growing submarine capabilities, including its aspirations for the capability to launch nuclear missiles from submarines, comprehensive analyses suggest that nuclear-powered submarines would be more efficacious if South Korea adopts a posture less focused on proximate and littoral defense against North Korean threats and more focused on integrating with the United States and other regional partners in supporting a "blue water" maritime posture toward regional threats.[11]

The desire for nuclear-powered submarines in South Korea also has roots in the country's longstanding interests in developing nuclear technologies more broadly, including nuclear weapons. South Korea has a well-developed civilian nuclear power infrastructure, which it operates under its obligations toward the Nuclear Nonproliferation Treaty (NPT), IAEA agreements to safeguard its nuclear facilities, and the terms of the bilateral US-ROK Agreement for Peaceful Nuclear Cooperation (commonly known as the "123 Agreement") that limits South Korea's nuclear fuel cycle activities.[12] The United States has long resisted the extensive expansion of South Korea's nuclear fuel cycle capacities out of

concern for the effect it might have on global nonproliferation efforts generally and on restraining North Korea's nuclear activities specifically and out of awareness of the historic and ongoing interest of some South Korean circles in indigenous nuclear weapons development, either latently or overtly.[13]

Such nuclear interests reflect endemic concerns in South Korea, which periodically surge in response to fluctuations in US nuclear weapons policies and North Korea's nuclear development, over the sufficiency of the US nuclear umbrella and its security guarantee to South Korea.[14] Most recently, in the context of North Korean efforts to develop nuclear ballistic missiles capable of threatening the US mainland, the United States and South Korea established the Nuclear Consultative Group (NCG), aiming to deepen the two countries' consultations on nuclear and strategic planning and "to enable joint execution and planning for ROK conventional support to U.S. nuclear operations in a contingency and improve combined exercises and training activities on the application of nuclear deterrence on the Korean Peninsula."[15]

Against this backdrop, the announcement that the United States would support Australia's acquisition of nuclear-powered submarines while continuing to resist South Korea's interests in nuclear-powered submarines elicited predictably complicated and, to a degree, contradictory reactions. Positive responses tended to focus on South Korea's benefits from the contributions AUKUS would make to bolstering regional security postures and other emerging multilateral security groups, such as the Quad, in the context of China's rising power and aggressive activities. Some saw AUKUS as heralding South Korea's need and opportunity to bolster its support of US security actions to secure maritime sea lanes in the Western Pacific that are critical for South Korea's own welfare.[16] Some also saw Australia's success at securing nuclear-powered submarines from the United States as a result of its readiness to align with the United States' strong China-oriented security posture, displaying a pathway that South Korea could and should follow by moving away from concentrating primarily on North Korea and more actively supporting the US Indo-Pacific security posture.[17] A variant of this view held that a stronger commitment to the US Indo-Pacific strategy by South Korea would also strengthen US and regional support against North Korean threats.[18] Lastly, some pointed to South Korea's submarine production capacity as a vital asset for AUKUS collaboration. Beyond being the world's second-largest commercial shipbuilder, in 2018, South Korea became the eighth country in the world to build a 3,000-ton submarine with its own technology, and it is assertively seeking to expand submarine exports to other countries.[19]

More negative responses to the creation of AUKUS in South Korea focused on the potential detrimental impacts on specific security interests. From one perspective, the United States providing nuclear-powered submarines to Australia signified its antipathy to such a deal with South Korea, rather than showing South Korea a pathway to follow.[20] Some observers expressed a more deep-seated concern that "passing over" South Korea's nuclear-powered submarine interests in favor of Australia expressed a lesser regard by the United States for South Korea as an ally, reinforcing concerns over the US extended deterrence commitment independent of debates over the efficacy of nuclear-powered submarines for South Korea's security needs.[21]

Any ambivalence in initial South Korean reactions to AUKUS Pillar One has gradually become overlaid by percolating South Korean interests in the possibility of joining AUKUS Pillar Two. Observers in South Korea on both sides of debates regarding nuclear-powered submarines have found common ground on the potential benefits of South Korea engaging with Pillar Two. These perceived benefits flow from both the specific opportunities for collaboration on advanced technology projects and the general opportunity to find functional roles in multilateral collaboration.

Accordingly, some saw South Korean engagement with Pillar Two's advanced technology development as a means to strengthen US perceptions of South Korea as a trusted and responsible partner, paving the way to US support for South Korea's own nuclear-powered submarine development program.[22] Alternatively, others focused on Pillar Two engagement as a practical means for South Korea to help improve the security environment in the Indo-Pacific region, whereas to follow Australia in obtaining US support for acquiring nuclear-powered submarines would be inappropriate due to the exclusion of China.[23] In one view, Pillar Two engagement would enable South Korea to enhance its security and deepen contributions to the US-led regional security posture more quickly and directly, while reducing the risk of collateral damage to the South Korea-China relationship that a nuclear-power submarine project would likely generate.[24]

More skeptical observers raised concerns about the objectives and process of Pillar Two engagement. Some feared that Pillar Two cooperation would embed South Korea more firmly in an Indo-Pacific security posture and the benefits of doing so would not outweigh the potential damage of Chinese retaliation.[25] Others cautioned that the benefits of Pillar Two cooperation would be unlikely to materialize easily and quickly, as some may hope, due to South Korea's limited access to classified information necessary for certain types of sensitive weapons technologies on which Pillar Two projects focus.[26] China's reaction to South Korea's decision to allow US deployment of the THAAD missile-defense system informs these concerns, albeit in a contradictory fashion.[27]

As noted, the April 2022 AUKUS statement expanding the range of Pillar Two activities promised to "engage allies and close partners" as these activities progressed.[28] Two years later, in a joint statement between defense ministers covering AUKUS developments, the partners reiterated their "intent to engage others in Pillar II projects as our work progresses" and announced that they would begin consultations with prospective partners on joining individual Pillar Two projects. The statement laid out the criteria for additional participants, including a set of domestic capacities and "impact on promoting peace and stability in the Indo-Pacific region," identifying Japan as a country under consideration for cooperation on Pillar Two advanced capability projects.[29]

Given the complex issues related to South Korea's potential participation in AUKUS, the announcement of Japan's active consideration as an additional partner generated predictably multifaceted responses in South Korea. Many observers perceived Japan's possible involvement in Pillar Two engagement as strengthening South Korean prospects as well. While the outreach to Japan touched raw nerves for some given unresolved historical issues, it also bolstered the appeal of AUKUS for those valuing greater multilateral engagement for South Korea and greater trilateral cooperation among the United States, Japan, and South Korea.[30]

The ROK Ministry of Foreign Affairs (MOFA) responded to the announcement by stating the South Korean government was also open to collaborating with AUKUS and there would be further discussions toward that end.[31] Shortly thereafter, at the foreign and defense ministerial meeting (2+2) between South Korea and Australia, the two countries agreed to expand cooperation in the areas of comprehensive security, cybersecurity, and maritime security and discussed positively the prospect of South Korea's participation in AUKUS Pillar Two activities, with both defense ministers remarking on the close technical cooperation and shared values that the two countries already enjoy.[32]

A public opening of AUKUS Pillar Two to South Korea was not long in coming. In a statement marking the third anniversary of the AUKUS consortium in September 2024, the partners noted progress in consultations with Japan to focus initially on the interoperability of maritime autonomous systems and announced that consultations were underway "with Canada, New Zealand, and the Republic of Korea to identify possibilities for collaboration on advanced capabilities under AUKUS Pillar II."[33] Since the first announcement of the creation of AUKUS, South Korea has been restively but hopefully knocking on its door—the September 2024 statement indicated that that door was now opening.

The opening to South Korea does not mean that tangible projects on Pillar Two advanced technology development will emerge quickly. Given the steady and measured progress of AUKUS activities overall, including careful preparation for outreach to new partners, all parties involved seem poised to explore and build new partnerships slowly and thoughtfully. All parties seem to recognize that successful collaboration will require understanding and balancing security and technological considerations. Opening consultations are likely to focus on identifying the most promising areas of initial cooperation, which will leverage the strongest innate capabilities of the widened circle of partners, pose the fewest obstacles to technical information exchange, and offer the clearest potential contribution to individual and collective security objectives. The following section provides an initial consideration of where opportunities with South Korea are most likely to emerge.

AUKUS Pillar Two Elements: Potential South Korean Contributions

AUKUS Pillar Two covers a range of initiatives to develop and field "advanced capabilities" among the three main contributing countries, separate from the provision of nuclear-powered submarines to the Australian Royal Navy. The eight advanced capability areas enumerated in April 2022 are undersea capabilities, quantum technologies, artificial intelligence and autonomy, advanced cyber, hypersonic and counter-hypersonic capabilities, electronic warfare, innovation, and information sharing.[34]

Of these eight areas, six focus on development in specific technological areas, while the other two address more functional areas.[35] Given the variety of challenges facing progress across these diverse areas, collaborative work in each area may proceed in different ways and at different tempos. Accordingly, announced accomplishments in Pillar Two initiatives have been uneven.

Nevertheless, Pillar Two activities carry distinctly more potential to impact deployed military capabilities in the near term. Pillar One's initiative—developing nuclear-powered submarine capabilities for Australia and the United Kingdom—will not show deployed results until the 2030s, at the earliest. In contrast, AUKUS Pillar Two may produce more immediate capability improvements that are directly relevant to near-term strategic security in the Indo-Pacific region. Senior officials in the US Department of Defense (DOD) have indicated that Pillar Two initiatives would focus on technology developments supporting regional war-fighting requirements.[36] Some analysts have termed these initiatives potentially "*game-changing*, securing the future military and economic advantage of the AUKUS nations and recasting the nature of [the strategic competition with China] for global influence."[37]

Given the Indo-Pacific focus of Pillar Two initiatives, it is not surprising Indo-Pacific countries that have the strongest security relationships with the United States would appear as prominent candidates. The Australian Strategic Policy Institute (ASPI) reviewed 23 critical technologies deemed integral to the advanced capability areas for AUKUS Pillar Two, observing the value of expanding partnerships in the context of competition with China:

> China is leading in high-impact research in 19 of these 23 technologies and has a commanding lead in hypersonics, electronic warfare and in key undersea capabilities. But in other key technologies such as autonomous systems operation technology, advanced robotics, adversarial AI-reverse engineering and protective cyber, the collective strength of the AUKUS countries shifts this picture, and they take the global lead. *A slightly larger grouping of countries would change the picture even further*.[38]

Nevertheless, the successful expansion of AUKUS partnerships in advanced technology development must surmount both technological and political hurdles. Understanding the opportunities as well as the constraints begins with a baseline appreciation of a candidate country's existing capacity and developmental potential in any given area—that is, what a candidate country has both to *bring* and to *gain* from collaborating on advanced technology development.

The following subsections provide an initial understanding of South Korea's potential engagement in the existing AUKUS Pillar Two areas of joint development, utilizing data on South Korea's relative stature in technology development from the ASPI's *Critical Technology Tracker*. The tracker provides an overview of the measurable achievements, relative rankings, and progress trajectories of countries on numerous advanced technologies. This database is optimal for the present study for two reasons. First, the tracker has collated data on specific capacities applicable to Pillar Two's six technology development categories. Second, the tracker has calculated the risk of China's monopolization in these categories, which enables evaluation of how much a South Korean contribution could support AUKUS partners' efforts to balance China's capabilities.[39]

Undersea Capabilities

Within AUKUS, undersea capabilities encompass technologies that operate underwater other than manned submarines, focusing on the development of autonomous unmanned underwater vehicles (UUVs). UUVs may have applications for many roles, including intelligence, surveillance, and

reconnaissance (ISR) and anti-submarine warfare. The United States, the United Kingdom, and Australia have all been developing and deploying UUV capabilities.[40] Hence, AUKUS collaboration in this area is a natural value-added enabler for these partners.

Efforts in this area were initiated by the AUKUS Undersea Robotics Autonomous Systems (AURAS) project.[41] Subsequently, the partners have announced a number of activities in this area, including the AUKUS Maritime Autonomy Experimentation and Exercise Series, entailing "integrated trilateral experiments and exercises aimed at enhancing capability development, improving interoperability, and increasing the sophistication and scale of autonomous systems in the maritime domain." AURAS was designed to enable defense industry participation as well as enhance maritime data sharing and provide "real-time maritime domain awareness" to the partners.[42] Another related activity is the Undersea Vehicle Launch and Recovery project, aiming to integrate the ability to launch and recover UUVs from torpedo tubes on current classes of submarines and the SSN-AUKUS for strike missions and ISR.[43] The partners have also collaborated on related exercises hosted by Australia's new Undersea Support Vessel to demonstrate and improve capabilities relating to the protection of underwater infrastructure, including mine countermeasure operations, using both autonomous and semi-autonomous undersea systems.[44]

South Korea has a strong capacity for collaboration in the development of UUVs and related underwater advanced technologies. Beyond South Korea's prodigious shipbuilding capacity, including significant submarine development, production, and export, South Korea also already has advanced autonomous systems capacity, ranking fifth in the world for autonomous systems operations technology and advanced robotics. This foundation suggests South Korea could be a strong contributing partner in this area of AUKUS advanced capabilities development, which is particularly valuable given China's dominant position in many of these technology categories.[45]

South Korea also would have a strong interest in such capabilities. Because of the broad range of applications for UUV technologies, South Korea would be able to both participate in joint operations supporting regional security postures and deepen its ISR and littoral defense capabilities against more proximate North Korean threats, particularly in response to North Korea's manned submarine and UUV development ambitions. Hence, undersea capabilities appear to be an area where the potential mutual benefits of South Korean engagement with AUKUS Pillar Two activities would be strong and lasting.

Quantum Technologies

Utilizing the principles of quantum physics, quantum technologies have a variety of potential applications to create, enhance, or support military capabilities. The DOD Defense Science Board (DSB) points to three applications that hold the most promise for applying quantum technologies for defense purposes: quantum sensing capabilities, information processing and security with quantum computers, and quantum communications systems.[46]

Within the quantum technologies working group, the AUKUS partners created the Quantum Arrangement (AQuA) initiative to coordinate US, UK, and Australian research and development (R&D) on applicable quantum technologies. Initial AQuA activities were planned to focus on integrating quantum technologies for positioning, navigating, and timing through trials and experimentation through 2025.[47] Subsequently, these activities were accelerated with the aim of creating resilience for environments in which Global Positioning System (GPS) systems are degraded and enhancing stealth in the undersea domain in support of other undersea activities, including the SSN-AUKUS.[48]

South Korea would likely benefit broadly from collaboration on quantum technology development projects. Applications for maritime positioning and navigation are mainly applicable at a broader regional level, but quantum technology enhancement of undersea activities would support the broad range of South Korea's peninsula and regional security interests.

However, South Korea's capacity for contribution and partnership in quantum computing is more limited. While South Korea is the fourth-ranked country for certain sensing, timing, and navigation technologies, it is not a leading state across a range of quantum technology categories, including the communications and sensing areas that are of most focus under AUKUS.[49] Therefore, relative to other Pillar Two activities, quantum computing appears to be a less auspicious category of potential collaboration for South Korea.

Artificial Intelligence and Autonomy

The term "artificial intelligence" encompasses an array of computing technologies. The definition used within the US government denotes "a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments."[50] Most basically, AI systems differ from other forms of computer software through their capacity to utilize dramatic quantities of data at speed to generate original response to queries and commands and their ability to incorporate new data and prior outcomes to improve performance over time—in short, to learn.

Potential applications of AI in defense organizations and for war-fighting functions are numerous. It is useful to note that AI systems are not themselves weapons—rather, AI is a technology that enables and enhances other instruments of military power. Even as new AI application possibilities continue to emerge, some prospects are clear, particularly at tactical levels:[51]

- Military logistics and transport, especially improving efficiency in the allocation of military resources.
- Pre-identification of maintenance problems in complex equipment, including combat vehicles, aircraft, and warships.
- Difficult control problems, such as flight and navigation, especially autonomous vehicles in air and maritime domains.
- Target selection, tactical maneuvering, and other aspects of battle management.
- Software vulnerability discovery tools to autonomously protect networks, computers, programs, and data while also contributing to offensive cyber operations.
- Battlefield medical care, including diagnosis and optimized treatment in mass casualty situations, and integration with robotic systems to support remote surgery and evacuation activities.[52]

At the operational level, many applications involve scaling up tactical capabilities, but AI also has applications for broader warfare planning. For example, AI can support both manned and unmanned ISR activities, from the surveillance front end to the intelligence production back end. Machine learning, combined with image recognition, has clear application to target identification, including previously unrecognized target types, in part through incorporating reports, documents, news feeds, and other forms of unstructured information. AI and machine learning are well-suited for sifting and assessing multiple streams of incoming intelligence collection, particularly given increasing requirements for broad-scope analysis incorporating open and classified sources. At the strategic level, current projects would build AI into multi-domain command and control (MDC2) capabilities. This may include fully integrated ISR capabilities, precision targeting of strategic assets, AI-guided cyber offensive and defensive operations, and AI incorporation into nuclear command and control.[53]

All three AUKUS partners have been focused on AI development. The US DOD is working to accelerate AI adoption across the department and military, scale up the utilization of AI solutions demonstrated to be effective, and create capacity to surge relevant services when needed.[54] The United Kingdom and Australia are undertaking similar efforts to incorporate AI capabilities across their defense postures.[55] Accordingly, the AI element has been prominent in AUKUS Pillar Two activities. Early work in this area sought to accelerate AI adoption with a focus on improving the resilience of autonomous and AI-enabled systems in contested environments.[56] More recently, the AUKUS partners have stated that the Resilient and Autonomous Artificial Intelligence Technologies (RAAIT) initiative has resulted in "delivering" AI systems for force protection, precision targeting, and ISR functions, with a companion effort yielding planned AI deployments to enhance maritime surveillance in support of anti-submarine warfare efforts.[57]

Given the wide scope of possible applications, South Korea's potential contributions to AUKUS Pillar Two's AI and autonomy initiatives are especially opportune. According to the ASPI data, South Korea is already a world leader in multiple categories of key AI technology and autonomous system capabilities. Specifically, South Korea ranks third in high-performance computing, fourth in AI algorithms and hardware accelerators, fifth in natural language processing and in machine learning, and sixth in adversarial AI and in advanced integrated circuit design and fabrication. In all of these categories, South Korea ranks either ahead of or just behind the United Kingdom and significantly ahead of Australia.[58] Hence, in AI development—an area of advanced technology within which cumulative efforts are particularly productive—South Korea can already bring to the table capacities comparable to the other AUKUS partners.

South Korea would be highly motivated to participate in this area of AUKUS Pillar Two advanced technology collaboration. Not only would such collaboration bring significant dividends to South Korea's existing capacities, but the defense and military applications that are the focus of AUKUS activities could bring substantial enhancements relevant to South Korea's core security interests. Considering North Korea, AI applications in the areas of multi-domain ISR, anti-submarine warfare, target identification, battle management, and software security would help South Korea generate more stabilizing deterrence responses to the mushrooming North Korean threat perception. More broadly, given the benefits that flow from AI integration in many military applications, such as ISR, South Korea's clear existing capacity to contribute to AUKUS development of deployable AI systems would pave the way for fulsome South Korean integration into a region-wide deterrence posture.

Advanced Cyber

While US policymakers have been focused on cybersecurity as a dimension of national security for some time now, the nature of the capabilities and the strategies for utilizing them have continued to evolve. The DOD's involvement in national cybersecurity has grown broad, incorporating military and intelligence activities under the conjoined operations of the US Cyber Command and the National Security Agency, as well as elements in all military services, combatant commands, and other DOD offices. DOD operations are diverse, encompassing ongoing engagements within the cyber domain itself and extensive planning for cyber operations in any emerging physical conflict. Most recently, the foundational premises of US cyberstrategy have been evolving from a Cold War-era deterrence-oriented motif toward a more cyber-intrinsic conception of persistent engagement, with both defensive and offensive dimensions.[59] Importantly, engagement with allies and partners to bolster collective cybersecurity has become an increasingly important element of US cyber strategy.[60] Military cybersecurity has also become an increasingly central focus for the other two AUKUS partners, who have also developed cybersecurity strategies.[61]

Collaborative work in the AUKUS Pillar Two Advanced Cyber area appears to have begun with broad attention to communications and operations systems and then incorporated a focus on working with the industry to improve the cybersecurity of critical suppliers to the naval supply chain.[62] Other efforts may be developing behind these representations, and it would not be surprising for the AUKUS partners to proceed particularly cautiously in building collaboration on cyber capability development. This is because the security of technical and operational information is uniquely vital to successful cyber operations, both defensively and offensively.[63] Collaboration with any partners intrinsically creates new potential vulnerabilities for that information, including partnerships among governments that already maintain an especially high level of intelligence collaboration. AUKUS partners, even as they perceive the necessity of collaboration to achieve collective cybersecurity goals, have not failed to recognize this concern.[64]

South Korea has an enduring interest in improving all facets of national cybersecurity for reasons it shares with the AUKUS partners and due to intensive ongoing North Korean cyber aggression.[65] Accordingly, South Korea already has a growing US partnership in response to these concerns, including the 2023 establishment of the US-ROK Strategic Cybersecurity Cooperation Framework, mapping out an array of specific initiatives to enhance cybersecurity tools,

information sharing, joint exercises, personnel training, private sector engagement, and capacity building.[66] Resonant of the direction of DOD cybersecurity posturing, South Korea issued an updated National Cybersecurity Strategy in February 2024, auguring a transition to a more offensively oriented posture, including a focus on the development of emerging technologies.[67]

South Korea has cyber capacities that would enable the country to benefit from significant collaboration with the AUKUS partners and contribute to that collaboration. According to the ASPI data, South Korea ranks fourth in the world in advanced communications systems, which is the initial focus within the AUKUS Pillar Two Advanced Cyber area and an area of particular risk of Chinese technological monopolization. The data also shows that South Korea has appreciable capabilities in protective cybersecurity technologies and reverse engineering of adversarial AI systems—the two elements identified as most central to the AUKUS cyber area of advanced technology research.[68] Notably, the data suggests that South Korea's contribution to the existing AUKUS partner capacities offers the greatest boost relative to China's capabilities in any of the six Pillar Two-focused technology categories (see Table 1, Appendix).

Given existing cyber defense weaknesses that have resulted in periodic exposures of defense and security information, South Korea will certainly benefit from greater cooperation on cyber defenses, whether directly with the United States or through an AUKUS collaboration. The dilemma is that those same weaknesses pose obstacles to greater collaboration due to the risks involved in sharing details of technological capacities and operational practices to support objectives for cybersecurity improvement. Resolving this dilemma is mainly a matter of time and trust—time to develop secure platforms and processes for effective cybersecurity collaboration and trust among all parties that, in an environment characterized by deception, the collaborative objectives are the top priority.

Hypersonic and Counter-Hypersonic Capabilities

Hypersonic capabilities refer to maneuverable missiles that fly at speeds above Mach 5 (3836 miles per hour, five times the speed of sound). Maneuverability enables these missiles to fly at a low altitude with variable courses, as opposed to the predictable ballistic trajectories of conventional missiles, making them harder to detect with existing early warning systems and harder to defeat with existing missile defenses. Counter-hypersonic capabilities refer to systems intended to overcome these limits and counter such weapons, which can entail developing new types of technologies. DOD

has developed a number of programs to develop hypersonic and counter-hypersonic defensive capabilities, and both the United Kingdom and Australia have also undergone efforts to develop hypersonic capability prior to the establishment of AUKUS Pillar Two collaboration in this area.[69]

Details on AUKUS hypersonic technology collaboration efforts are limited. The April 2022 statement that introduced this area only expressed the intention to "accelerate development of advanced hypersonic and counter-hypersonic capabilities."[70] Subsequent updates providing additional details on other Pillar Two activities have not mentioned hypersonic technology development collaborations.[71] Australia has stated that its facility for hypersonic R&D, which opened in 2022, would enable Australia and its international partners "to develop and characterize sovereign hypersonic technologies and generate 'true' hypersonic flight conditions at large scale in a classified laboratory."[72] More recently, joint US-Australia R&D of hypersonic technology, and potentially joint production, is reportedly progressing.[73]

South Korea has a definitive interest in this area of AUKUS collaboration. Like the AUKUS partners, South Korea has preexisting hypersonic and counter-hypersonic R&D efforts underway. South Korea's Agency for Defense Development (ADD) has a hypersonic cruise missile program with the goal of fielding the capability in the late 2020s.[74] South Korea also has a clear interest in developing a capability to counter North Korea's hypersonic missiles.[75] Now that engagements with AUKUS partners to explore Pillar Two collaboration prospects are underway, South Korea has reportedly proposed hypersonic technologies as a potentially fruitful area.[76]

However, the ASPI data suggest that South Korea's potential contribution in this area may be less beneficial than in other areas. In the principal elements contributing to hypersonic and counter-hypersonic capabilities development, South Korea maintains a negligible portion of global capacity, and its potential contribution to existing AUKUS capacities barely dents China's dominant position.[77] On the other hand, given the relative opacity of current AUKUS efforts in the hypersonic technology area, more specific considerations than overall capacity may influence prospects for South Korea joining AUKUS partners on advanced technology collaboration on particular elements.

Electronic Warfare

Electronic warfare (EW) has a deeper pedigree than other areas of Pillar Two advanced technology development. EW mainly entails actions to undermine an

adversary's military use of the electromagnetic spectrum (EMS) while ensuring one's own use. Activities can include achieving and defending against detecting, locating, identifying, intercepting, jamming, disrupting, cloaking, and analyzing EMS signals, which can contribute to intelligence gathering and support military operations across the war-fighting domains.[78] EW capabilities have existed since World War II, and all the AUKUS partners have ongoing EW development and operations distributed across various military services and organizations.

As with hypersonic technologies, the April 2022 statement only conveyed for EW the intention to "share understanding of tools, techniques, and technology."[79] Similarly, further updates to EW collaborations have been sparse. In 2024, AUKUS sponsored an "Electronic Warfare Challenge," encouraging private sector development of novel EW capabilities, with winners announced in September.[80] Solicitation of these contributions would serve a general objective to identify and develop new technologies and perhaps to germinate other specific collaborative activities within the EW area.

Specific information on South Korea's EW capabilities and operations is slim, but the ASPI data indicates that South Korea's EW technology capacity is the world's fourth largest, offering a distinct potential contribution to the overall AUKUS capacity.[81] Intriguingly, some analysis suggests that EW advanced technology development may be particularly apropos as an AUKUS Pillar Two activity because all three partners are set to operate the US Air Force E-7 Wedgetail, an airborne command-and-control and EW platform.[82] South Korea is the only other country in the Indo-Pacific region that is also procuring this platform.[83] If collaborative development of EW capabilities for this platform is an AUKUS objective, South Korea is a natural fit. Taken together, these factors suggest that, compared to other potential new AUKUS Pillar Two partners, a collaboration with South Korea offers unique opportunities to contribute to new EW technology development and bolster collective EW capabilities.

Innovation

As a functional area of defense collaboration, the developmental objectives of innovation are harder to specify than in the more tangible technological Pillar Two project areas. Innovation, despite being a focal topic of strategic studies, is notoriously difficult to define.[84] For military technology, innovation colloquially means the development of new capabilities and incorporation into military operations resulting in improved outcomes in the field. The 2022 US National Defense Strategy emphasizes the importance of "maintaining an enduring competitive edge over the PRC."[85] This is an objective often considered to

depend on superior innovation capacities. But for collaboration among national partners, strong innovative capacities can introduce new challenges, including synchronizing technological innovation trajectories and managing disparate adoption capacities.[86]

The initial AUKUS representation of the innovation project area implicitly recognizes these challenges by directing initial efforts toward building familiarity with mutual capacities: "Our work on innovation aims to accelerate our respective defense innovation enterprises and *learn from one another,* including ways to more rapidly integrate commercial technologies to solve warfighting needs."[87] This could include fostering greater engagement among the three partners' governmental agencies with innovation mandates, such as the US DOD's Defense Innovation Unit (DIU) and Defense Advanced Research Projects Agency (DARPA), and their UK and Australian counterparts.[88] But early public activities suggest a clear interest in collectively tapping into the private sector's innovation capacities, represented by the institutionalization of the AUKUS Innovation Challenges, "in which companies from across all three innovation ecosystems will be able to compete for prizes on a common innovation challenge topic."[89] This outlook reflects an underlying reality that, relative to Cold War-era circumstances, Western militaries today are adopting rather than directing technology development.

South Korea displays a parallel interest and capacity to integrate commercial technologies into defense capabilities—exemplified by efforts on AI and autonomous drones, discussed earlier. In terms of overall innovation capacity, one assessment ranks South Korea sixth in the world, behind the United States (third) and the United Kingdom (fifth) but ahead of Australia (twenty-third), Japan (thirteenth), and China (eleventh).[90] Unlike the technology capacities in the ASPI data, innovation capacities are not cumulative, but South Korea's strong position as a source of global innovation suggests potentially positive synergies are available through its incorporation into AUKUS defense technology innovation cooperation.

Information Sharing

Information sharing is another functional area of defense collaboration whose developmental objectives are harder to specify. Initially, AUKUS set out to "expand and accelerate sharing of sensitive information, including as a first priority enabling workstreams that underpin our work on agreed areas of advanced capabilities."[91] In other words, this functional area is an enabler for other Pillar Two elements.

The challenge is distinct. The AUKUS partners have a long history of information sharing on security and defense matters, including intelligence sharing through the Five Eyes (FVEY) network. Yet, despite this intimacy, effective information sharing has been an enduring challenge. Pillar Two advanced capability activities engage particularly protected areas, such as nuclear technology and cyber capabilities, and the partners have acknowledged that many of these activities will remain classified.[92] The challenge of creating new avenues for information sharing among the partners in these areas likely presents an endemic resistance to the fluid collaboration necessary for the success of these activities. Some analysts have proposed specific remedies for these challenges, such as creating a new category of classified information, "Releasable to AUKUS Nations" (REL-AUKUS), to eliminate the need for piecemeal dissemination authorization and establishing a specialized AUKUS visa to facilitate the movement of expertise among the partners.[93] Ultimately, the success of promoting information sharing in AUKUS will come down to building trust in both information infrastructure security and intergovernmental relations.

South Korea has established important information-sharing conduits with key partners, including dedicated channels for sensitive information exchange within the US-ROK alliance and the General Security of Military Information Agreement (GSOMIA) established with Japan in 2016.[94] This existing foundation of information-sharing capacity makes South Korea a more credible potential partner, not only in the information-sharing area but across all AUKUS Pillar Two activities. However, the challenges facing the existing AUKUS partners are likely magnified with the inclusion of the new candidates, South Korea and Japan, that are outside the existing Five Eyes intelligence sharing network.[95] And, as with the existing partners, the viability of South Korean inclusion in AUKUS Pillar Two collaboration will surely hinge on developing trust. This is a principal reason why the development of advanced technology cooperation with South Korea under AUKUS is likely to emerge slowly and in a piecemeal fashion, allowing the incremental development of institutional and intergovernmental trust necessary to open other doors down the line.

Conclusion

The findings and analysis of the preceding section indicate that South Korea, through joining selective AUKUS Pillar Two activities, has much *to gain from* and *to bring to* advanced technology development collaboration. Some specific areas, such as undersea capabilities and AI, have potentially strong mutual benefits for South Korea and the AUKUS partners. Other areas appear

to offer relatively fewer compelling prospects. South Korea's inclusion in some elements of the functional information-sharing area is likely a prerequisite to fulsome engagement in other areas. Table 1 in the Appendix provides the ASPI data underlying some of these findings.

South Korea's motivations for seeking involvement in AUKUS Pillar Two activities are evident. The technological, economic, and military benefits could be significant, including the addition of key capabilities directly applicable to responding to North Korean threats. At the same time, such partnerships would enable South Korea to become a valuable contributor to a broader multilateral regional security posture, increasing the country's integration with key allies and partners while enhancing its regional status and influence. Not least among the potential benefits is the likely strengthening of the US-ROK alliance that would result from more extensive joint capabilities development and information sharing under AUKUS auspices. Concurrently, some observers suggest that increasing South Korea's inclusion in more multilateral security mechanisms could bolster the country's security autonomy and self-determination, which somewhat ironically could also strengthen the US-ROK alliance.[96]

More contentiously, some observers also see South Korea's inclusion in Pillar Two advanced capability development projects, and many of the inclusiveness benefits that could accrue from that, as a means to gradually persuade the United States and other regional partners to support some form of a Pillar One program enabling South Korea to acquire nuclear-powered submarines.[97] Yet, as noted, that ambition rekindles an awareness of longstanding interests within some South Korean circles in expanding nuclear technology capabilities and perhaps developing a latent nuclear weapons capacity. From current US and regional partner perspectives, such aspirations are antithetical to South Korea's deeper integration into a multilateral regional defense posture. Conversely, these allies and partners are likely to hope that South Korea's greater regional security inclusion, and in particular the strengthening of the US-ROK alliance that is likely to flow from South Korea's participation in AUKUS, would in turn provide long-term amelioration of South Korean concerns regarding allied abandonment that motivate calls for more independent South Korean conventional forces and strategic deterrent capabilities.

These considerations spotlight how the creation of AUKUS, and the subsequent initial opening of the door to include South Korea and select countries in certain Pillar Two collaborative projects, have had the unintended consequence of kindling more fundamental discussions in South Korea over the country's core security interests and how best to pursue them. The definitive concern over North Korean threats has oriented South Korean security priorities for

decades and is in some respects graver now more than ever. Yet, many South Korean analysts increasingly acknowledge the threat that growing Chinese power and assertiveness pose to the country's security interests, not only mediated through US concerns projected through the US-ROK alliance. Cutting across this antinomy, some analysts suggest that greater South Korean inclusion in regional multilateral security mechanisms beyond the bilateral US alliance can bolster South Korea's responses to both these security concerns. AUKUS, and the crack in the door for South Korea's participation in it, propels these debates.

Appendix - Table 1

AUKUS Advanced Technology Capabilities with South Korea								
Undersea Capabilities								
Technology	United States	UK + Australia	South Korea	AUKUS Total	AUKUS + S. South	China	SK Additional v. China	Technology monopoly risk
Coatings	7.3%	2.9%	3.2%	10.2%	13.4%	58.5%	5.5%	8/10 & 7.96 high
Autonomous underwater vehicles*	9.5%	4.8%	2.3%	14.3%	16.6%	56.9%	4.0%	10/10 & 6.00 high
Sonar and acoustic sensors*	11.0%	5.2%	3.0%	16.2%	19.2%	44.9%	6.7%	8/10 & 4.08 high
Air-independent propulsion (focused on compact energy generation)*	11.1%	3.2%	3.7%	14.3%	18.0%	41.6%	8.9%	5/10 & 3.75 medium
Autonomous systems operation technology	21.0%	8.6%	3.5%	29.6%	33.1%	26.2%	13.4%	3/10 % 1.25 low
Advanced robotics	24.6%	`8.4%	3.8%	33.0%	36.8%	27.9%	13.6%	4/10 & 1.13 low

Quantum Technologies								
Technology	United States	UK + Australia	South Korea	AUKUS Total	AUKUS + S. South	China	SK Additional v. China	Technology monopoly risk
Quantum computing	33.9%	8.9%	1.0%	42.8%	43.8%	15.0%	6.7%	8/10 &2.26 medium
Post-quantum cryptography	13.3%	7.5%	1.0%	20.8%	21.8%	31.0%	3.2%	4/10 & 2.33 low
Quantum communications	16.7%	9.7%	1.0%	26.4%	27.4%	31.5%	3.2%q	5/10 & 1.89 low
Quantum sensor	23.7%	6.7%	1.0%	30.4%	31.4%	23.3%	4.3%	2/10 % 1.02 low

Artificial Intelligence and Autonomy								
Technology	United States	UK + Australia	South Korea	AUKUS Total	AUKUS + S. South	China	SK Additional v. China	Technology monopoly risk
Drones, swarming and collaborative robots	10.3%	6.6%	1.0%	16.9%	17.9%	36.1%	2.8%	5/10 & 3.50 medium
Artificial intelligence (AI) algorithms and hardware accelerators	13.3%	6.0%	4.2%	19.3%	23.5%	36.6%	11.5%	7/10 & 2.76 medium

Artificial Intelligence and Autonomy (cont.)								
Technology	United States	UK + Australia	South Korea	AUKUS Total	AUKUS + S. South	China	SK Additional v. China	Technology monopoly risk
Advanced data analytics	154%	7.6%	1.0%	23.0%	24.0%	31.2%	3.2%	8/10 & 2.02 medium
Machine learning (incl. neural networks and deep leanring)	17.9%	6.6%	3.3%	24.5%	27.8%	33.2%	9.9%	7/10 & 1.85 low
Advanced integrated circuit design and fabrication	24.2%	4.2%	3.5%	28.4%	31.9%	21.2%	16.5%	4/10 & 1.14 low
Natural language processing	25.7%	7.2%	3.4%	32.9%	36.3%	23.6%	14.4%	5/10 & 1.09 low

Advanced Cyber								
Technology	United States	UK + Australia	South Korea	AUKUS Total	AUKUS + S. South	China	SK Additional v. China	Technology monopoly risk
Advanced communications (incl. 5G and 6G)	9.5%	7.0%	4.9%	16.5%	21.4%	29.7%	16.5%	8/10 & 3.12 high
Protective cybersecurity technologies	16.8%	11.0%	2.7%	27.8%	30.5%	22.3%	12.1%	5/10 &1.33 low
Adversarial AI - reverse engineering*	25.1%	8.6%	3.5%	33.7%	37.2%	30.9%	11.3%	7/10 & 1.23 low

Hypersonic and Counter-hypersonic Capabilities								
Technology	United States	UK+ Australia	South Korea	AUKUS Total	AUKUS +S. South	China	SK Additional v. China	Technology monopoly risk
Hypersonic detection, tracking and characterization*	14.1%	4.6%	0.5%	18.7%	19.2%	73.3%	0.7%	9/10 & 3.25 high
Advanced aircraft engines (incl. hypersonics)	11.7%	5.5%	1.0%	17.2%	18.2%	48.5%	2.1%	7/10 & 4.15 medium

Electronic warfare								
Technology	United States	UK+ Australia	South Korea	AUKUS Total	AUKUS +S. South	China	SK Additional v. China	Technology monopoly risk
Electronic warfare*	14.3%	5.6%	3.5%	19.9%	23.4%	46.5%	7.5%	9/10 & 3.25 high
Photonic sensors	12.5%	3.5%	3.6%	16.0%	19.6%	42.7%	8.5%	8/10 & 3.41 high
Directed energy technologies	19.1%	7.2%	5.9%	26.3%	32.2%	39.1%	15.1%	7/10 & 2.05 mediumt

Note: South Korea values of 1.0% or less are estimates drawn from available data in the dataset.

Note: UK_Australia advanced communications value is an estimate drawn from available data in the dataset.

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[52] In the Asia-Pacific in particular, AI solutions may offer valuable remedies to critical challenges in planning for prospective medical challenges that a 21st century maritime conflict would pose. On the dramatic scope of these challenges, see Kaitlin R. Cugno, "Leveraging NATO Doctrine for Medical Operations in Asia" (Master's Thesis, Naval Postgraduate School, September 25, 2024).

[53] For an additional concise summary of potential AI applications for the DOD, see "Artificial Intelligence and National Security," Congressional Research Service, November 10, 2020.

[54] US Department of Defense, "Chief Digital and Artificial Intelligence Office," https://www.ai.mil.

[55] For reference, see UK Ministry of Defence, "Defence Artificial Intelligence Strategy," June 15, 2022, https://www.gov.uk/government/publications/defence-artificial-intelligence-strategy; Australian Government, "Australia's AI Action Plan," June 2021, https://www.industry.gov.au/publications/australias-artificial-intelligence-action-plan. Note both these documents were published by governments no longer in power.

[56] The White House, "Fact Sheet: Implementation of the Australia – United Kingdom – United States Partnership (AUKUS)."

[57] US Department of Defense, "AUKUS Defense Ministers Meeting Joint Statement," December 1, 2023, https://www.defense.gov/News/Releases/Release/Article/3604511/aukus-defense-ministers-meeting-joint-statement/.

[58] Gaida, Wong Leung, Robin, and Cave, "Critical Technology Tracker"; "AUKUS Relevant Technologies: Top 10 Country Snapshot," Australian Strategic Policy Institute, https://techtracker.aspi.org.au/our-report/. In only one prominent AI category spotlighted in the ASPI data—advanced data analytics—is South Korea's ranking below both the United Kingdom and Australia. Also worth noting: in all these categories, South Korea ranks well ahead of Japan. Lastly, in all these categories, the United States and China hold the top two rankings, with China ahead in all but natural language processing.

[59] The current benchmark articulation of the latter perspective is Michael P. Fischerkeller, Emily O. Goldman, and Richard J. Harknett, *Cyber Persistence Theory: Redefining National Security in Cyberspace* (New York: Oxford University Press, 2022). See also Catherine A. Theohary, "Defense Primer: Cyberspace Operations," Congressional Research Service, December 14, 2023.

[60] US Department of Defense, "Unclassified Summary of the 2023 Cyber Strategy," September 2023, https://media.defense.gov/2023/Sep/12/2003299076/-1/-1/1/2023_DOD_Cyber_Strategy_Summary.pdf.

[61] UK Government, "National Cyber Strategy 2022," December 15, 2022, https://www.gov.uk/government/publications/national-cyber-strategy-2022/national-cyber-security-strategy-2022; Australian Government, "2023-2030 Australian Cyber Security Strategy," November 22, 2023, https://www.homeaffairs.gov.au/about-us/our-portfolios/cyber-security/strategy/2023-2030-australian-cyber-security-strategy.

[62] Note the evolution in two statements separated by 20 months: The White House, "Fact Sheet: Implementation of the Australia – United Kingdom – United States Partnership (AUKUS)"; US Department of Defense, "AUKUS Defense Ministers Meeting Joint Statement," December 1, 2023, https://www.defense.gov/News/Releases/Release/Article/3604511/aukus-defense-ministers-meeting-joint-statement/.

[63] For a thorough articulation, see Erik Gartzke and Jon R. Lindsay, "Weaving Tangled Webs: Offense, Defense, and Deception in Cyberspace," *Security Studies* 24, no. 2 (June 2015), https://www.tandfonline.com/doi/full/10.1080/09636412.2015.1038188.

[64] Stew Magnuson, "AUKUS Agreement Poses Cybersecurity Risk to Allies," National Defense Magazine, September 29, 2022, https://www.nationaldefensemagazine.org/articles/2022/9/29/aukus-agreement-poses-cybersecurity-risk-to-allies.

[65] For recent discoveries in a long series, see Jack Kim, "North Korea hacking teams hack South Korea defence contractors," Reuters, April 22, 2024, https://www.reuters.com/technology/cybersecurity/north-korea-hacking-teams-hack-south-korea-defence-contractors-police-2024-04-23/, and Mariko Oi, "North Korea hacked South Korea chip equipment makers," BBC, March 4, 2024, https://www.bbc.com/news/business-68476035.

[66] Office of the President, "Strategic Cybersecurity Cooperation Framework Between the Republic of Korea and the United States of America," April 2023. For a recent assessment, see Sebastian Garcia, "Facing the North Korean Cyber Threat: United States-South Korea Coordination in Cyberspace," Asia Dispatch, Wilson Center, August 29, 2024, https://www.wilsoncenter.org/blog-post/facing-north-korean-cyber-threat-united-states-south-korea-coordination-cyberspace.

[67] Natasha Wood, "South Korea's 2024 Cyber Strategy: A Primer," Center for Strategic and International Studies, August 2, 2024, https://www.csis.org/blogs/strategic-technologies-blog/south-koreas-2024-cyber-strategy-primer.

[68] Gaida, Wong Leung, Robin, and Cave, "Critical Technology Tracker: The Global Race for Future Power"; and "AUKUS Relevant Technologies: Top 10 Country Snapshot," Australian Strategic Policy Institute, https://techtracker.aspi.org.au/our-report/.

[69] More information on technology characteristics and global development programs is available at Kelley M. Sayler, "Hypersonic Weapons: Background and Issues for Congress," Congressional Research Service, August 14, 2024, https://crsreports.congress.gov/product/pdf/R/R45811/41.

[70] The White House, "Fact Sheet: Implementation of the Australia – United Kingdom – United States Partnership (AUKUS)."

[71] For example, US Department of Defense, "AUKUS Defense Ministers Meeting Joint Statement," December 1, 2023, https://www.defense.gov/News/Releases/Release/Article/3604511/aukus-defense-ministers-meeting-joint-statement/.

[72] Statement by then-Australian Minister for Defence Peter Dutton, quoted in Mikayla Easley, "AUKUS Partners Aim to Catch China in Hypersonics Race," National Defense, February 17, 2023, https://www.nationaldefensemagazine.org/articles/2023/2/17/aukus-partners-aim-to-catch-china-in-hypersonics-race.

[73] Kirsty Needham, "Australia, US Look to Joint Production of Hypersonic Missile," Reuters, August 16, 2024, https://www.reuters.com/world/australia-us-look-joint-production-hypersonic-missile-us-lawmaker-says-2024-08-16/.

[74] Hyuk-cheol Kwon, "우리도 극초음속미사일 개발하고 있었다…'북한보다 기술 앞서' [We were also working on hypersonic missiles… technologically ahead of North Korea]," *Hankyoreh*, January 6, 2022, https://www.hani.co.kr/arti/politics/defense/1026272.html.

[75] Dong-seok Kim, "韓 방공망, 北 저고도·극초음속 미사일 못 막는다 [South Korea's air defenses can't stop North Korea's low-altitude, hypersonic missiles]," *Maeil Shinmun*, January 28, 2024, https://www.imaeil.com/page/view/2024012820095644716.

[76] Seong Hyeon Choi, "South Korea Brings Hypersonic Tech to the AUKUS Table," *South China Morning Post*, May 5, 2024, https://www.scmp.com/news/china/diplomacy/article/3261304/south-korea-brings-hypersonic-tech-aukus-table-sign-seoul-moving-closer-us-and-its-other-allies.

[77] For example, in "hypersonic detection, tracking, and characterization," China commands 73.3 percent of global capacity; South Korea with less than 0.5 percent is not in the top ten of countries. "AUKUS Relevant Technologies: Top 10 Country Snapshot," Australian Strategic Policy Institute, https://techtracker.aspi.org.au/our-report/.

[78] For more information on electronic warfare, see "Defense Primer: Electronic Warfare," Congressional Research Service, Updated November 14, 2022, https://crsreports.congress.gov/product/pdf/IF/IF11118. Directed energy weapons, such as lasers and high-powered microwaves, generally are considered distinct from EW capabilities.

[79] The White House, "Fact Sheet: Implementation of the Australia – United Kingdom – United States Partnership (AUKUS)."

[80] Defense Innovation Unit, "First Trilateral AUKUS Pillar II Prize Competition Completed," September 25, 2024, https://www.diu.mil/latest/first-trilateral-aukus-pillar-ii-prize-competition-completed.

[81] Relatedly, South Korea ranks third in directed energy technologies, behind only China and the US, with a high value-added to AUKUS relative to China. See "AUKUS Relevant Technologies: Top 10 Country Snapshot," Australian Strategic Policy Institute, https://techtracker.aspi.org.au/our-report/; and the Appendix, Table 1.

[82] "AUKUS Pillar 2 (Advanced Capabilities): Background and Issues for Congress."

[83] The only other country is Turkey. See "E-7A AEW&C," Boeing, https://www.boeing.com/defense/e-7-airborne-early-warning-and-control/.

[84] For a recent review and evaluation of the extensive literature on military innovation, see Michael C. Horowitz and Shira Pindyck, "What is a Military Innovation and Why It Matters," *Journal of Strategic Studies* 46, no. 1 (2023), https://doi.org/10.1080/01402390.2022.2038572.

[85] US Department of Defense, "National Defense Strategy of the United States of America," October 2022, https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF.

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[87] The White House, "Fact Sheet: Implementation of the Australia – United Kingdom – United States Partnership (AUKUS)." Emphasis added.

[88] "AUKUS Pillar 2 (Advanced Capabilities): Background and Issues for Congress."

[89] US Department of Defense, "AUKUS Defense Ministers Meeting Joint Statement," December 1, 2023, https://www.defense.gov/News/Releases/Release/Article/3604511/aukus-defense-ministers-meeting-joint-statement/. As discussed in the prior sub-section, the first round focused on electronic warfare.

[90] "Global Innovation Index 2024 - GII 2024 Results," Global Innovation Index 2024, accessed October 4, 2024, https://www.wipo.int/gii-ranking/en/rank.

[91] The White House, "Fact Sheet: Implementation of the Australia – United Kingdom – United States Partnership (AUKUS)."

[92] US Department of Defense, "AUKUS Defense Ministers Meeting Joint Statement," December 1, 2023, https://www.defense.gov/News/Releases/Release/Article/3604511/aukus-defense-ministers-meeting-joint-statement/.

[93] John Christianson, Sean Monaghan, and Di Cooke, "AUKUS Pillar Two: Advancing the Capabilities of the United States, United Kingdom, and Australia," Center for Strategic and International Studies, July 10, 2023, https://www.csis.org/analysis/aukus-pillar-two-advancing-capabilities-united-states-united-kingdom-and-australia. Italics original.

[94] Sangbo Park, "Implications of the General Security of Military Information Agreement for South Korea," Stimson Center, December 16, 2016, https://www.stimson.org/2016/implications-general-security-military-information-agreement-south-korea/. This assessment notes that South Korea had signed a GSOMIA agreement with 32 countries and NATO, compared with six such agreements by Japan.

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[96] Author interviews in Seoul, Korea, September 8-13, 2024.

[97] Author interviews in Seoul, Korea, September 8-13, 2024.

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