Industrial Open Strategic Autonomy in the Indo-Pacific

Focusing on high-tech industrial innovation and supply chain security

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Editors |
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Foreword

As has recently been observed, the global economic order is undergoing a profound transformation. The intensifying geopolitical rivalry among great powers, the retreat from multilateralism, the resurgence of protectionist policies, and the weaponization of trade and technology have shaken the foundation of the open and inclusive global economic order, which has been around for a long period. These changes underscore the growing importance of technological leadership, secure supply chains, and resilient industrial ecosystems in shaping the economic security and strategic autonomy of individual nations. However, pursuing security and autonomy does not mean isolation. Ironically, the necessity for like-minded countries to cooperate has never been greater, as no single nation can cope alone with the shift in the global economic order.

The Republic of Korea (Korea, henceforth) and the Netherlands, as middle powers and trading nations, share a deep interest in preserving the stability, openness, and resilience of the global economy, which ultimately contribute to the prosperity of all participating countries. South Korea, for example, has long been a globalized manufacturing power house, heavily relying on global value chains to support its growth. However, a series of shocks, including China's economic retaliation over THAAD, Japan's export controls, the COVID-19 pandemic, and US–China technology competition, revealed structural vulnerabilities of Korea's export-oriented economy. Korea's new economic security strategy, as detailed in this volume, reflects efforts to reconcile its position as an export leader and an import-dependent economy. Similarly, the Netherlands, one of Europe's most open trading nations, faces the challenge of mitigating risks while preserving openness. The country positions itself as a logistics hub, a high-tech innovator, and a host of globally competitive firms such as ASML. As the European Union attempts to lower its external dependencies in strategic sectors, the Netherlands plays a significant role in shaping Europe's economic security agenda.

Against this backdrop, Korea and the Netherlands emerge as natural partners. Their complementary strengths in semiconductors, advanced manufacturing, quantum technology, and clean energy transition can create opportunities for them to build resilient supply chains and shape global standards jointly. Their partnership also aligns with broader Indo-Pacific regional frameworks, including the EU–Korea Strategic Partnership and the international component of Horizon Europe, positioning both countries to contribute to a stable, rules-based global order.

This edited volume, "Industrial Open Strategic Autonomy in the Indo-Pacific: Focusing on High-tech Industrial Innovation and Supply Chain Security", examines how

Korea and the Netherlands can deepen their cooperation across key policy areas and critical technologies to advance open strategic autonomy. Drawing on contributions from leading experts, the volume is organized into two parts. **Part I** analyzes the policy foundations of economic security and strategic autonomy and **Part II** explores the technological domains essential to achieving these goals.

In the chapter of Part I, **Seungjoo Lee** traces the development of South Korea's economic security strategy. He emphasizes Korea's triple vulnerability - high trade dependence, reliance on specific countries, and structural weaknesses in value chains – and outlines the institutional reform to address this challenge, including new supply chain laws, strategic technology programs, and expanded international cooperation.

Richard Ghiasy, in the next chapter, situates Korea–Netherlands cooperation within the broader geopolitical landscape of the Indo-Pacific. He overviews Europe's evolving approach to economic security and how the Netherlands deals with the pressures from technological rivalry, supply chain geopolitics, and economic coercion. The chapter also proposes actionable frameworks, including Dependency Tolerance Guardrails and an Asymmetric Interdependence Index, to guide bilateral cooperation.

Myong Hwa Lee then focuses on science and technology (STI) cooperation as a critical driver of open strategic autonomy. She highlights Korea's and the Netherlands' different strengths in key technologies and identifies the complementarities that can support joint innovation. Korea's new status as an associate member of Horizon Europe's Pillar II opens up new avenues for structured collaboration. This chapter proposes joint R&D mechanisms, talent mobility programs, and coordinated technology diplomacy efforts to intensify STI cooperation between the two countries.

In the last chapter of Part I, **Joris Vierhout and Amber Geurts** introduce the Control Points Framework as an analytical tool that identifies strategic choke points and dependencies in global value chains. This chapter provides policymakers with a methodology to identify both vulnerabilities and areas of strategic advantage, emphasizing the need for selective cooperation among trusted partners like Korea and the Netherlands.

The following four chapters of Part II explore the avenues of cooperation in four key sectors: AI Semiconductor, quantum technology, energy, and critical raw materials for defense.

Seokjoon Kwon analyzes how the global semiconductor industry is restructuring under the pressure of AI innovation. The chapter argues that AI-optimized chips—GPUs, NPUs, TPUs, and ASICs—will define the next phase of semiconductor innovation. Cooperation between Korea and the Netherlands is essential for breakthroughs in angstrom-scale manufacturing. The chapter outlines joint opportunities in design automation, next-generation lithography, and semiconductors for manufacturing AI.

Then **Anna Grashuis, Ingrid Romijn, Ulrich Mans and Mayra van Houts** jointly contributed to the next chapter, exploring how quantum technologies—computing, communication, and sensing—have become strategic assets for national security and technological sovereignty. The Netherlands is a leader in quantum communication networks and photonic integration, while Korea does so in industrial deployment, telecom-based QKD, and superconducting qubits. The authors propose joint testbeds, standardization efforts, and talent exchange programs between the two countries.

In the next chapter, **Sunghun Cho** compares the green transitions of Korea and the Netherlands, emphasizing the evolving nature of energy security. The Netherlands is a leader in renewable deployment and hydrogen infrastructure, while Korea faces structural challenges due to its reliance on fossil fuels and its isolated grid system. The chapter identifies opportunities for cooperation in LNG infrastructure, offshore wind, hydrogen market development, and regulatory reform.

The final chapter of Part II by **Irina Patrahau and Benedetta Girardi** investigates vulnerabilities in defense supply chains arising from dependence on critical raw materials (CRM). Both Korea and the Netherlands face concentrated dependencies in materials essential for aerospace, electronics, munitions, batteries, and other defense-related technologies. The authors explain how joint CRM stockpiles, efforts to diversify the supply chain upstream, sharing supply chain intelligence, and coordinated investment in recycling and substitution can mitigate these risks.

The volume is finally closes with a reflection on the topics discussed by the various authors, highlighting that middle powers can shape the future of the global economic order by jointly investing in strategic capabilities, aligning standards, and deepening trusted partnerships, rather than by decoupling. The last chapter also systematically summarizes the authors' key policy recommendations.

Part 1

Key Policies for Open Strategic Autonomy

01

The Evolution of South Korea's Economic Security Strategy

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Chung-Ang University

Introduction

South Korea's economic security strategy has similarities and differences with those of other countries. The country has implemented countermeasures against supply chain disruptions triggered by the global spread of COVID-19, U.S.-China strategic competition, and increased geopolitical risks such as the Russia-Ukraine war as the core of its economic security strategy. Meanwhile, asymmetric interdependence with China, high external dependence of its main export industries, and experiences with economic coercion have served as factors driving South Korea to pursue an economic security strategy distinct from other countries. This paper examines the impact of triple vulnerabilities and experiences of economic coercion on the formation of South Korea's economic security strategy. Based on this analysis, the paper explains the key characteristics of South Korea's economic security measures.

The Origins of Economic Security Strategies

Triple Vulnerabilities

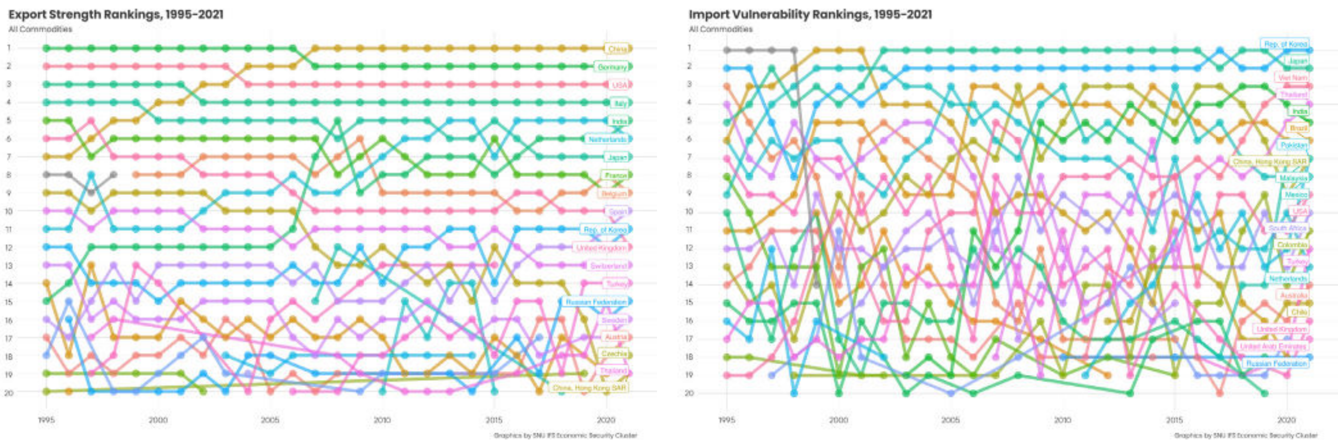
From a structural vulnerability standpoint, South Korea's new industrial policy is closely integrated with its economic security strategy. The South Korean economy simultaneously faced a "triple vulnerability" in the 2000s. First, South Korea's high trade dependency fostered a perception of vulnerability to changes in the external environment. In 2022, South Korea's trade dependence stood at 97%, 34 percentage points higher than the global average of 63%. It is also 33.1 percentage points higher than the 2021 OECD member average of 63.9%. Geopolitical conflicts such as the US-China strategic competition, supply chain disruptions triggered by COVID-19, and the Russia-Ukraine war have amplified uncertainty for highly trade-dependent countries like South Korea.

Second, South Korea's high overall trade dependency extended to its significant reliance on a small number of countries. In 2018, just before the US-China strategic competition and supply chain disruptions emerged, South Korea's export and import dependence on China stood at 26.8% and 19.9%, respectively. These levels were higher than those for the US (7.2%, 21.6%), the EU (10.7%, 19.9%), Germany (7.1%, 9.8%), Japan (19.5%, 23.2%) and ASEAN (18.5%, 26.3%). South Korea's diversification efforts, China's economic slowdown, and changes in the South Korea-China division of labor structure combined to reduce South Korea's export and import dependence on China to 19.7% and 22.2%, respectively, in 2023. However, these figures remain higher than the global average (11.2%, 15.6%).[1] This high level of trade dependence on China not only complicates responses to supply chain disruptions but also leaves South Korea vulnerable to China's economic coercion.

Third, South Korea exhibits high vulnerability at specific stages within its value chains. Despite strong competitiveness in key high-tech industries like semiconductors, batteries, automobiles, EVs, biotechnology, shipbuilding, nuclear power generation, and defense, South Korea exhibits an imbalanced structure where these industries rely heavily on imports for materials, parts, and equipment within their value chains. South Korea has a structural characteristic of high export competitiveness coupled with high import vulnerability. South Korea has pursued an economic security strategy leveraging its manufacturing competitiveness in key high-tech industries like automobiles, semiconductors, and batteries. However, as shown in <Figure 1>, while South Korea ranks among the top 10 globally in export competitiveness, it is also one of the countries with the highest import vulnerability, alongside Japan.

1 KIEP 2024

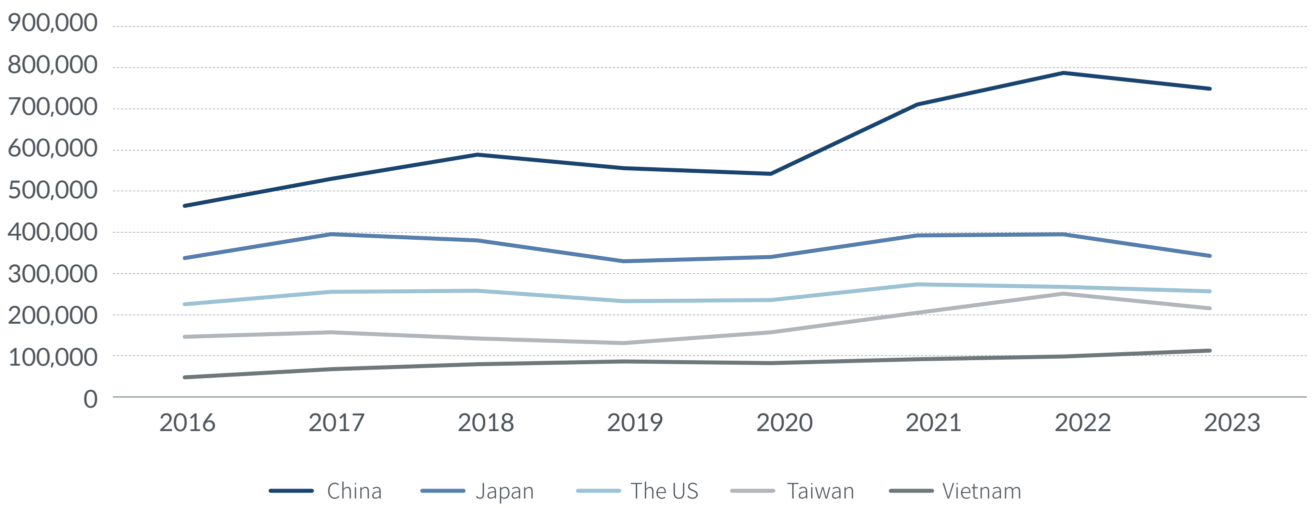
Figure 1. South Korea's Export Strength and Import Vulnerabilities



Source: SNU (2024).

The dilemma facing the South Korean government is that industries with high export competitiveness are also industries with high import dependency. Semiconductors, batteries, and electric vehicles are prime examples of industries with strong export competitiveness yet high vulnerability in materials, parts, and equipment. South Korea records a trade deficit in over half of the thirteen semiconductor equipment items. Specifically, South Korea relies on the Netherlands and Japan for photolithography equipment, the United States for measurement equipment, the United States, Singapore, and Japan for ion implantation equipment, and Japan, the United States, and Singapore for etching equipment (see <Graph 1>).

Graph 1. South Korea's External Dependence on Materials, Parts, and Equipment



Source: SOBUJANG.net.

These characteristics of South Korea are also evident at the individual industry level. In key export industries such as semiconductors, batteries, displays, EVs, and biotechnology, South Korea exhibits a high degree of import dependency. The simultaneous presence of competitiveness and vulnerability within the same industries resulted from the nature of South Korea's chosen catch-up strategy and its strategic choice to leverage the global value chain to secure competitiveness. Initially, South Korea pursued a substituting strategy, directly competing with leading countries during its high-growth period. During this time, South Korea came to rely on foreign firms rather than domestic ones for intermediate goods production to rapidly enhance the competitiveness of final goods. Even after successfully catching up to the leading countries, South Korea maintained a strategy of forming global value chains in its key export industries, importing intermediate goods from foreign firms for production. Leveraging global value chains maximized productivity and enhanced the competitiveness of its final goods.

Experiences of Economic Coercion

The South Korean government's pursuit of industrial policies focused on supply chain strategy is the result of the interaction between the structural vulnerability of its supply chains and its experience with economic coercion. China and Japan not only significantly influenced the formation of South Korea's triple vulnerability but also share the commonality of having exerted economic coercion against South Korea. The experience of economic coercion amplifies anxiety about structural vulnerabilities. Examples include China's economic sanctions in 2017 over the 2016 THAAD deployment decision compelled South Korea, with its high external dependency, to pursue industrial policy from an economic security perspective. The Chinese government banned group tours to South Korea and implemented de facto economic coercion targeting the cosmetics, entertainment, and wholesale/retail industries. The resulting economic damage was estimated to reach 0.5% of South Korea's GDP. In addition, a series of supply chain disruptions catalyzed by geopolitical risks such as Japan's removal of South Korea from its white list in 2019, China's suspension of urea solution exports in late 2021 and in December 2023, and China's export controls on gallium and germanium in July 2023 further facilitated the shift in South Korea's industrial policy.

<Figures 2 ~ 4> show changes in South Korea's trade of materials, parts, and equipment from 2017 to 2019, when China and Japan imposed economic sanctions on South Korea, through 2023. Despite economic coercion, China remains both South Korea's largest export destination and largest import source for materials, parts, and equipment. As of 2018, South Korea's exports and imports of materials, parts, and equipment to China totaled \$113.8 billion and \$58.8 billion, respectively. In 2020, South Korea's exports to China totaled \$90.5 billion, while imports from China

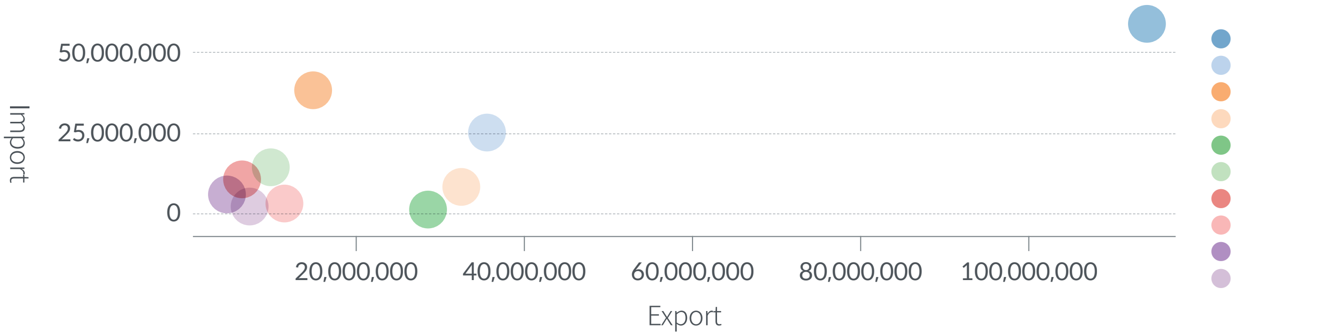
amounted to $54.2 billion. By 2023, exports to China reached $85 billion, and imports from China rose to $74.9 billion (see <Graph 2>). South Korea's dependence on China for materials, parts, and equipment is also evident in individual items. An analysis of import dependency by country for 185 key items used in South Korea's core export sectors—semiconductors, batteries, automobiles, and shipbuilding—revealed that of items imported in quantities exceeding $1 million, the proportion of items with over 50% dependency on China reached a staggering 54.1%.

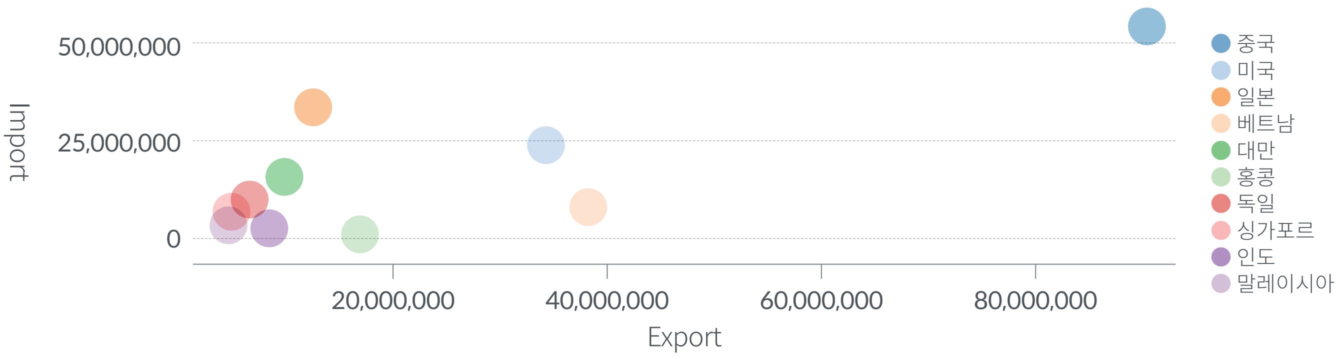
South Korea's dependence on Japan is also extremely high. In July 2019, Japan implemented de facto export controls by removing South Korea from its White List. Japan's Ministry of Economy, Trade and Industry (METI) export controls target essential materials for semiconductor production, such as hydrogen fluoride and fluorinated compounds, and Japan's export restrictions have significantly impacted South Korea's semiconductor industry (effectively imposing export controls by removing it from its white list). Dependence on Japan is also very high. Japan's Ministry of Economy, Trade and Industry (METI) export controls focused on essential materials for semiconductor production – hydrogen fluoride, fluorine polyimides, and photoresist. Prior to the 2018 export controls, South Korea's exports and imports of materials, parts, and equipment to and from Japan were $15 billion and $38.1 billion, respectively (SOBUJANG Net 2024).

China's economic sanctions in 2017 and Japan's export controls in 2019 directly targeted South Korea. In response, the South Korean government formulated strategies to enhance supply chain stability and resilience, swiftly implementing countermeasures. The enactment of the three supply chain laws, the establishment of a supply chain stabilization fund, increased self-reliance in key advanced technologies, and strengthened international cooperation with like-minded countries clearly demonstrate the South Korean government's commitment to supply chain industrial policy.

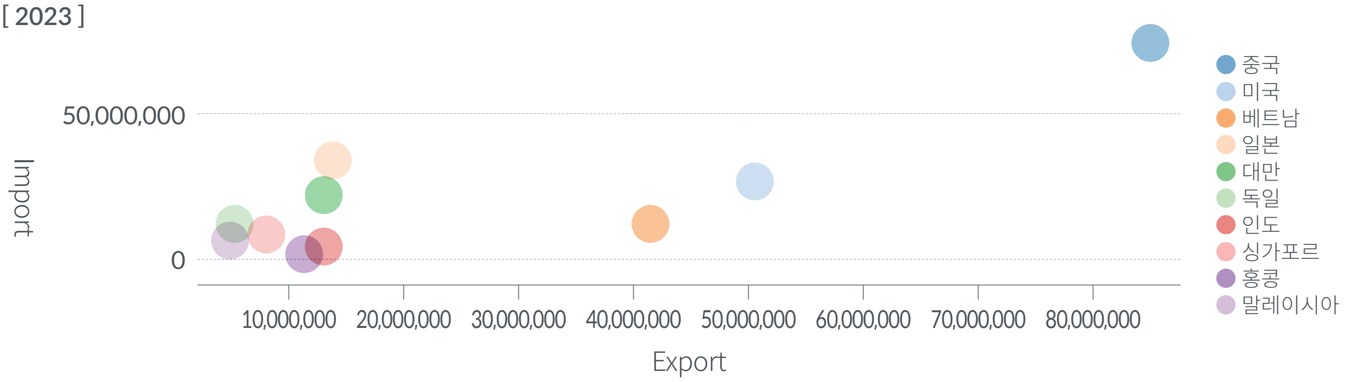
Figure 1. South Korea's Export Strength and Import Vulnerabilities

[2018]





[2023]



Source: SOBUJANG.net.

The Evolution of South Korea's Economic Security Strategies

Reactive Nature

A reactive nature is a defining characteristic of South Korea's economic security strategy. This reactive nature involves responding to pressure for market opening, offensive measures, or economic coercion from other countries after the fact rather than preemptively. This focus is on minimizing the damage and impact caused by the other country's actions rather than retaliating with the same means. South Korea has directly experienced economic coercion, such as China's economic sanctions concentrated on retail, tourism, and content industries, and Japan's export controls on materials that could disrupt the semiconductor industry's supply chain. For example, amid China's economic coercion over the THAAD deployment decision and the deterioration of South Korea-Japan relations, South Korea prioritized minimizing economic damage rather than responding with the same type of economic coercion against Japan's decision to remove South Korea from its white list.

This reactive stance was evident in its responses to China's economic sanctions in 2016 and Japan's export control measures in 2019. Although it was estimated to have suffered damages amounting to approximately 0.5% of GDP due to China's economic sanctions, the South Korean government attempted to minimize the impact of China's economic coercion rather than respond with counter-coercive measures against China.

The Primacy of Supply Chain Strategy

The risks inherent in the triple vulnerability—high trade dependency, dependence on specific countries, and vulnerability to specific segments within the value chain—were triggered by China's and Japan's economic coercion in 2017 and in 2019, respectively. Instead of focusing on direct countermeasures against economic coercion by other countries, South Korea prioritized strategies to prevent supply chain disruptions. While the US, EU, and Japan also treat supply chain policies as critical from an economic security perspective. Unlike these countries, South Korea conducted a comprehensive analysis of supply chain vulnerabilities at the governmental level at an early stage and established the fundamental direction of its supply chain strategy based on this analysis.

For example, the South Korean government also analyzed import dependency for key items to identify supply chain vulnerabilities. This analysis revealed that, in 2020, 1,088 of South Korea's imported items had a dependency on China exceeding 50%, and 653 of those items exceeded 70%. Of the intermediate goods imported, 604 showed a dependency on China exceeding 50%, and 366 items exceeded 70%.[2] In 2020, South Korea's imports of materials, parts, and equipment from Japan reached $34 billion. Based on this analysis, the South Korean government selected eight key areas – cathode materials, semiconductor materials, rare gases, rare earth permanent magnets, urea, magnesium, and molybdenum – as "Supply Chain Leadership Projects." The government also launched the "Industrial Supply Chain 3050 Strategy" to reduce dependency on specific countries for these items to below 50% by 2023.[3]

The Emergence of New Industrial Policy: A Nexus between Industrial Policy and Technological Innovation

Another characteristic of South Korea's economic security strategies is shifting away from industrial policies that focus solely on enhancing industrial competitiveness. Instead, it pursues strategies centered on the industrial policy-technological innovation nexus, focusing on strengthening technological innovation capabilities. While South Korea's supply chain management, advanced technological innovation, and industrial policy strategies are pursued individually, they are also advanced on two interconnected dimensions: the linkage between supply chain management and advanced technological innovation, and the linkage between advanced technological innovation and industrial policy.

The first topic is the linkage between supply chain management and advanced technological innovation. Regarding supply chain strategy, South Korea prioritized strengthening the legal and institutional foundation for supply chain management by enacting and revising the three supply chain laws. In 2023, South Korea designated 33 types of critical minerals, including lithium, nickel, cobalt, and manganese. Among these, 10 were selected as the most critical and prioritized for supply chain stabilization. The criteria for core minerals considered supply risks and domestic economic impact. The South Korean government did not stop at defensive supply chain management, however, it also linked it to fostering advanced technologies. They are cultivating core strategic technologies to enhance the competitiveness of core components, materials, and equipment is being pursued from a supply chain management perspective.

Second, the South Korean government also strengthens the linkage between advanced technological innovation and industrial policy. As demonstrated by the Min-

2 KIET 2021/11/18

3 Ministry of Trade, Industry and Energy 2024

istry of Science and ICT selecting the 10 National Essential Strategic Technologies in 2021 and the Ministry of Trade, Industry and Energy (MOTIE) announcing the "Super Gap R&D Strategy" in April 2023, South Korea pursues a strategy that links advanced technology innovation with strengthening industrial competitiveness.

In 2024, the MOTIE decided to pursue the "Super Eul" strategy to foster a "South Korean ASML" that possesses unrivaled technological capabilities in materials, components, and equipment, secures a pivotal position in the global supply chain, and market leadership. The Ministry of Trade, Industry and Energy provides selected companies with a seven-year package of integrated support covering (1) consolidated R&D, (2) patent applications in the US, EU, and Japan, and (3) integrated tax, M&A, and infrastructure assistance.[4]

The importance of strengthening advanced technological capabilities is evident in the South Korean government's selection of 12 core national strategic technologies in 2021 and its subsequent decision to provide concentrated support. The South Korean government made this decision because it recognized that strengthening technological sovereignty serves as a means to respond to advanced technology competition. These policies allow the government to link supply chain strategy to fostering advanced technologies as it increases the self-sufficiency of core strategic technologies to enhance the competitiveness of high-tech industries. Expanding the scope of industrial policy to link it with advanced technological innovation has the effect of complementing the limitations of reactive economic security strategies. The utilization of advanced technology can be considered a key element of new industrial policy, as continuously enhancing technological innovation capabilities helps proactively prepare for uncertainties like the U.S.-China strategic competition.

Strategic Utilization of Advanced Technology for Inclusive Cooperation

Advanced technology is the third core instrument of South Korea' economic security strategy.[5] The South Korean government attempts to leverages its high technological capabilities as a tool to counter economic coercion as well as to drive international cooperation. At the same time, high technology has become a core element in strengthening cooperation with the United States, essential for enhancing

4 Ministry of Trade, Industry, and Energy (2024), "Beyond the Pursuers to a Leapfrog Advantage: 12 National Strategic Technologies - Roadmap Completion and Core Project Selection." January 31 (in South Korean).

5 Seungjoo Lee (2025), "High technology and economic statecraft: the emergence of techno-economic statecraft in South Korea." *Business and Politics* 1-20. doi:10.1017/bap.2023.34.

economic security. Representative examples include the two states cooperating as mutually beneficial partners in restructuring supply chains for advanced industries like semiconductors and batteries, and expanding cooperation in advanced science and technology to areas such as cybersecurity, space exploration, and quantum technology.

The success of the economic security strategy largely depends on effectively linking domestic initiatives with international partnerships. The South Korean government has provided targeted support to bolster the competitiveness of key industries such as semiconductors, batteries, and electric vehicles (EVs) while strategically leveraging these sectors for international collaboration. South Korea's active roles in U.S.-South Korea and U.S.-Japan-South Korea partnerships, as well as its participation in multilateral initiatives such as the Minerals Security Partnership (MSP), demonstrate its ability to effectively integrate domestic and international strategies to enhance economic security.[6] Thus, high technology has emerged as a means of not only responding to economic coercion, but also strengthening international cooperation.

Governance Reform

The South Korean government, in response to supply chain disruptions, has created and reorganized supply chain-related organizations within various ministries. As of 2024, the government has completed the legal basis for its economic security strategy and is in the process of building an integrated, government-wide governance system. This enables the government to systematically integrate previously fragmented information across ministries and to increase the level and speed of information sharing. Furthermore, the South Korean government is promoting an expansion of governance to include public-private cooperation, strengthening communication and collaboration with the private sector. It is also expanding private-sector participation to establish effective support and response measures by exchanging quick and accurate information with advanced technology industries and the materials, parts, and equipment (So-Bu-Jang) sectors.

Reforming Institutional Foundation

The lack of a robust institutional framework was seen as a source of vulnerability. To address these concerns, the South Korean government enacted several pivotal laws, including the Key Supply Chain Acts (comprising the Framework Act on Sup-

6 Government of the Republic of South Korea (2024), South Korea-U.S.-Japan Economic Security Dialogue [Press Release].

ply Chain Stabilization Support for Economic Security, the Act on Special Measures to Strengthen Competitiveness and Stabilize the Supply Chain of the Materials, Components, and Equipment Industry, and the National Resource Security Special Act), the Special Act on the Fostering of National Strategic Technology, and the Act on Special Measures for Strengthening the Competitiveness of, and Protecting National High-Tech Strategic Industries."[7] This stronger legal foundation enabled the South Korean government to pursue a more systematic and integrated policy package.

Conclusion

I have examined the key characteristics that have emerged in the evolution of South Korea's economic security strategy to date. The structural vulnerabilities of South Korea's major export industries and its experience with economic coercion have significantly influenced the formation and transformation of its economic security strategy. While maintaining a highly cautious stance in adopting counter-coercive measures against economic coercion, South Korea has established strengthening supply chain resilience as the cornerstone of its economic security strategy. First, South Korea has expanded and strengthened the necessary policy support to enhance technological sovereignty in materials, components, and equipment, aiming to reduce its external dependence in these areas. Second, Korea has also strengthened advanced technology cooperation with like-minded countries through its production capabilities in high-tech industries. Third, South Korea has simultaneously focused on linking its technology innovation strategy with industrial policy, strengthening the legal and institutional foundation, and reforming governance.

7 Ministry of Economy and Finance (2022), Proposal for the Basic Law on Supply Chain Stabilization Support (in South Korean).

02

Partners Under Pressure: Strengthening Dutch-South Korean Economic Security amid a Fractious Indo-Pacific

Richard Ghiasy
Leiden Asia Centre

Introduction

Economic security has moved rapidly from a peripheral concern to the center of strategic policymaking across Europe and Asia. As two of the world's largest and most interconnected markets, the prosperity and security of Europe and Asia are deeply intertwined. The Indo-Pacific, today the principal arena of geopolitical competition, has remained stable, but fissures are plentiful. Governments are increasingly seeking to protect their economies from (prospective) external shocks and coercive pressures.

Europe first articulated its economic security agenda through 'open strategic autonomy,' an attempt to balance the benefits of free trade while reducing excessive dependencies. As one of the larger European economies, the Netherlands has long pursued a primarily market-driven, open trade policy in the wake of WWII, transforming it into a top 10 global economy per capita.[8] South Korea has pursued a different strategy, emphasizing an East Asian tradition of state-supported industrial resilience in sectors deemed vital to national security.

The contrast between the Netherlands and South Korea highlights the diverse approaches adopted by two mid-sized, innovative, and technologically advanced economies. The Dutch tradition has long relied on openness and comparative advantage amid the 'luxury' of the integrated European common market. In contrast, South Korea's policies were shaped by the legacies of a developmental state in a geopolitically volatile region, and as a relatively recent entrant, it rapidly climbed

8 Based on 2024, both nominal and in PPP terms, see World Bank. *GDP per Capita (Nominal Current US$) – Netherlands*. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=NL; and *GDP per Capita, PPP (Current International $)* – Netherlands. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=NL.

into the ranks of advanced industrial economies. Yet despite these differences and successes, both countries face converging pressures from (great-)power rivalry in and beyond the Indo-Pacific, fierce technological competition, and the increased weaponization of interdependence.

Recent policy developments point to a shift from shared rhetoric to more pragmatic economic security coordination. Similar to the semiconductor 'chip alliance' announced by the Netherlands and South Korea in December 2023, new initiatives have emerged in the fields of batteries, digital technologies, and clean energy. These initiatives are underpinned by new bilateral frameworks, the broader EU-Korea level 2010 Strategic Partnership, the 2022 Digital Partnership, and the Economic Security Dialogue launched in 2023.

This policy brief uses the relationship between South Korea and theNetherlands as a starting point and case study to analyze and enhance evolving economic security cooperation between two of their continents' most innovative and strategically positioned economies. The brief examines the differing policy traditions, areas of convergence, and the scope for joint action in further strengthening resilience amid tensions and power shifts in the Indo-Pacific. Particular attention is given to semiconductors, critical raw materials, and green technologies. The analysis concludes with recommendations on how the two countries can better align policies, diversify their supply chains, and strengthen institutional partnerships to bolster their economic security and safeguard the competitiveness that underpins their prosperity.

First, the brief outlines the geopolitical landscape of the Indo-Pacific, followed by an overview of the conceptualization of economic security and Europe-Asia trade.

A Precarious Yet Predominantly Stable Indo-Pacific

There is widespread empirical, scholarly, and policy recognition that the Indo-Pacific, with Asia at its heart, will remain the world's principal arena of geopolitical competition and economic growth for many decades to come.[9] This region has the largest share of the world's population, the fastest-growing major markets, unmatched

9 See for instance McKinsey Global Institute. The Future of Asia: Asian Flows and Networks Are Defining the Next Phase of Globalization. September 2019. https://www.mckinsey.com/capabilities/mgi/our-research/the-future-of-asia; Medcalf, Rory. Indo-Pacific Empire: China, America and the Contest for the World's Pivotal Region. Manchester: Manchester University Press, 2020; and European External Action Service. EU Strategy for Cooperation in the Indo-Pacific. Brussels: European Commission, September 16, 2021. https://www.eeas.europa.eu/eeas/eu-strategy-cooperation-indo-pacific_en.

manufacturing depth, and five of the largest economies: China, Japan, India, the ASEAN bloc, and the US, which serves as a key power in the region. The Asia-Pacific region alone is responsible for approximately 39 percent of global nominal exports and around 37 percent of imports.[10] No other region combines this level of economic dynamism with geopolitical importance.

At the same time, the Indo-Pacific is characterized by enormous multiplicity and a 'deceptive coherence.' Residents of the Indo-Pacific region do not identify themselves as such. The area is the seat of reemerging civilizational states, and Asia's great religious and spiritual traditions are deeply embedded in its social, political, and strategic fabric. In at least two civilizational states, China and India, there is an immense sense of pride and a drive to lead again in the world economically, technologically, and politically. In China's case, this ambition is accompanied by a desire for Asia, including its security, to be led by Asians.[11] Amidst this demographic and economic dynamism, diversity, and vastness, the Indo-Pacific is at once a contested concept, a vision, a strategy, a process, and a fractious geographic space.[12]

What makes the Indo-Pacific geopolitically and geoeconomically particularly unique is its composition of various regional, major, and great powers. The interplay of these powers and the shifting security landscape creates a dynamic that sometimes boosts a sense of security, for example, through the Shanghai Cooperation Organization (SCO), yet simultaneously erodes it. Despite the geopolitical tensions and persistent crisis risks on the Korean Peninsula, between India and Pakistan, and related to Taiwan, the Indo-Pacific, except for West Asia (the Middle East), is a remarkably stable region. With West Asia excluded, the last major interstate wars in Central, South, East, and Southeast Asia occurred in the 20th century. Northeast Asia has seen no major interstate conflict since the Korean War, and South Asia's crises have remained brief and short of protracted war.

This stability, of course, is precarious. The absence of war is not due to a lack of flashpoints or low tensions. Rather, it is primarily because major powers have thus far exercised restraint. Should that restraint falter, a Taiwan contingency could upend the Indo-Pacific's stability. The roles of many regional actors and middle pow-

10 United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP), Trade in Goods and Services Outlook in Asia and the Pacific (2024/2025) (Bangkok: UN ESCAP, 2024), 1, https://repository.unescap.org/server/api/core/bitstreams/43cb1e18-f351-4ff4-b251-e20ac27bf885/content.

11 Richard Ghiasy and Jagannath Panda, "Will China Succeed in Creating an Asian Security Order?," *The Diplomat,* May 18, 2024. https://thediplomat.com/2024/05/will-china-succeed-in-creating-an-asian-security-order/.

12 Rajeshwari Krishnamurthy and Richard Ghiasy, *The Transitioning Security Order in the Indo-Pacific: Furthering India-EU & Triangular Collaboration.* Special Report No. 215, Institute of Peace and Conflict Studies and Leiden Asia Centre, led by Friedrich-Ebert-Stiftung, December 2022.

ers, like South Korea, should also be acknowledged. They are exercising agency through strategic pluralism by forming flexible minilateral coalitions and avoiding binary choices between the US and China.

By and large, the major powers of the Indo-Pacific—China, India, the ASEAN bloc, Japan, the US and, to a lesser extent, Russia—are deeply engaged with one another economically. Many have come to learn how to pragmatically pursue economic development, cooperation, and selective integration. This is no guarantee for peace, as WWI poignantly taught us.[13] Yet, it is telling that the world's current major interstate war, Russia's invasion of Ukraine, is unfolding on the fringes of what was considered a stable and tightly integrated Europe, not the flashpoint-ridden, fractious Indo-Pacific.

Contemporary conflicts in the Indo-Pacific are predominantly internal, asymmetric, or involve short-lived, contained border skirmishes such as the 2025 one between Thailand and Cambodia, rather than full-scale interstate wars. Certainly, amidst power shifts, reconfigurations of economic supply chains, a degree of US-China technology bifurcation and decoupling, as well as limited pan-Asian political and security integration, tensions are rife, and the Indo-Pacific is riddled with flashpoints. Among these numerous, the most prominent and significant ones with the most global economic repercussions remain the Taiwan contingency and the South China Sea.

President Trump's transactional policies, tariffs, and aversion to costly wars may have eased US-China tensions, although they have heightened anxiety among allies over US reliability in the event of a contingency. Among some of the US' security allies and partners in the Indo-Pacific, this dampens spirits or increases concerns about US commitment if the Taiwan and South China Sea flashpoints ignite. Yet, Trump's apparent instinct to give great powers 'breathing space' lessens geopolitical tensions between the two largest powers in the Indo-Pacific. Arguably, US-China competition is the principal structuring axis of the Indo-Pacific. If this axis does not devolve into full-scale conflict, then that is a major geopolitical win for the region and its numerous stakeholders, including South Korea and the Netherlands.

In Europe, the Indo-Pacific, amidst more pressing (local) challenges and ambitions, has receded somewhat as a strategic priority. The main drivers are Ukraine and the allocation of resources to the dawning post-Ukraine European security order and architecture, persistent inflation, the trepidations of the Trump II administration (2025–), and, perhaps, a growing realization that Europe, in security terms, will

13 However, this preference for stability over armed conflict in the region differs starkly from what has long characterized Europe's 19th- and 20th-century history of recurrent interstate wars.

have limited hard power projection capabilities in the Indo-Pacific to begin with. Europe's comparative advantage may lie in supporting stability through economic partnerships and norm-based frameworks, rather than military power projection. As an extension of this, South Korea's constructive 2023 Indo-Pacific strategy underscores its commitment to regional stability and could serve as a platform for cooperation with the EU and the Netherlands.

With the Indo-Pacific canvas set out, we examine economic security and Europe-Asia economic ties before focusing on South Korea and the Netherlands.

The New Grammar of Economic Security

Economic security, defined here as a set of policies that promote control over critical assets, limit strategic risks, and sustain international competitiveness, is becoming a central priority for many economies of all levels of development. The scope and instruments differ depending on resources and vulnerabilities; evidently, it is a pursuit that is more realistic for advanced economies than for less developed ones. Economic security is sometimes also equated with 'de-risking.' Still, that term is problematic since it does not necessarily translate into, yet implies an omission of risk, which, of course, is illusory.

Similarly, the term 'deglobalization' is flawed. It mischaracterizes current structural trends. The vast majority of states are not withdrawing from the global economy and integration; some are recalibrating the terms of engagement through economic security policies. This paper is cautious in using 'de-risking' and 'deglobalization.'

In the EU, 'open strategic autonomy,' a term coined by the EU in 2020 to describe a trade policy framework balancing openness with resilience, has largely been subsumed by the broader 'economic security' agenda, particularly after the adoption of the June 2023 European Economic Security Strategy. 'Open strategic autonomy' has not entirely vanished and continues as a pillar of the broader economic security agenda. It thus makes more sense to refer to and adhere to 'economic security' than any of the other terms. Indeed, South Korea's framing, as seen in its 2022 National Security Strategy, also emphasizes economic security, referred to as 'gyeongje anbo.' In essence, this differs little from the EU's approach. South Korea's framing emphasizes partnerships, resilience, and diversification, whereas the EU defines economic security in terms of three priorities—promote, protect, and partner—emphasizing competitiveness, defensive measures, and alliances with like-minded nations.

In practice, economic security can be viewed as a delicate balance between controlling risk, limiting risk, and achieving efficiency. Economic security in and with the Indo-Pacific is not about choosing one over the others, but playing all three—

control, risk limitation and efficiency—simultaneously. Those who focus too much on control tend to lose some dynamism. Prioritizing efficiency alone, as many countries have in relation to China, exemplum primum, has made many countries vulnerable and some anxious. Those who now over-invest in risk limitation may also drain resources and efficiency. Europe and Asia need to strike an intelligent balance.

Statistics partially hint at this direction. Indeed, Europe and Asia remain deeply economically interdependent through trade, investment, and supply chains. Extra-EU trade with Asia reached €1.8 trillion in 2024, making Asia Europe's largest external trading partner, accounting for nearly half (46 percent) of total EU imports and 28 percent of exports by value.[14] In the same year, China remained the EU's top supplier, with imports totaling €517 billion, accounting for nearly a third of the Asian total and almost 40 percent of total trade.

Over the past five years, South Korea's trade patterns have shown a deepening reliance on Asia, too, alongside steady expansion with both the US and Europe. Exports to China fell from nearly 26 percent of Korea's total in 2020 to about 19 percent in 2024. This reflects China's slowdown and technology restrictions, while shipments to the US rose from 14 percent to nearly 18 percent in the same period.[15] South Korea–EU trade has steadily expanded, reaching €123 billion in 2024, with balanced flows of €68 billion in Korean exports and €55 billion in imports, underscoring the EU's position as Korea's third-largest external market.[16]

EU trade patterns over the past five years highlight the growing diversification towards South and Southeast Asia alongside enduring dependence on China. Imports from India more than doubled between 2020 and 2024, rising from €33 billion to €71 billion, while exports climbed by over 50 percent to nearly €49 billion.[17] Such diversification is a positive sign for Europe's economic security. Similarly, trade with ASEAN increased by about 20 percent in the slightly shorter 2021–2024 window, reaching €164 billion in imports and €94 billion in exports.[18] In contrast, EU trade with China grew unevenly: imports expanded to those above €517 billion, but ex-

14 European Commission. *European Union – Trade with Asia (All Countries), DG Trade & Economic Security Factsheet.* Brussels: European Commission, May 8, 2025. https://webgate.ec.europa.eu/isdb_results/factsheets/region/details_asia-all-countries_en.pdf.

15 Korea International Trade Association (KITA), *Trade Statistics,* https://www.kita.org/.

16 European Commission, *EU–South Korea Trade Relations: Statistical Summary,* Brussels: European Commission, 2024, https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/south-korea_en.

17 European Commission, *European Union – Trade with India, DG Trade Factsheet,* May 8, 2025, https://webgate.ec.europa.eu/isdb_results/factsheets/country/details_india_en.pdf.

18 European Commission, *European Union – Trade with ASEAN (Association of South-East Asian Nations), DG Trade Factsheet.* Brussels: European Commission, May 8, 2025. https://webgate.ec.europa.eu/isdb_results/factsheets/region/details_asean-association-of-south-east-asian-nations_en.pdf.

ports compared to 2020 rose only 5 percent to €213 billion—a persistent concern for Brussels. As for Asia's other two top economies, Japan and South Korea, between 2020 and 2024, EU exports to Japan grew at an average annual rate of 4.9 percent, while imports rose by 3.8 percent. This reflects consistent engagement despite fluctuating global dynamics.[19] Meanwhile, bilateral trade with South Korea saw imports at €68 billion and exports at €55 billion.[20] In sum, China alone accounts for more EU–Asia trade than ASEAN, India, Japan, and South Korea combined.

This is clearly not in full harmony with the principles of economic security. In a multipolar world where no friend or foe is absolute or permanent, Europe and Asia—neither of which is monolithic by any measure—are best off tapping into each other's markets and avoiding leaning heavily on any single actor or market. The reality is that countries that can afford it, such as the Netherlands and South Korea, are increasingly securitizing their economies amid geopolitical tensions, multipolarity, external shocks including those caused by climate change, economic coercion, growing AI-driven automation, and sometimes an outright belief in a great degree of autarky or 'democratic autarky,' i.e., the belief in collective self-sufficiency among democracies. This paper asserts from the outset that great degrees of democratic autarky[21] (or authoritarian autarky, for that matter) are highly impractical. The economic laws of comparative and competitive advantage, cost efficiency, and market demand categorically oppose such an approach.

Yet, amid geopolitical tensions and a tightly knit international trade and investment system, strategic planning for and acting on the securitization of economic ties and supply chains is a prudent exercise. A fact often overlooked in Europe, a continent that is by and large not eager to learn from the best practices of the non-West, is that, from the outset of their development, East Asian economies, including the Four Tigers, adopted economic security measures to offset the competitive asymmetry vis-à-vis the advanced Western economies.[22] This concept is not an Asian invention, but rather the foundation of virtually every successful state's industrial rise. Larger Western economies, such as, the US, UK, Germany, and France, championed

19 European Commission, *European Union – Trade with Japan, DG Trade Factsheet.* Brussels: European Commission, May 8, 2025. https://webgate.ec.europa.eu/isdb_results/factsheets/country/details_japan_en.pdf.

20 European Commission, *European Union – EU–South Korea Trade Relations, DG Trade Statistical Summary.* Brussels: European Commission, 2024. https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/south-korea_en.

21 Socio-political values-based self-reliance.

22 South Korea has historically relied on state-led industrial policies, while Japan has structurally protected its internal automotive market, and China has shielded and strategically nurtured its critical technology sectors.

free trade, while still (covertly) practicing economic security.[23]

One could argue that the unfettered globalization-dominated consensus of the 1990s and 2000s was a short-lived outlier in the history of economic security policies. With the East Asian economies having caught up technologically to the West, and in increasing cases, exceeding them, the current focus is on preserving a technological edge and building more resilience against disruptions caused by natural disastors, adversaries, and competitors. With this in mind, we shift our focus to South Korea and the Netherlands to explored how they can further their economic security cooperation.

South Korea and the Netherlands

South Korea

South Korea is a prime example of a highly competent, high-tech and export-driven economy. Shaped by the legacies of a developmental state in a geopolitically volatile region, , South Korea has become a global leader in electronics manufacturing, shipbuilding, steel production, and the automotive industry. Its government actively keeps nurturing strategic sectors, including healthcare, industrial chemicals, aerospace, defense, energy, environmental technologies, and transportation. In essence, South Korea's primary challenge is primarily recalibrating its approaches to remain competitive.

One of the primary challenges South Korea faces is balancing its export-driven growth model with the rising trend of high-technology localization and strategic autonomy in major economies, such as the US, China, and Japan, as well as others, including India, Singapore, and Vietnam, which are also eyeing a key node status in high-tech. Semiconductors remain Korea's lifeblood, accounting for about 21 percent of exports in 2024.[24] While this overconcentration yields world-class output, it also exposes the country to potential shocks if the US and China ultimately squeeze high-end capabilities. Moreover, South Korea's industrial policies are delivering output, not commensurately jobs.[25] Chaebols account for about 84 percent of South

23 Even during the heyday of globalization, major economies shielded key sectors, e.g., the US maintained buy-American provisions in defense, Europe subsidized agriculture, and Japan protected its auto market. See also Chang, Ha-Joon. *Kicking Away the Ladder: Development Strategy in Historical Perspective.* London: Anthem Press, 2002, 17–24, 39–45, 54–58.

24 Reuters. "South Korea Unveils $23 Billion Support Package for Chips amid US Tariff Uncertainty." April 14, 2025. https://www.reuters.com/technology/south-korea-unveils-23-billion-support-package-chips-amid-us-tariff-uncertainty-2025-04-14/.

25 Ministry of SMEs and Startups (MSS). "SME Overview." https://mss.go.kr/site/eng/ex/bbs/View.do?bcIdx=1050186&cbIdx=244.

Korea's GDP but only 10-15 percent of employment.[26]

Korea's model is considered top-heavy, with limited support for the SMEs. Without structural shifts in services and increased support for SMEs, this top-heavy approach could exacerbate inequality and lead to political backlash. Indeed, SMEs employ 81 percent of Koreans and make up more than 99.9 percent of firms, yet policy subsidies and industrial support overwhelmingly target chaebols like Samsung, SK Hynix, and Hyundai Heavy Industries.[27] An example of this is that breakthrough technologies remain concentrated in a few chaebols, while SMEs lag in scaling innovation.[28] The gap between world-class R&D at the top,[29] a lack of broad-based innovation, compounded by demographic decline, and the contingencies of Taiwan and the South China Sea are arguably South Korea's Achilles' heel in economic security. It can be concluded that several of these risks are internal rather than external.

The Netherlands

The Dutch tradition of an open, market-driven trading economy dates back to the 17th century. In modern institutional terms, it has been firmly established since the late 1940s, particularly through the Benelux and the European integration processes. Unlike South Korea, the Netherlands relies heavily on services, serving as a logistical gateway through Amsterdam and Rotterdam to the EU and global value chains, as well as the agro-business sector.

A 2025 Dutch parliamentary study by TNO analyzed the major 2024 Draghi report on Europe's competitiveness and economic security, highlights structural weaknesses in the Dutch economy, including sluggish productivity and R&D, a lack of scale-up capital, high energy costs, and reliance on external defense and critical minerals.[30] The Netherlands is attempting to address these, for example, through the National Growth Fund and EU innovation programs. The Netherlands, too, faces an innova-

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26 Kim, Bo-yeon. "Korean Conglomerates Account for Half of GDP, but Just 10% of Jobs." *Hankyoreh,* October 14, 2020. https://english.hani.co.kr/arti/english_edition/e_business/949236.html.

27 KOSMES. "Reference Page." https://www.kosmes.or.kr/sbc/SH/EHP/SHEHP025M0.do; and *Financial Times.* "South Korean Conglomerates Dominate GDP Despite Employing Few Workers." https://www.ft.com/content/b34e8bc8-9f78-45c8-a15b-3df9cdfd858f.

28 Atkinson, Robert D., and Sejin Kim. *South Korean Policy in the Trump and China Era: Broad-Based Technological Innovation, Not Just Export-Led Growth*. Washington, DC: Information Technology and Innovation Foundation, May 18, 2025.

29 OECD. "R&D Spending Growth Slows in OECD, Surges in China; Government Support for Energy and Defense R&D Rises Sharply." March 2025. https://www.oecd.org/en/data/insights/statistical-releases/2025/03/rd-spending-growth-slows-in-oecd-surges-in-china-government-support-for-energy-and-defense-rd-rises-sharply.html.

30 TNO. *Draghi Analysis for the Netherlands.* The Hague: TNO, 2025. 1–3.

tion diffusion problem, similar to South Korea's, albeit on a smaller scale, due to the absence of chaebols, with ultra-niche ASML being the notable exception. As a relatively small but pivotal economy, the Netherlands embodies the control-point paradox: its strength as a chokepoint generate global leverage but also expose it to disproportionate geopolitical risk.

The Netherlands has shifted from merely diagnosing vulnerabilities to proactively building control points across global value chains. These control points are synonymous with chokepoints/strategic nodes, which can be a single firm, a cluster, or even a geographic hub that provides an irreplaceable capability.[31] The Netherlands is utilizing tools such as the Geo-Economic Monitor and ministerial task forces to identify high-risk segments. It is also deploying export controls on semiconductors, enacting the National Security Screening Act for sensitive technologies, and investing in strategic stocks and partnership. This is all in an effort to secure technological leadership and resilience.[32] This mirrors South Korea's approach in securing its own supply chains, underscoring how both countries are moving in a parallel direction on economic security.

Ways Forward

In light of the global and Indo-Pacific pressures facing 'natural partners' South Korea and the Netherlands, it is critical that they sustain their competitive advantages and realistically seek means of enhancing individual and joint economic security. This implies hedging against geopolitical uncertainty and mitigating overreliance on any single power, whether China, the US, or anyone else. The US's more transactional, inward-looking approach is likely to persist; its security guarantees are no

31 *Ibid.*

32 See Clingendael Institute. *Exploring Economic Security Toolkits.* The Hague: Clingendael, March 2025. https://www.clingendael.org/sites/default/files/2025-03/Policy_brief_Exploring_Economic_Security_Toolkits.pdf; OECD. Economic Surveys: Netherlands 2025. Paris: OECD, July 2025. https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/07/oecd-economic-surveys-netherlands-2025_aa9d215c/2dd1f4aa-en.pdf; Government of the Netherlands. "Klever: Export Controls on Advanced Semiconductor Manufacturing Equipment to Be Tightened." January 15, 2025. https://www.government.nl/latest/news/2025/01/15/klever-export-controls-on-advanced-semiconductor-manufacturing-equipment-to-be-tightened; Reuters. "Netherlands to Expand Export Controls on Semiconductor Equipment." January 15, 2025. https://www.reuters.com/technology/netherlands-expand-export-controls-semiconductor-equipment-2025-01-15; Cleary Gottlieb Steen & Hamilton LLP. "Dutch Foreign Direct Investment Screening Regime Enters into Effect." Client Alert, 2023. https://www.clearygottlieb.com/-/media/files/alert-memos-2023/dutch-foreign-direct-investment-screening-regime-enters-into-effect.pdf; and Government of the Netherlands. Government Programme: Foreign Policy. The Hague: Government of the Netherlands, September 13, 2024. https://www.government.nl/binaries/government/documenten/publications/2024/09/13/government-programme-foreign-policy/Government%2Bprogramme-foreign%2Bpolicy.pdf.

longer as robust as before. This merits greater defense (supply-chain) cooperation between South Korea and the Netherlands. An open, rules-based Indo-Pacific can be partially stimulated by closer economic ties between Europe and Asia; this, in effect, deepens the stakes of maintaining order in the region.

As underlined in this paper, risk is inherent to the economy and integral to a multipolar world where major powers can weaponize dependencies with relative ease. The Netherlands and South Korea are not in fully identical situations; they have different strategic constraints. South Korea has had to develop early warning systems for supply shocks as a survival strategy, while the Netherlands can leverage EU-wide multilateral tools. Indeed, many levers of economic security for the Netherlands lie at the EU level. This paper acknowledges these parameters. Yet, there are synergistic ways forward that provide a rational, repeatable playbook at the system level.

This paper proposes three pillars for this economic security playbook that the Netherlands may need to champion in Brussels. These pillars can be pursued bilaterally or expanded to include otherinterested countries:

1) Dependency Tolerance Guardrails (DTG)

To the extent that this has not already been completed, the Netherlands and South Korea define export-control alignment in advanced lithography and evaluate joint exposure to coercion in upstream inputs, particularly photoresists, specialty gases, high-purity chemicals, critical raw materials for batteries, and critical minerals more generally.

Building on this, the proposed Dependency Tolerance Guardrails (DTG) involves defining acceptable dependency thresholds. For instance, no single-country share should exceed 30 percent for a given critical input. When a metric breaches the band, automatic triggers can be activated, such as stockpile drawing, expedited licensing, or supplier onboarding. The two countries can consider paired, audited stockpiles in Rotterdam/Brainport and Busan/Gyeonggi for, among others, pellicles, photoresist families, high-purity gases, and critical tool spares. By 2026, a joint NL–Korea working group could identify which materials to stockpile and outline trigger mechanisms.

The EU and Korea have recognized these challenges through the Digital Partnership and the Economic Security Dialogue, which complements the DTG. At the EU–Korea level, the Economic Security Dialogue could serve as the institutional anchor for this mechanism.

2) Asymmetric Interdependence Index (AII)

South Korea and the Netherlands could quantify their individual and mutual economic coercion leverage. The Asymmetric Interdependence Index (AII) would quantify coercion leverage by calculating the dependence of South Korea and the Netherlands on state X for product Y, minus state X's dependence on South Korea and the Netherlands for the same product. Any highly positive AII nodes that apply to both countries can be targeted first. Considering Korea's industry-heavy economy and the Netherlands' climate goals, the development of a hydrogen economy and renewable energy is critical.[33] Both countries rely on imports of critical minerals for their electric vehicle batteries and wind turbines, mainly from a limited number of suppliers. Joint efforts to diversify sources, such as coordinating the sourcing of critical raw materials through the EU–Korea supply chain cooperation platform, or investing in recycling and substitution, could be mutually beneficial.

Moreover, economic security should not only be about de-risking but also recovery time. Joint studies can be conducted to determine the expected time required to restore, say, 80 percent of baseline performance following a supply disruption. Results indicating less than six months can be considered resilient, whereas those of more than 12 months should raise a red flag. Think tanks such as KIEP and HCSS could conductthis research.

3) The Economic Security Stack

Economic security in advanced economies can be viewed a four-layer stack, each layer of which needs to be as secure as possible.

Stack 1. Inputs: examples are critical raw materials, specialty gases, and chemicals. Both South Korea and the Netherlands are highly import-dependent and exposed to supply shocks.

Stack 2. Tools and Capex: production equipment. The Netherlands holds unique leverage through ASML's lithography systems, while Korea runs the world's most advanced semiconductor fabrication plants. The 'chip alliance is proof-of-concept of layer 2 cooperation.

Stack 3. Know-how & Intellectual Property: this included design software, tacit expertise, and global R&D pipelines. Both Korea and the Netherlands remain heavily reliant on US design tools, yet possess world-class potential in AI, quantum computing, and biotechnology.

Stack 4. Rules: export controls, investment screening, subsidies. The Netherlands aligns closely with the EU and the US, while Korea balances between alliances and Chinese interdependence. The Economic Security Dialogue could act as a venue to

33 Also acknowledged in the December 2023 Korea–Netherlands MoU on civil nuclear energy and commitment to work on hydrogen and renewables.

harmonize export controls.

Securing only one of the four layers is insufficient. Policy action should focus on joint stockpiles (Layer 1), coordinated R&D safeguards (Layer 3), and harmonized export-control policies (Layer 4), while leveraging Dutch control points (Layer 2) and Korean industrial scale. Within the next one or two years, the Netherlands and South Korea could map their critical interdependencies and set target bands. Within three years, stockpiles for the most critical items, such as specialty gases and rare earths, could be established and tested.

On a final note, both nations must guard against an over-securitization that stifles innovation or investment. After all, economic security entails calibrating measures to manage risks without unduly deterring trade and investment. South Korea and the Netherlands are well-positioned to strike a balance between control, risk limitation, and efficiency in their pursuit of greater economic security. In the end, it is simple: measure dependencies, move fast, and maintain an open mindset—security without rigidity.

03

Toward a Strategic Partnership in Science and Technology between Korea and the Netherlands

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Introduction

South Korea and the Netherlands are recognized as leading middle powers in science and technology in East Asia and Europe, respectively. Both countries have long recognized innovation as a driver of economic growth and as a tool to address complex societal challenges. They have cultivated open and dynamic innovation ecosystems, and share strategic priorities in digital transformation, carbon neutrality, and the response to aging societies. These shared objectives create a natural basis for closer collaboration.

The need for bilateral cooperation is reinforced by broader global dynamics. Science and technology are no longer confined to the domain of national innovation policy but have emerged as core assets of diplomacy, industrial strategy, and economic security. International cooperation increasingly extends beyond joint research and development (R&D) to encompass the establishment of global technology standards, resilient supply chains, ethical frameworks, and regulatory norms. In this rapidly evolving environment, no single country can address challenges in areas such as semiconductors, AI, quantum technology, or climate change alone. Strong partnerships between like-minded countries such as South Korea and the Netherlands are therefore indispensable.

For South Korea, with its global leadership in ICT infrastructure, semiconductors, and digital health, and for the Netherlands, with its recognized strengths in advanced manufacturing equipment, sustainable agriculture, water management, and applied AI, cooperation is not only mutually beneficial but also strategically necessary. By combining complementary capabilities, the two countries can amplify their global competitiveness and work together to solve pressing international challenges.

A particularly timely opportunity to deepen bilateral collaboration arises from South Korea's recent accession as an associate member of Horizon Europe Pillar 2, the EU's largest framework program for research and innovation. This development creates an institutional pathway for South Korea and the Netherlands to participate together in European consortia, secure joint funding, and align their research agendas with broader EU initiatives in areas such as green transition, digital innovation, health, and advanced technologies. Horizon Europe thus provides a unique platform to elevate bilateral cooperation from ad hoc projects to structured, long-term partnerships with global impact.

In light of these considerations, strengthening Korea–Netherlands cooperation in science and technology is not merely desirable but a strategic imperative. Deeper collaboration will allow both countries to maintain technological leadership, reinforce economic resilience, and contribute to shaping international standards and governance frameworks.

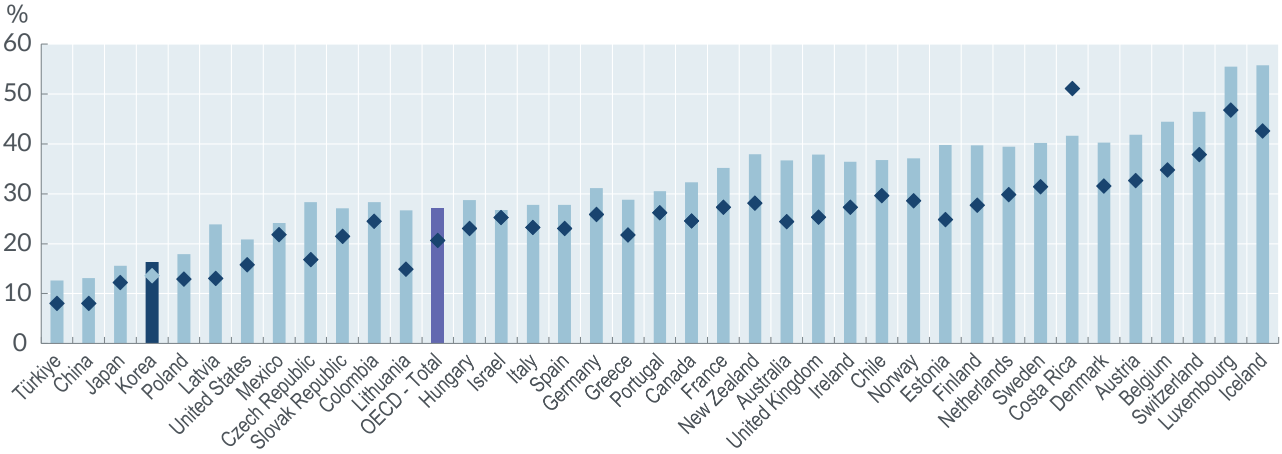
This report therefore examines the current state of Korea–Netherlands science and technology cooperation, while identifying potential areas and agendas for future collaboration.

International STI Cooperation in South Korea

According to the European Innovation Scoreboard (EIS), South Korea remains the most innovative and top-performing country, followed by Canada, the US, and Australia. South Korea is among the world's leaders in R&D investment, especially when measured as a share of GDP and leads the OECD in science and engineering graduates and ranked 6th in the 2024 Global Innovation Index.

However, international cooperation in science and technology has not been very active in Korea. As shown in Figure 1, international co-publications accounted for less than 14% of Korea's total publications in 2011, rising to about 16% in 2021. In contrast, France, Germany, and the United Kingdom recorded higher shares of co-publications in 2011—27%, 26%, and 25%, respectively—with those figures increasing by 2021 to 36% for both France and the United Kingdom, and 31% for Germany.

Figure 1. Percentage of total scientific publications involving international collaboration



Note: International collaboration refers to publications co-authored among institutions in different countries. Estimates are computed for each country by counting documents for which the listed affiliations include at least one address within the country and one outside. Single-authored documents with multiple affiliations in different countries count as institutional international collaboration.

However, Korea's accession as an associate member of Horizon Europe's Pillar II this year provides the country witha significant opportunity to advance international scientific and technological cooperation with European countries.

International STI Cooperation in the Netherlands

According to the European Innovation Scoreboard 2025, the Netherlands ranks third among the 27 EU Member States in the Summary Innovation Index, classifying it as an Innovation Leader. However, public R&D investment (0.67% of GDP in 2023) is below the EU average of 0.72%. The share of sales from new products or new-to-market innovations is 67.5%, placing the country 20th, indicating a relatively low position. Meanwhile exports of knowledge-intensive services reach 102.4%, placing the country 8th. The proportion of new doctorate graduates is 86.9% (16th), which may pose challenges for securing future research talent.

Despite these challenges, the Netherlands leads all EU countries in the share of the population with above basic digital skills (200.3%). It also ranks first in the share of scientific publications among the top 10% most cited, reflecting its active engagement in international scientific cooperation. Overall, its economy is knowledge-intensive, with 39.2% of employment in knowledge-intensive services compared to the EU average of 28.5%. These strengths highlight the Netherlands' advanced digital infrastructure, skilled workforce, internationally connected research ecosystem, and high value-added, knowledge-driven economic structure.

Participation in Horizon Europe is also highly active. According to the European Commission's Horizon Europe Dashboard, the Netherlands demonstrates a strong performance in the Horizon Europe program, ranking 5th among the 27 EU member states in terms of project participation. The country has secured a total net contribution of €4.11 billion, accounting for 8.59% of all Horizon Europe funding. Table 1 shows the total funding received by Dutch participants, excluding amounts allocated to linked third parties. Dutch organizations have been involved in 7,155 projects, representing 6.27% of total Horizon Europe participation. A total of 29,469 applications were submitted by Dutch entities, corresponding to 5.31% of all applications under the program. The country achieved a success rate of 21.71% for eligible applications—slightly above the Horizon Europe average of 20.44%. This performance profile underscores the Netherlands' strategic involvement in European research and innovation initiatives, maintaining both high participation levels and achieve above-average funding success.

Table 1. Horizon Europe country profile: Netherlands

Indicators	Key findings
Net EU Contribution	4.11B (Horizon Europe의 8.59%)
Participation	7,155 (Horizon Europe의 6.27%)
Application	29,469 (Horizon Europe의 5.31%)
Success rate	21.71% (average 20.44%)
Participation Rank	5 out of 27 member countries

Note: Net EU Contribution is funding received by the project's participation after deduction of their linked third parties' funding; Participation is number of organizations involved in Horizon Europe project; Application is number of organizations applying for Horizon Europe grants; Success rate is ratio of the retained application to the total number of eligible applications received; Participation rank is based on the participation in Horizon Europe for a country in its country group.

Current State of Korea-Netherlands STI Cooperation

Since establishing diplomatic relations in 1961, Korea and the Netherlands have maintained a strategic partnership. During Prime Minister Mark Rutte's visit to Korea in 2022, a Joint Statement on the establishment of the Strategic Partnership was adopted. In December 2023, President Yoon Suk Yeol paid a state visit to the Netherlands, during which the two leaders agreed to the following:

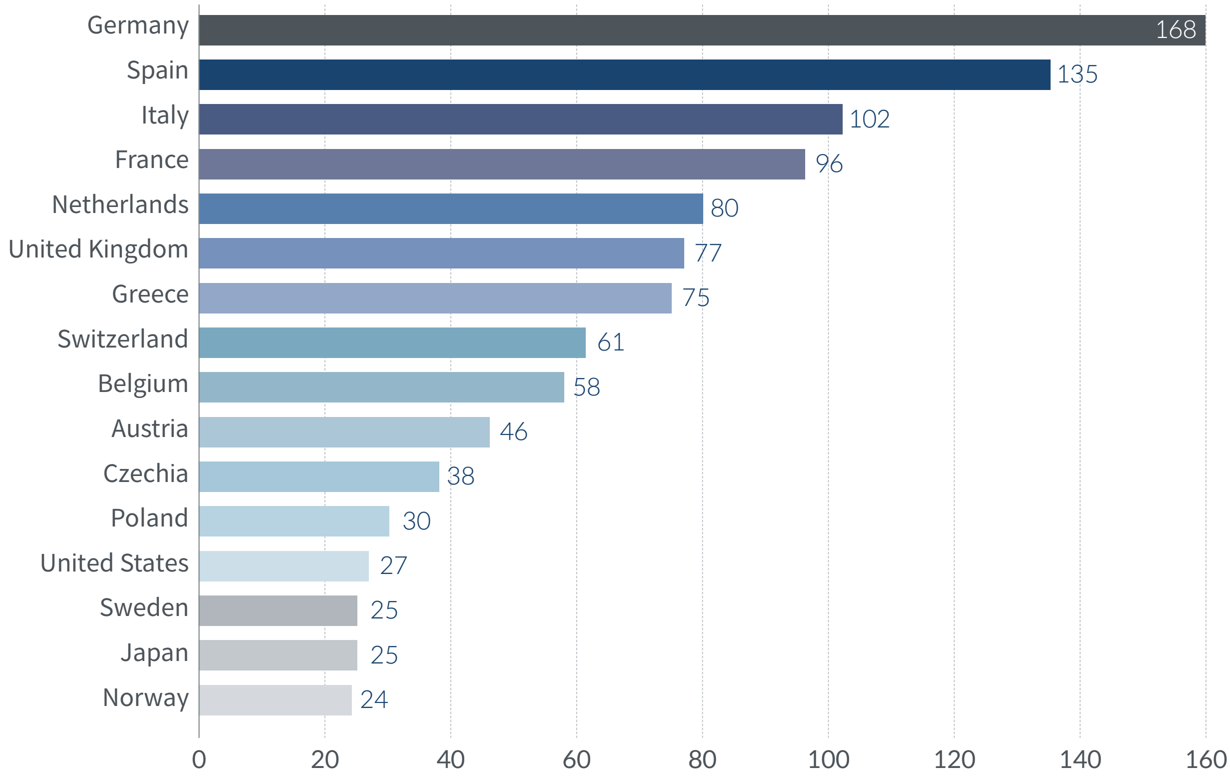
In this statement, both leaders recognized the unique and complementary positions of the two countries in the semiconductor value chain, and reaffirmed their commitment to build a semiconductor alliance encompassing the participation of governments, businesses, and universities. Furthermore, the two leaders recognized the role nuclear energy can play in enhancing energy security, combatting climate change and reaching carbon neutrality, and agreed to maintain and further develop bilateral cooperation on nuclear energy topics such as construction and operation of nuclear power plants, workforce development, and related areas.

In addition to intergovernmental cooperation, both countries have also been promoting collaboration at the institutional level. For example, in March 2023, the Netherlands Organization for Applied Scientific Research (TNO) signed an MoU with KAIST, KRIHS, and the Seoul Institute in the field of smart city development. Through this agreement, the parties are jointly developing solutions for e-mobility, digital infrastructure, intelligent transport systems, and digital twin-based urban planning tools, thereby advancing comprehensive urban sustainability.

In February 2024, Eindhoven University of Technology (TU/e), together with ASML, IMEC, and NXP, launched the Future Chips Academy. Korean universities such as KAIST, Sungkyunkwan University, and UNIST participated, focusing on joint training programs in semiconductors and fostering global talent. In August 2024, Wageningen University & Research (WUR) signed an MoU with Chungnam Province and Yeonam University to promote cooperation in smart agriculture technology.

Since Korea joined Pillar II of Horizon Europe as an associated country this year, cooperation with Dutch researchers is expected to increase significantly. In March 2024, the Korean Ministry of Science and ICT and the Dutch Ministry of Education, Culture and Science signed an MoU to expand collaboration in the fields of research and science. Notably, the Netherlands ranks fifth in terms of the number of participating institutions involving Korean researchers.

Figure 2. Top collaborations: South Korea



Note: This figure shows collaboration links in the projects where South Korea is involved.

STI Policy Priorities in South Korea

According to the Five-Year Plan for State Administration announced in August 2025 by the Lee Jae-myung government, Korea will pursue innovation in both future industries—such as AI, energy, and biotechnology—and current key industries.

In the field of AI, the plan highlights the goal of transforming manufacturing through industrial AI and embedding AI technologies across urban spaces. In the bio-health sector, the government aims to expand R&D in healthcare to achieve USD 50 billion in exports. In the energy sector, the government will accelerate the transition toward renewables, establish an emissions reduction target for 2035 that is more ambitious than the 2030 target, and achieve carbon neutrality to ensure a sustainable future.

The plan also emphasizes fostering strategic technologies in collaboration with the private sector, including semiconductors, secondary batteries, AI, biotechnology, quantum technology, advanced and future materials, and future energy sources.

Furthermore, in pursuit of becoming one of the world's top five science and technology powers, Korea will strengthen international cooperation to secure technological sovereignty and global leadership in advanced science and technology. To this end, the government will establish a legal framework to promote researcher- and institution-centered international cooperation strategies, and enhance strategic collaboration in advanced technology sectors.

With regard to cooperation with major partners, the plan also specifies strengthening new trade partnerships with European countries to address trade barriers such as carbon regulations and supply chain restrictions.

STI Policy Priorities in the Netherlands

According to the Netherlands National Technology Strategy, the Dutch government has identified ten strategic technologies where the Netherlands aims to have a positive impact and establish a unique position as follows. These technologies have been selected for their potential to establish a distinct Dutch position globally.

Table 2. Ten Strategic Technologies in the Netherlands

No.	Technologies
1	Optics and Integrated Photonics
2	Quantum Technology
3	Green Chemical Production Processes
4	Biotechnology, particularly in molecules and cells
5	Imaging Technology
6	(Opto)Mechatronics, which includes industrial systems, machines, and equipment
7	Artificial Intelligence (AI) and Data Science
8	Energy Materials
9	Semiconductors
10	Cybersecurity

As of 2025, the Dutch government is in discussions with Nvidia and AMD on the supply of technology and hardware for building an AI supercomputer, and has already invested more than €200 million in the field of AI.

Potential Areas for Future STI Collaboration

Based on the policy priorities and capabilities of both countries, cooperation can be envisioned in the following areas.

First, semiconductors and advanced manufacturing. The Netherlands is home to ASML, a global leader in semiconductor equipment, while South Korea is a world leader in both memory semiconductors and HBM. South Korea holds a strong position in the global semiconductor market—accounting for about 17.7% of it in 2022—and is especially dominant in memory chips, with SK Hynix representing around 36% of the global DRAM market as of Q1 2025. The two countries could create synergies through joint research on semiconductor materials and processes, talent development, and supply chain cooperation.

Second, artificial intelligence (AI). South Korea has strong capabilities in ICT hardware such as semiconductors, displays, and 5G/6G, as well as in application services, and is rapidly integrating AI into healthcare, mobility, and manufacturing. Meanwhile, the Netherlands is recognized as one of Europe's AI research hubs, with notable expertise in applied AI, data governance, ethical AI, robotics, and AI applications in agriculture, food, and energy. In 2024, the Netherlands ranked first in the Global Index on Responsible AI published by the Global Center on AI Governance. Combining Korea's strengths in hardware with the Netherlands' expertise in applied and ethical AI is expected to generate significant synergies.

Third, quantum technology. Quantum technology—including quantum communication, quantum computing, and quantum sensing—is a critical field that will determine future national competitiveness. With major countries such as the United States, China, the EU, and Japan already making large-scale investments, closer cooperation between Korea and the Netherlands would help both remain competitive within the global supply chain and research ecosystem. South Korean telecommunication companies, including SK Telecom, have been actively developing and demonstrating both quantum key distribution (QKD) and post-quantum cryptography (PQC) technologies, while the Netherlands has established a European quantum research hub centered on Delft University.

Fourth is the topic of climate change response technologies. Both countries are pursuing strategies to achieve carbon neutrality. South Korea is strong in hydrogen energy, secondary batteries, smart grids, and eco-friendly mobility. The Netherlands is recognized worldwide for its expertise in water management, flood control, and sustainable agriculture, as well as for leadership in offshore wind, carbon capture and storage (CCS), and the circular economy. Collaborating on on climate-related technologies is expected to generate synergies that will accelerate progress toward carbon neutrality.

Fifth, digital health and aging society response technologies. South Korea is entering a super-aged society at one of the fastest rates in the world, while the Netherlands also faces an above-average aging rate compared to other European countries. Korea boasts world-class ICT infrastructure and medical data, along with advanced AI-based diagnostic and predictive technologies. The Netherlands, in turn, has a public health system that emphasizes elderly care and prevention, and is a leader in e-health, remote monitoring, and smart care solutions. Cooperation between Korea and the Netherlands in digital health and aging-related technologies is expected to effectively address shared challenges of rapid population aging and rising healthcare costs.

Conclusion and Policy Recommendations

With their complementary technological capabilities and converging policy priorities, South Korea and the Netherlands are uniquely positioned to establish a strategic partnership in science and technology. As outlined in this report, there is considerable potential for cooperation across multiple strategic technology domains, with promising prospects for generating synergies that can enhance both countries' competitiveness and global influence.

To translate this potential into sustained outcomes, systematic institutional support will be required. The following policy recommendations are proposed:

1. Institutionalize high-level dialogues

- Hold regular high-level meetings on science and technology between the two governments.
- Pursue a formal declaration on strategic cooperation to provide a clear framework and long-term direction.

2. Develop a joint funding framework for strategic technologies

- Create bilateral or multilateral funding schemes that support collaborative projects in key areas such as semiconductors, AI, quantum technologies, climate solutions, and digital health.

3. Expand and formalize exchanges among research institutes and startups

- Promote mobility programs, joint research centers, and collaborative innovation networks.

- Encourage cross-border startup collaboration and scaling opportunities.

4. Strengthen cooperation in technology diplomacy and international norm-setting

- Coordinate positions on global technology governance, standards, and ethical frameworks.
- Build joint initiatives to engage with multilateral platforms, including the EU, OECD, and other international organizations.

By advancing these measures, South Korea and the Netherlands can not only strengthen their bilateral partnership but also take the lead in navigating global technological competition and shaping the evolving international science and technology order.

04

Cooperation on Control Points is Needed for Strategic Autonomy

Joris Vierhout, Amber Geurts
TNO Vector

Rising tensions in the Indo-pacific present new challenges for policymakers worldwide

Decades of globalization have lowered the costs of doing business and created interconnected economies with mutual interests towards further globalization. Companies increased their profits by outsourcing manufacturing to lower-cost countries, which in turn contributed to the rapid industrialization of those countries. Over the past several decades we have seen the rise of the Asian Tigers, and China's entry into the World Trade Organization (WTO) and becoming the world's manufacturing hub. This led to a complex web of supply chains among the globe's economic production networks.[34]

Today, the world faces geopolitical and geo-economic challenges. During the Covid-19 crisis, for instance, vulnerabilities in global production and supply chains were brought to light, showing some shocks could spread rapidly to other countries in the globalized system.[35] When the Ever Given was stuck in the Suez Canal, a single ship blocked a straight through which 12% of world trade flows.[36] This resulted in delays for companies and consumers in products as diverse as oil and gas to auto parts and clothing.[37] However, the risks and uncertainties in the center of many of the world's value chains have further increased with rising geopolitical tensions, putting global value chains and technological dependencies under greater scrutiny and increasing neo-mercantilist concerns. This poses significant geo-economic risks.[38] Thus, an important question is: How can countries ensure their strategic au-

34 Richard Baldwin and Javier Lopez-Gonzalez, *Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses,* 2013.

35 M. Damen, EU Strategic Autonomy 2013–2023: *From Concept to Capacity.* 2022.

36 "A Giant Container Ship Accidentally Blocks the Suez Canal," *The Economist,* March 25, 2021.

37 LaRocco, Lori Ann. "Suez Canal Blockage Is Delaying an Estimated $400 Million an Hour in Goods." *CNBC,* March 25, 2021.

38 Farrell, H., & Newman, A. L. (2019). Weaponized Interdependence How Global Economic Networks Shape State Coercion. International Security, 44, 42-79.

tonomy goals and objectives, and with whom can they do so?

The Netherlands and the Republic of Korea are two countries that can be characterized as open economies that rely on imports from abroad for many of the products they need. For instance, for the Republic of Korea foreign trade accounted for 97% of its economy in 2022,[39] while for the Netherlands this was 184% in the same year.[40] Such openness is not inherently problematic, but dependencies will need to be robust and reciprocal. That is, when these dependencies aremarked by one-sided dominance, a lack of alternatives, or political influence, they become risky and can quickly turn into vulnerabilities that affect strategic autonomy.[41] “Open” strategic autonomy thus reflects the aspiration to combine openness with strategic caution, emphasizing cooperation where possible and strategic restraint where necessary, in line with the guiding principle: “as open as possible, as closed as necessary”.[42]

While high-level policy goals for Open Strategic Autonomy (OSA) thus dominate current geopolitical and geo-economic debates, actionable strategic diagnostics are needed to support OSA policymaking in countries such as the Netherlands or the Republic of Korea. This brief therefore offers an analytical, operational, measurable and comparative way to approach OSA by introducing the Control Points framework. Control Points refer to valuable and unique strategic positions within global value chains, production networks and RD&I systems where influence is concentrated and dependencies can be governed.[43] This framework has been developed to help policymakers systematically address power relations in value chains and improve its ‘open strategic autonomy.’

Conceptual Foundations

Open Strategic Autonomy’s rise on the policy agenda

“Strategic autonomy” refers to a country’s or region’s capacity to act and provide without being dependent on other countries in strategically important policy are-

39 De Esperanza Picardo, Cristina, Mario Esteban, en Raquel Jorge-Ricart. *The EU-Republic of Korea Economic Security Engagement:* Policy Recommendations and Next Steps. 2024.

40 World Bank. *Trade % of GDP. Web page accessed 27 September.* 2025.

41 Daan Pisa, Veerle Zuurdeeg and Amber Geurts (2025). From containers to the cloud: how control points turn into chokepoints. (The Hague: TNO).

42 Tocci, N. *European Strategic Autonomy: What It Is, Why We Need It, How to Achieve It.* (Rome: Istituto Affari Internazionali (IAI), 2021.

43 Daan Pisa, Joris Vierhout, Amber Geurts, and Thijmen van Bree, *Getting a grip on Control Points: An exploration of the literature* (The Hague: TNO, 2024).

as.[44] To acknowledge the aspiration to remain an important cooperative actor on the global stage while safeguarding the capacity to act autonomously , the concept has developed into "Open" Strategic Autonomy (OSA) to stress the need to cooperate with partners as much as possible. For small countries with open economies like the Netherlands and the Republic of Korea, OSA thus does not imply self-sufficiency, but rather, it signifies the ability to act and provide independently when needed, particularly during periods of geopolitical and geo-economic tensions.

One challenge for OSA is that it is a positive externality, an outcome in which the market doesn't provide automatically. In the classical trade theory by David Ricardo from 1817 goods are produced in the country with a comparative advantage for it.[45] Both countries involved in trade then gain economically as goods are traded and both can consume at a higher level. Most nations are now heavily engaged in intermediate production. They earn their income by making parts or components and selling those abroad, while also relying heavily on imports from abroad for inputs.[46] From an economic perspective, this dependency is not inherently problematic as long as it remains advantageous for both parties to continue specializing and trading. If, however, a (high-concentration) trading partner is not geopolitically aligned, these dependencies can turn into vulnerabilities to coercion that limit the decision-making autonomy.[47]

To maintain the ability to pursue their own policy goals, it is crucial for countries like the Netherlands and the Republic of Korea to work towards strategic autonomy.[48] The Netherlands' ability to pursue its policy goals is under pressure from several factors.[49] First, investments in innovation run behind those in the US and China. Second, high energy and carbon prices undermine competitiveness. Third, the Netherlands has significant strategic dependencies in the fields of defense and critical raw materials. However, the Netherlands can build upon a high level of income, has an excellent knowledge and innovation position, and maintains strong positions in a number of strategic value chains, for example several strong positions

44 M. Damen, *EU Strategic Autonomy 2013–2023: From Concept to Capacity* (Brussels: European Parliamentary Research Service, 2022).

45 Daniel M. Bernhofen and John C. Brown, "On the Genius Behind David Ricardo's 1817 Formulation of Comparative Advantage" (2018).

46 Richard Baldwin and Javier Lopez-Gonzalez, *Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses,* 2013.

47 Draghi, *The Draghi Report: A Competitiveness Strategy for Europe* (Part A) (Luxembourg: Publications Office of the European Union, 2025).

48 Idem.

49 Johannes Bollen, Sabine Kerssens, Kimberley Kruijver, Carine van Oosteren, Daan Pisa, Caroline Schipper, Arnold Tukker, and Joris Vierhout, *Dutch Competitiveness in the Light of the Draghi Report: "The Future of European Competitiveness"* (The Hague: TNO Vector, 2025).

in the semiconductor industry. Policy therefore needs to identify and balance dependencies and capacities to ensure its open strategic autonomy.

To proactively work towards open strategic autonomy, strategic intelligence is needed to support policymaking. That is, for policymakers OSA is often too broad a term for tailored policy making, while more concrete concepts like “chokepoints” or “strategic sectors” remain largely undefined due to lack of strategic intelligence. What is needed is therefore “a detailed and deep consideration of value chains, as well as an understanding of the ‘control’ needed over the value chain(..)”.[50] The Control Points framework provides a concrete and tangible way to establish this intelligence.

Control Points as the building blocks of Open Strategic Autonomy

Control points are unique points in value chains that provide a valuable public good, creating dependence.[51] In a literature review conducted by TNO, we traced the concept of control points back to strategic management. Initially, this field focused on firms achieving an advantageous position (*firm perspective*) in relation to their direct competitors by developing and exploiting strategic resources and capabilities (i.e. competitive advantage). In our literature review, we argued that the concept evolved to encompass key positions within value chains or ecosystems, not only in relation to competitors but also to other (private) actors such as suppliers or clients (*network perspective*). Finally, in light of recent geopolitical and geo-economic developments, we argue that control points should also recognize the influences and dependencies that key positions in global value chains have on public interests and states’ functioning (*geopolitical and geoeconomic perspective*).

Strategic intelligence to identify control points

Control points are linked to OSA as they enable states’ ability to stimulate economic earning power, safeguard national security and meet broader societal needs. It does not matter whether these control points are occupied by a single firm or a

50 Jakob Edler, Technology Sovereignty of the EU: Needs, Concepts, Pitfalls and Ways Forward (Karlsruhe: Fraunhofer Institute for Systems and Innovation Research ISI, 2023).

51 Daan Pisa, Joris Vierhout, Amber Geurts, and Thijmen van Bree, *Getting a grip on Control Points: an exploration of the Literature* (The Hague: TNO, 2024).

geographically concentrated group of firms. Identifying control points via strategic intelligence is therefore crucial. To enable this, a more recent TNO study has operationalized control points by arguing that control points need to meet three criteria:[52]

- Control points provide **value** (*i.e. they provide geopolitical, economic, democratic and societal value, which includes public needs, like earning capacity or healthcare*),
- Control points are **unique** (*i.e. they are difficult to imitate or replicate*),
- Control points create **dependencies** (*i.e. they are difficult to substitute, or access can be denied or disrupted*).

A business activity needs to meet all three criteria to be a control point. Take the example of cloud computing explained by Pisa, Zuurdeeg and Geurts (2025). The ***value*** of cloud computing stems from the fact that 90% of companies and public services (e.g., healthcare, education, and government administration) use cloud services for secure data storage and processing. However, there is strong *dependence*, as just three American hyperscalers (Amazon, Microsoft, and Google) together control nearly 70% of the global market. The *uniqueness* stems from the depth and breadth of the functionality of the well-integrated platforms provided by US cloud providers. The recent case of ICC prosecutor Karim Khan, who allegedly lost access to his email and bank account due to U.S. sanctions over the Court's investigation of Netanyahu, illustrates the risks of foreign control over digital infrastructure.[53] The consensus is that only a combination of regulation, investment in European cloud alternatives, and an active role for open source can truly ensure greater control over the cloud as the digital backbone of our society.[54]

52 Daan Pisa, Amber Geurts, Joris Vierhout, Veerle Zuurdeeg and Maike Conijn. Eyes on control points: an operationalization and methodological framework. TNO 2025 R11318.

53 Molly Quell, "Trump's Sanctions on ICC Prosecutor Have Halted Tribunal's Work," *AP News*, May 15, 2025.

54 Daan Pisa, Veerle Zuurdeeg and Amber Geurts (2025). From containers to the cloud: how control points turn into chokepoints. (The Hague: TNO).

Box 1: Policymakers focus on control in value chains

In its Framework Act on Supply Chain Stabilization Support for Economic Security, the Korean government defined economic security as follows: “The term “economic security” refers to a state in which items, services, technology, etc. essential for the overall economic activities of the State and its citizens, such as domestic production, consumption, and distribution, are smoothly introduced and prevented from being inappropriately leaked overseas, regardless of changes in economic, trade, political, or diplomatic circumstances or natural disasters, etc. that have occurred or are likely to occur at home and abroad, thereby maintaining national security and causing no obstacles to the economic activities of the State and its citizens”.

Within the national security framework of the Netherlands, economic security is defined more abstractly as “the undisrupted functioning of the Kingdom of the Netherlands as an effective and efficient economy”. Specifically it states impact criteria for economic security being “costs” that are “affecting the vitality of the economy of the Kingdom of the Netherlands”. The Dutch government has also been focusing on reducing high-risk strategic dependencies. It examines supply chains, intensifies investment screening, and has set up and inter-ministerial taskforce.

The most direct way in which control points can be valuable to policymakers is their use as a means of diplomatic (de-)escalation. That is, control points are needed to have ‘mutually asymmetric dependencies’ that deter adversaries from using their own control points.[55] This can be valuable in the relationship with the dependent country itself, but also in the diplomatic relations with a third country seeking to exert influence on the dependent country. Control points are therefore one of the primary ways to influence the incentives of other geopolitical actors.[56] This makes them a potentially logical policy lever.

55 Tobias Gehrke, *Brussels Hold’em: European Cards Against Trumpian Coercion,* Policy Brief (European Council on Foreign Relations, March 20, 2025).

56 Olivier Kooi, *Overheid Moet Voortouw Nemen bij Organiseren Weerbaarheid* (ESB, 2025).

Identifying categories of control points for OSA

The discussion so far has highlighted that control points can be held domestically (i.e. *own control points*) or by a foreign country, creating strategic dependencies (i.e. *chokepoints*). Current control points are positions other countries rely on to meet their societal needs, while current chokepoints are the economic dependencies a country faces, like critical raw materials from China or Cloud computing from the US. Policymakers can focus on understanding their strengths and expanding the preconditions for the international competitiveness of these control points, while balancing their dependencies that can undermine competitiveness. Once policymakers identify which risks they wish to mitigate, their main policy focus will be on diversification or substitution, for instance through friend-shoring or near-shoring or by investing in substitutes.[57]

Importantly, we acknowledge that economic dynamism is essential for a future-proof economy and technological leadership. Current control points are no guarantee for the future - especially since technologies are developing rapidly with large international investments. This is why it is important to look into future control points (i.e. *potential control points*) and risks for dependencies (i.e. *potential chokepoints*). One way to identify potential control points is by looking at the knowledge or technological position of a country, which provides a strong foundation for a potential competitive edge in the future. A comparative position assessment thereby provides an indication of potential future dependencies. With these insights policymakers can focus on promoting innovation in fields with potential positions of control. Similarly, promoting innovation in niches of fields where they risk dependence can help to stay relevant. Japan for example promotes its firms' 'strategic indispensability' as suppliers in strategic stages of supply chains. Another policy option is to act early and restrict import or export of foreign technology. For instance, in the Republic of Korea, foreign location service providers (i.e. Google Maps) are restricted from offering full location services, both due to national security concerns but also to protect domestic navigation capacities.[58]

These four categories are illustrated in Figure 1.

57 Cinzia Alcidi, Tamas Kiss-Gálfalvi, Doina Postica, Edoardo Righetti, Vasileios Rizos, and Farzaneh Shamsfakh. *What Ways and Means for a Real Strategic Autonomy of the EU in the Economic Field?* Brussels: European Economic and Social Committee, November 10, 2023.

58 Raphael Rashid, "South Korea Postpones Decision to Let Google Maps Work Properly – Again," *The Guardian*, August 8, 2025.

Figure 1 Identifying control points and chokepoints

	Now	Future
Own	Control point	Potential Control point
Foreign	Strategic dependency (chokepoint)	Risk on dependency (chokepoint)

OSA and the capacity to respond

With strategic intelligence on (potential) control points as well as chokepoints, policymakers can thus draft policies to support OSA. This requires new knowledge, data, strategies and policy ideas. Importantly, policymakers' *responses* to identified positions of control versus dependencies should consider competitiveness implications. The debate on OSA has mainly emphasized the comparative dimensions of OSA, highlighting strategic positioning against rival firms and countries and protectionist policies like reshoring and friend-shoring initiatives that deteriorate multilateralism. These policies are unlikely to lead to favorable economic outcomes. In the most extreme case, pursuing such strategic autonomy goals would contradict Ricardo's logic of trade between specialized nations along their comparative advantages and bring inefficiencies that reduce living standards and might undermine competitiveness in the long term due to a lack of international competition and knowledge spillovers. This means that new initiatives are needed to turn the tide and strengthen multilateralism in times of OSA.

OSA can be addressed more effectively via cooperative efforts, as in many cases the capacities and expertise available to individual companies or states are not sufficient.[59] This approach strikes a balance between preventing excessive dependencies and avoiding a decline in living standards or competitiveness. Cooperation is

59 Amber Geurts, Thijs Broekhuizen, Wilfred Dolfsma and Katharina Cepa, Tensions in multilateral coopetition: Findings from the disrupted music industry. *Industrial Marketing Management,* 105.

especially important when considering future control points, whereby science and technology positions are crucial for achieving future OSA goals. What is more, technological developments in areas such as AI, semiconductors and quantum technologies benefit from knowledge integration, long-term investments and collaboration among experts and institutions. In those instances, isolation and competition can pose a significant barrier to technological advancements long before the value created can be captured by those advancing it. Protectionist efforts thus risk reduced exposure to international competition and knowledge spillovers, which can stall progress and reduce international competitiveness – especially when protectionism leads to isolation from well-positioned countries. In the context of open strategic autonomy, the question therefore is not just *how to innovate*, but also *how to collaborate with partners to reap the benefits of* innovation at different policy levels (regional, national and international).

International cooperation gains in importance

In this sense collaboration and cooperative efforts are crucial strategies for managing the tensions between competition and cooperation in a context of growing geopolitical and geo-economic tensions for achieving OSA. Coopetition can be defined as a strategy capable of simultaneously combining cooperative and competitive dynamics between two or more entities to achieve mutual and significant advantages, thereby increasing the ability to effectively respond to complex challenges.

Control points play a pivotal role in devising such strategies, as they imply the pursuit of stronger domestic capacities while collaborating internationally with strategic partners to leverage complementary knowledge and resources. Countries like the Netherlands and the Republic of Korea are too small to build many control points independently, as this would result in the dilution of resources. It is therefore important to put resources to the most effective use (i.e. *directional initiatives*) and cooperate as closely as possible with trusted partners along the full innovation chain. As such, the ability to strategically manage long-term RD&I relationships at the international level becomes a fundamental element of OSA policies, via which states compete for technological leadership while deliberately collaborating, in an informed way, with partner countries with complementary knowledge and resources. The appropriate countries for cooperation therefore need to be selected based upon strategic intelligence regarding control points.

Conclusions & Recommendations

In the face of growing geopolitical risks and uncertainties, countries are looking to safeguard their OSA. These concepts are often too broad for specific policymaking. Therefore, we propose the more concrete concept of 'control points', connected to the need for strategic intelligence in order to identify these control points. This meets the criterion that an in-depth understanding of value chains and the positions of control therein is needed for policymaking on OSA. Policy recommendations connected to this are:

1. *Invest in strategic intelligence to be able to identify and prioritize current control points;*
2. *Utilize strategic intelligence to strengthen efforts towards new control points.*

The international dimension is an important consideration when thinking about current and future control points for OSA. As tensions increase with (former) partners in trade and innovation, increased attention towards cooperation with partner countries will be important. Addressing the challenges surrounding OSA and economic resilience will require knowledge from the fields of international affairs, technology and innovation sciences, and economics, when balancing competition and collaboration. The following policy recommendations are connected to this:

1. *nvest in new, multilateral directional initiatives that enable international competition and knowledge spillovers.*
2. *Consider a level playing field considerations at regional, national and international levels.*

These investments in strategic intelligence for control points and international partnerships will help countries increase their OSA amid geopolitical and geo-economic challenges.

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Part 2

Key Technologies for Open Strategic Autonomy

01

Korea-Netherlands Cooperation Agenda for Advanced AI Semiconductor R&D

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Introduction

Since the late 2010s, the global semiconductor supply chain has faced multiple layers of uncertainty. This includes the intensifying US-China advanced technology hegemony war; the growing importance of semiconductors in terms of technological and economic security; the decline of free trade and the resurgence of protectionism and the rapid expansion of artificial intelligence (AI) across all areas. In particular, the development speed of foundation AI models such as large language models (LLMs) is advancing exponentially, much like Moore's Law, a concept that was once taken for granted in the semiconductor industry. As a result, the global semiconductor value chain is increasingly shifting toward artificial intelligence. The AI-driven semiconductor value chain ultimately signifies a shift in focus toward new semiconductors specialized for AI. Currently, NVIDIA dominates the AI semiconductor market. NVIDIA's GPUs have been selected as the optimal computing hardware for AI models due to their unique architectural advantages in high-speed parallel processing of matrix- or tensor-shaped data, the accessibility and optimization provided by APIs such as CUDA, and the parallelization of server racks where multiple GPUs are synchronized and linked. Together with TSMC, a foundry specialist based in Taiwan, NVIDIA dominates the global AI semiconductor value chain. However, as AI evolves beyond learning to inference and further beyond inference to specialized data processing in specific domains, key issues for AI semiconductors are emerging, including energy efficiency, cost-effectiveness, customized or hybrid memory, and multimodal scalability. In particular, the shockwave caused by Chinese AI start-up Deepseek in January 2025 demonstrates that simultaneous optimization of both hardware and software will become the core of competition in the future development of AI semiconductor technology.

At this turning point, the advanced semiconductor industry value chain is undergoing rapid change due to AI. Traditional semiconductor manufacturing powerhouses like South Korea must strategically rebuild their global cooperative relationships to adapt to new industries and the evolving international landscape. As the industry transitions from the nanometer era to the angstrom era, the technical, physical, and economic limits of semiconductor manufacturing are approaching. To create a breakthrough in advanced semiconductor manufacturing, including AI semiconductors, the Korean semiconductor industry will continue to face the challenge of innovation in all areas, including semiconductor materials, devices, processes, parts, equipment, and design. Therefore, a customized strategy is needed to establish comprehensive partnership agreements with countries that have technological strengths in this field and to ensure mutual benefits.

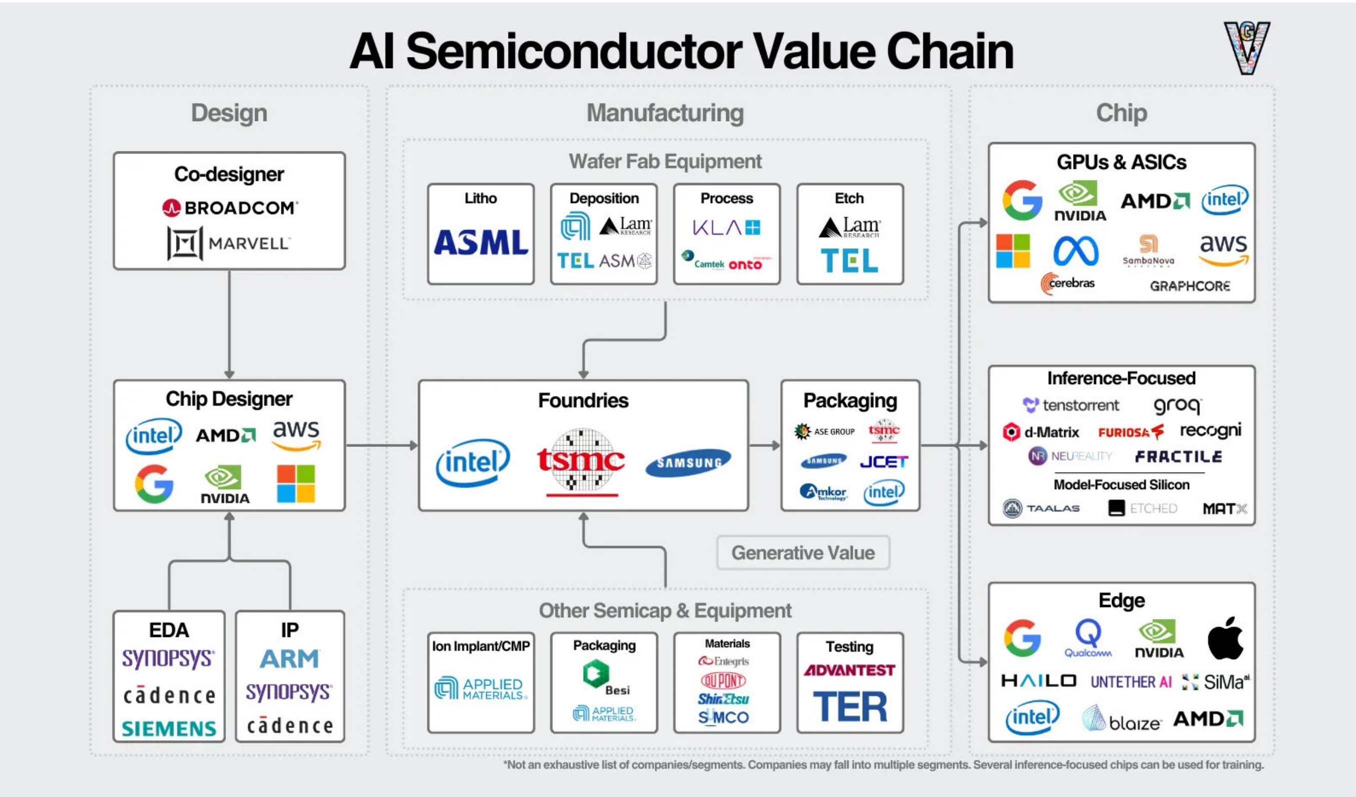
In this chapter, I will examine the current state of innovation in AI semiconductors and explore strategies for the Korean semiconductor industry to build global cooperation in response, using cooperation with the Netherlands as a case study. In particular, I will analyze the areas where technological cooperation is needed to optimize the current global semiconductor value chain for AI, and also explore specific implementation plans for cooperation between the two countries in areas where semiconductor technology development can be utilized to break through the limitations of AI in the future. Furthermore, I will examine the opportunities that the so-called physical AI-driven transformation of existing industries (AI transformation, AIX, or AX) could bring to the Korean semiconductor industry. I will also discuss the preliminary investments required for the success of such strategies and policies to enhance sustainability.

Areas of technological cooperation and implementation measures

AI semiconductor optimization

The current trend in AI model development is shifting towards a two-track approach: large LLM-based models with larger and more powerful parameter sets, and SLM-based models that pursue energy efficiency in specific domain areas and can be implemented with on-device components. The first track involves servers with hundreds to thousands of high-performance GPUs such as NVIDIA's H100 or A100, forming the main hardware infrastructure. The second track focuses on ASIC-based semiconductors, which are smaller and more energy-efficient custom semiconductors, as the industry gradually moves away from NVIDIA's dominant ecosystem. This suggests that the competitive landscape for AI-specialized GPUs, which NVIDIA has previously dominated, will diversify to include NPUs, TPUs, as well as traditional CPUs and other parallel computing innovations. High-bandwidth memory (HBM), which has been dominated by Hynix, is also expected to diversify into more efficient AI computing environments, ranging from existing LPDDR to GDDR general-purpose memory, or other forms of HBM specialized for AI hardware. As competition intensifies, the diversification of bottlenecks also implies that, new players, especially from countries outside the US, may emerge with more innovative ideas. Of course, NVIDIA is not merely targeting the market for large-scale LLM-specific accelerators but is also strategizing to dominate the market for on-device SLM-specific chips, which are likely to become the core of AI manufacturing. This dominant structure is summarized in Figure 1.

Figure 1. Global supply chain structure of AI semiconductors centered on NVIDIA



Although NVIDIA currently dominates the AI accelerator market, but it lacks full control over key technologies. For one thing, NVIDIA does not develop AI models directly as OpenAI and Google do. It also lacks its own chip manufacturing facilities. To manufacture high-performance GPUs composed of ultra-precise, highly integrated transistor devices, NVIDIA outsources all production to TSMC, a Taiwanese foundry specialist. TSMC has a significant technology advantage in terms of mass production costs. It monopolizes the production of logic semiconductors for not only NVIDIA but also major US fabless companies such as AMD, Qualcomm, Tesla, Google, and Apple. The fact that NVIDIA exclusively entrusts TSMC with the manufacturing of its latest AI model-specific accelerators is not an advantageous situation for NVIDIA. In particular, Taiwan is facing increasing tensions with China, tariff restrictions and investment pressure from the US government since Trump's second term, and the possibility of TSMC's CAPEX investments and future revenue securing issues becoming chronic. Therefore, NVIDIA needs a second foundry. NVIDIA's influence in the future AI semiconductor market is not limited to GPUs. At GTC 2024, NVIDIA announced its vision to evolve beyond its status as an AI semiconductor company to become a comprehensive AI service provider. At GTC 2025, Nvidia revealed its plan to enter the field of physical AI and become a leader in AI manufacturing . This reveals NVIDIA's strategy of targeting the next market by not only producing AI accelerators but also strengthening the developer ecosystem, such as CUDA, and automating various industries based on NVIDIA's AI solutions to enhance efficiency through AI.

One particularly notable aspect is NVIDIA's collaboration with Cadence, a leading provider of EDA, a chip design automation software, to automate the design of system semiconductors such as GPUs, ARM-based ASICs, and FPGAs. Designing semiconductor chips to place hundreds to millions of units on a narrow chip die while minimizing latency and reducing energy consumption between each unit's data input and output is one of the most challenging aspects of semiconductor chip design. Creating a design tool with an AI model built in to optimize this process is akin to creating a "hand that draws a hand." In the future, transistor integration will increase, creating more frequent situations where multiple types of heterogeneous chips, or chiplets, need to be integrated onto a single die for packaging. This will exponentially increase the number of possible combinations of chips. For example, while the state space of Go (the number of possible moves) is approximately 10^{360}, the state space for unit placement on a narrow die area is 10^{2500}, which is much larger. NVIDIA has proposed a strategy to bridge the gap between chip design and performance, as well as the resulting uncertainty in predictions. This strategy leverages AI-optimized techniques to overcome the challenges posed by the exponential increase in possible combinations. In the future, EDA companies will incorporate AI-based EDA IP solutions developed by NVIDIA, Google, OpenAI, and Anthropic into their software, and this is likely to become an increasingly important factor in the design optimization of advanced semiconductor chips in various fields, including not only AI semiconductors but also high-performance memory, communications, power, and autonomous vehicle semiconductors.

One collaborative project between South Korea and the Netherlands should focus on developing solutions that address technical uncertainties by filling mutual technological gaps throughout the entire process of AI semiconductor design and manufacturing. For example, to manufacture high-performance GPUs approaching the angstrom range, South Korea and the Netherlands can collaborate on the development of elemental technologies such as angstrom process optimization materials, optical devices for the process, photochemical process stabilization technologies, laser equipment, and precision inertial control devices. In particular, the two countries can reduce the costs of next-generation technology R&D by ensuring that Dutch equipment or material companies secure a stake in the process of developing key elemental technologies for material-device co-optimization in the angstrom domain. This process requires significant capital investment. Additionally, based on the technology deployed in mass production in Korea, the two countries could jointly pursue royalties for technologies that can be utilized by other companies as well.

Collaboration in the Semiconductor Ecosystem for Manufacturing AI

At the start of his second term, US President Donald Trump announced the so-called "Stargate" project. This $500 billion project centers on the US strategy to take the lead in artificial intelligence and general artificial intelligence (AGI) in the future. However, a more explicit goal is the so-called full-stack artificial intelligence ecosystem. In July, the Trump administration released a White House report outlining the U.S.'s strategy for winning the AI competition. This strategy aims not only to advance AI itself but also to secure new markets and value created as AI spreads into various industries, including manufacturing. At CES 2025, NVIDIA's Jensen Huang mentioned "physical AI," and the U.S. manufacturing reshoring policy also naturally includes robots, manufacturing automation, advanced biotechnology, and digital twins. The main players will likely be partners who can share the United States' security values, possess AI technology (learning and inference models), participate in the AI-specialized semiconductor supply chain, and mobilize sufficient capital, as well as have sufficient competitiveness in other industries such as biotechnology and robotics.

Even if the Stargate Project takes the lead in terms of technology, capital, and domain industry dominance, there are still some bottlenecks. More powerful AI requires more computing resources, so more efficient AI models and the semiconductors that support them are important. China's DeepSeek's LLM model shows that the price-performance ratio will be increasingly important in the industrial application of AI. This means that developing models that can learn and infer, as well as specialized, more affordable, and low-power AI-dedicated computing technologies tailored to these models, will become new bottlenecks. When these bottlenecks extend to specific manufacturing sectors, the technological foundation to lead a customized semiconductor ecosystem capable of addressing them becomes even more critical.

To respond to the rapidly changing AI landscape, South Korea must build on its existing capabilities and lay the groundwork for innovation in traditional manufacturing sectors that the United States alone cannot handle. These areas include sectors where Korea still has an industrial base and which are important from a security perspective, such as machinery, shipbuilding, defense, energy, petrochemicals, and nuclear power. While these sectors will face increasingly intense competition from China, which leverages economies of scale and a massive domestic market, they are areas that must be protected from a security standpoint. However, if the two countries fail to innovate promptly using AI, other countries or companies that can innovate first will inevitably overtake us. This is where Korea still has an opportunity.

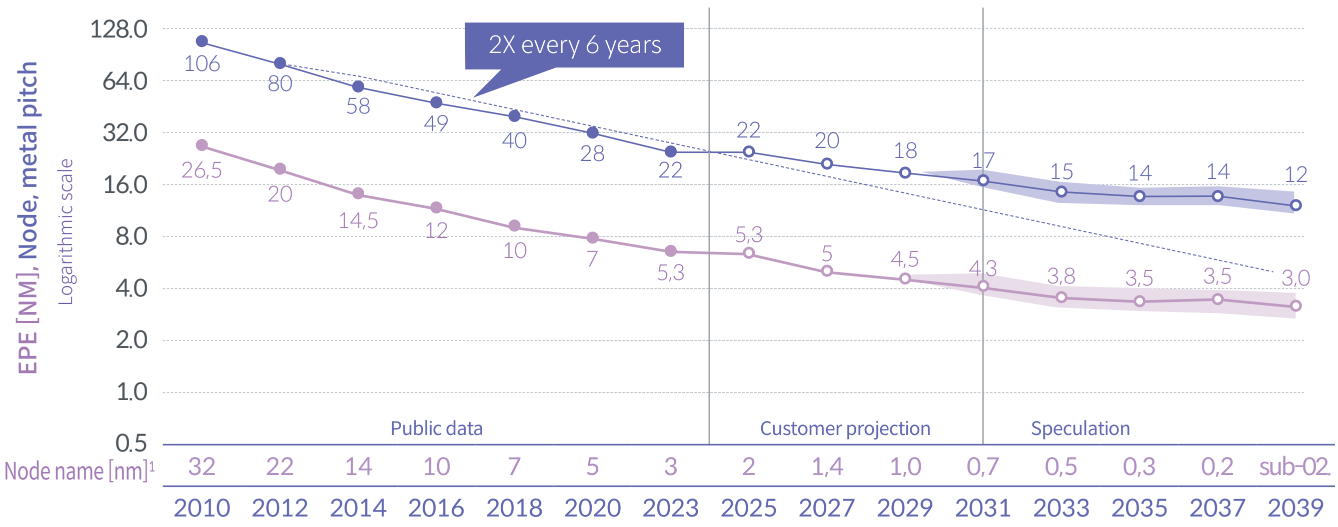
To this end, Korea and the Netherlands can cooperate to establish a customized semiconductor ecosystem for AI manufacturing. Dutch AI semiconductor design companies and model developers can collaborate with South Korean semiconductor manufacturers to design and manufacture semiconductors optimized for domain-specific data in various fields of advanced manufacturing where South Korea has strengths, such as shipbuilding, steel, construction, energy, and petrochemicals. South Korean fabless companies specializing in high-performance AI semiconductor design can find opportunities for collaboration in Dutch domains such as agriculture, transportation, logistics, and finance. In particular, South Korea's manufacturing AI strategy can be used as a good model for collaboration with the Netherlands and other Western European countries with similar democratic political systems, as well as EU member states, in order to expand its scope.

Exploration of next-generation high-performance semiconductor technology

Cooperation between South Korea and the Netherlands in the development of artificial intelligence and next-generation high-performance semiconductor technology needs to focus on the development of next-generation technology that will bypass or break through the current limitations of semiconductor technology. As shown in Figure 2, there is extreme ultraviolet (EUV) lithography technology, for which a technical roadmap has not been established beyond the mid-to-late 2030s. ASML, a leading Dutch advanced semiconductor process equipment company, dominates the global market for extreme ultraviolet lithography technology and leads the lithography equipment ecosystem. However, ASML's extreme ultraviolet lithography equipment is extremely expensive: the first-generation equipment costs around 143 million dollars, and the second-generation equipment costs around 360 million dollars. Furthermore, the demand for this equipment is limited to five companies in the global semiconductor ecosystem: TSMC, Samsung Electronics, Intel, SK Hynix, and Micron. This makes supply chain expansion and diversification unstable. Furthermore, as the optical technical limitations of lithography become apparent, profitability pipelines cannot be guaranteed due to yield limitations.

Figure 3. ASML's EUV lithography technology roadmap

Litho density scaling continues in the coming decade



Source: ASML.

Currently, based on 12-inch wafer mass production standards, ASML's EUV lithography equipment is being fully deployed in processes at the angstrom level, such as Intel's 18A, Samsung Electronics' 14A, and TSMC's 18A. However, unlike the first-generation EUV lithography equipment, the second-generation EUV lithography equipment has limitations in terms of scalability due to the slow development of photoresist (PR) suitable for photochemical reactions, its high sensitivity to external noise as a high-precision device utilizing ultra-short electromagnetic waves optically, and the slow processing speed of wafers, which is not suitable for mass production. Third-generation extreme ultraviolet lithography equipment is expected to enter mass production in five to eight years. However, except for the use of the same extreme ultraviolet light, there are still areas where sufficient exploration for practical application has not yet been carried out. Therefore, it is not clear how much it will be used in actual advanced semiconductor manufacturing processes.

South Korea and the Netherlands could establish a strategic technological partnership in all areas related to third-generation and later extreme ultraviolet lithography processes in the global semiconductor ecosystem. This partnership could include processes, equipment, optical technology, control technology, and material technology. Through this partnership, the two countries could share leadership in the global market. In particular, since it is almost certain that two of the five major customers for ASML's second-generation lithography equipment will likely be Korean companies (Samsung Electronics and SK Hynix), from ASML's perspective, jointly developing technical solutions with major Korean semiconductor manufacturers and minimizing technical development uncertainties is a crucial approach not only for customer management but also for stabilizing the global supply chain. In addition, ASML can also share solutions that shorten technology development periods and reduce costs by jointly promoting next-generation lithography technologies, such as e-beam lithography and X-ray lithography, which will be the next generation after extreme ultraviolet lithography, with the Korean semiconductor manufacturing ecosystem and technology.

In addition to lithography technology, South Korea and the Netherlands could collaborate on exploring various next-generation semiconductor technologies. These include technologies that can be directly applied to processes, such as self-assembly technology that creates ultra-fine self-assembled patterns at the molecular or atomic level, and technologies that utilize high-energy photons obtained from particle or electromagnetic wave accelerators. Other technologies include those applicable to optical computers, photonics, and plasmonics, which utilize both electrons and photons; spintronics, which utilizes electron spin; and new information device technologies based on spintronics, such as neuromorphic computers, memristors, and high-performance memory semiconductors like HBM, which can be stacked in three dimensions based on finer patterns. Other technologies include PRAM and MRAM, which are new types of memory devices, as well as new physical materials capable of controlling quantum entanglement for use in quantum computers. We can collaborate on a wide range of elemental technologies spanning TRL stages 1-7, from basic science to applied technology, for these promising candidates that could emerge as future technical solutions. To this end, major research universities in both countries can promote joint intergovernmental R&D programs on next-generation semiconductor candidate technologies. Leading semiconductor companies from both countries can participate in these programs as major demand-side companies, driving the advancement of industry-academia collaboration programs. In addition, this process can facilitate talent exchange between researchers in both countries. Korea and Europe could also share strategies for entering the Asian and European markets, respectively. Furthermore, to implement this collaborative program, the governments of South Korea and the Netherlands could establish concrete cooperative relationships to create spatial-geographical foundations enabling research institutions or companies from the other country to establish R&D centers within each nation's semiconductor clusters. This would facilitate collaboration with local companies or research institutions.

Global Standard Cooperation

In order to increase the effectiveness of cooperation on semiconductor element technologies that will lead to new technological breakthroughs in the future, as well as on artificial intelligence semiconductors and next-generation semiconductors, the governments of South Korea and the Netherlands can participate in policy co-operation for global standardization. To standardize new materials, processes, and equipment for angstrom-process-specialized semiconductors, the two countries can explore ways to collaborate with technical committees and preliminary standard item discovery committees of international semiconductor-related standardization organizations such as IEEE, ISO, JEDEC, and IEC, as well as quasi-standardization organizations. By doing so, they can reduce development uncertainties and achieve cost savings based on global standards for next-generation semiconductor technologies.

Conclusion

South Korea and the Netherlands will continue to play important roles in the global semiconductor ecosystem, as well as in the increasingly important field of artificial intelligence semiconductors and the domain-specific advanced artificial intelligence semiconductor supply chain expanding into manufacturing AI. To maintain this influence, they must secure a stable foundation capable of leading technological solutions. A strategy is needed to strengthen the influence of both countries within the semiconductor value chain. The two countries need to jointly explore specific research and development, as well as commercialization-related collaboration solutions, in areas where they can cooperate to achieve these common goals. In the process of jointly resolving technical and physical issues in the most advanced semiconductor process, the angstrom process, it will be possible to promote specific R&D programs. This will help to clarify technical, physical, and economic limitations, as well as narrow the technical uncertainty of unexplored areas in the development of next-generation semiconductor materials, processes, parts, and equipment. Furthermore, to solidify their position as sources of next-generation semiconductor technology, the two countries can identify areas where they can mutually benefit each other in various fields. These areas include global standard cooperation, the exchange of specialized personnel, the expansion of industry-academia collaboration between research institutions and demand-side companies, intergovernmental research cooperation, a joint response to global issues, the establishment of AI transition standards for manufacturing, and the establishment of concrete R&D cooperation plans.

02

Quantum Technology as a New Frontier of Cooperation: NL-ROK Partnership Opportunities

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Introduction

The Global Quantum Tech Landscape

Quantum technologies are key enabling technologies that open opportunities for national competitiveness and technological and digital sovereignty. In the context of growing geopolitical uncertainty, they are increasingly viewed as dual-use technologies, with both civil and military applications as well as far-reaching implications for national and international security. The global race to establish leadership in quantum computing, quantum communications, and quantum sensing is accelerating. Leading quantum nations are investing in sovereign capabilities, while managing foreseeable quantum value chain interdependencies by forging international partnerships to ensure access to infrastructure, talent, and industrial scaling. Within this context, the Netherlands and the Republic of Korea (ROK) each bring strong and complementary assets to the strategic landscape of global quantum innovation.

Bilateral & Multilateral Alignments

The ROK and the Netherlands are gradually strengthening their bilateral relationship, driven by a shared ambition to lead in technological innovation and to navigate growing geopolitical uncertainty. This cooperation reached a new level with the signing of the 2022 Strategic Partnership Agreement, which expanded collaboration across trade, security, and culture, while reaffirming a mutual commitment to democratic values and the rules-based international order. This partnership is built on complementary strengths in advanced technology and a shared focus on supply chain resilience.

Dutch–Korean cooperation is now advancing across a number of strategic domains, including emerging technologies, artificial intelligence and digital security. Quantum technology is part of this development. Both the ROK and the Netherlands have robust quantum ecosystems and bold ambitions when it comes to R&D and commercialization. The Netherlands has long invested in this field alongside European initiatives, such as the EU Quantum Flagship. For example, several explorations are underway between the ROK and the Netherlands for the initiation of various projects. Specifically, IMEC Netherlands, together with the Korea Advanced Institute of Science & Technology (KIAST), is launching an initial quantum project focused on the development of an on-chip quantum light source platform, combining quantum technology and integrated photonics. The growing ties between the ROK and its European allies are also reflected in recent EU policy documents: the ROK has been explicitly mentioned in the 2025. Meanwhile, ROK has joined the Horizon Europe programme, becoming the first Asian country to associate with the EU's main research and innovation initiative. This association opens up new funding and cooperation opportunities for Dutch and Korean stakeholders in emerging technologies, including in quantum technologies. Moving forward, there is a significant potential for the Netherlands and the ROK to collaborate on quantum technology, consolidating bilateral ties and building on the existing partnership agreements between the ROK and the EU.

The Netherlands' and ROK's Quantum Strategies

Both the ROK and the Netherlands have national quantum strategies that emphasise global leadership, significant public investment, and international collaboration. The ROK launched its strategy in 2023, aiming to become a leader in the quantum economy by 2035, with a total investment of approximately ₩3 trillion KRW (around €2.02 billion EUR), including ₩210 billion KRW (about €141 million EUR) earmarked for international cooperation. The ROK national strategy includes building a universal 1000-qubit computer by 2031 and expanding access to quantum research infrastructure (including fab facilities and testbeds); it also includes the establishment of inter-city links with quantum communication technology.

In turn, the Netherlands launched its strategy back in 2019 and allocated €615 million in public investment (approximately ₩913 billion KRW) for its implementation. This is executed by an independent foundation: Quantum Delta NL (QDNL). QDNL has long emphasised the need to forge international partnerships in order to build a successful international quantum ecosystem. The organization is widely seen as a front runner in this and created various pathways for international engagement. QDNL's programme has a wide scope, including R&D in various technical domains, start-up support, talent development, and its unique Centre for Quantum & Society.

Both national strategies go beyond fundamental research to encompass applied research infrastructure, innovation, industry development, and talent development. International collaboration is a priority for both countries, with the ROK seeking both bilateral and multilateral partnerships. The Netherlands has already established close ties with selected national partners in the quantum domain including the UK, France, Germany, the US and Japan.

Exploratory paper objectives

This exploratory paper examines two possible priority areas where the ROK and the Netherlands could begin to proactively collaborate while building on their mutual strengths: quantum communication networks and quantum computing. In addition, it highlights some of the enabling conditions necessary for such collaboration. By outlining the strategic rationale, national capabilities, and practical models for cooperation, the paper aims to provide an agenda for strengthening Dutch-Korean engagement in quantum technologies, while emphasizing that this is a bottom-up exploration of the ecosystem.

Collaboration Pathways

Pathway I – Quantum Communication Networks

1) National Capabilities

The Netherlands is recognised as a global leader in quantum communication networks, particularly in the field of Quantum Key Distribution (QKD), integrated telecom infrastructures and more advanced quantum internet technology. For example, the Netherlands successfully deployed the world's first Measurement-Device-Independent (MDI) QKD systems, in close collaboration with telecom operators, service providers, and classical network component suppliers.

As part of this effort, several large-scale QKD pilots are taking place in the Netherlands. One major initiative delivers 'untappable internet for the Port of Rotterdam', a pilot project that has seen the successful deployment of this technology in a real-life setting. For governmental networks, a pilot is under way in collaboration with the Ministry of Foreign Affairs and the Ministry of Justice & Security, supported by commercial partners RINIS and Eurofiber. In the educational sector, SURF in Amsterdam has set up a testbed that invites researchers to develop and experiment with new use cases for entanglement-based QKD. In addition, an industrial testbed in Eindhoven is enabling trials aimed at advancing industrial applications; and a consortium of Q*Bird, Single Quantum, and Eurofiber are building a large-scale operational inter-city quantum network between Amsterdam and Rotterdam. This network will feature multiple QKDhubs and provides options to connect many end users to the same network, without the need for trusted (classical) nodes in between the quantum links. Financial institutions, medical centers, and industry leaders can test their use cases within this infrastructure.

At the research level, QuTech leads the Quantum Internet Alliance, a world-leading programme aimed at developing the technologies for the future quantum internet. TU Delft hosts various research groups working on the full stack of quantum internet. For example, the Hanson group is working on processing nodes and repeater technology, and the Wehner group is focused on software and quantum operating systems. The University of Twente (UT) and the Technical University in Eindhoven (TU/e) leverage their strengths in integrated photonics. Duch quantum start-ups play a role here as well, as they provide the quantum entanglement generating central hub, which entangles qubits from different processing nodes (forming a quantum link between distanced quantum processors).

In turn, the ROK is leading the way in terms of roll-out and real-life applications for this technology. South Korea lays out a phased development plan (2023–2027) focused on commercialising quantum cryptography and quantum communication technologies, aiming to cultivate quantum networks and related infrastructure. The strategy sets clear technical goals including the development of quantum memory, quantum repeaters, satellite-based quantum communication, and a 100 km-scale intercity quantum entanglement network. As a result, South Korea already has several QKD networks, which are operated by its national telecom providers KT and SKT. These networks have been deployed with a clear public use case in mind and include deployments supporting governmental services and critical infrastructure. With these developments, the ROK is the first country worldwide to introduce a certification process for QKD systems.

These efforts span across various institutions. ETRI's Quantum Technology Division includes a dedicated Quantum Communication Research Section that develops secure communication systems – over wired, wireless, and satellite channels – targeted at applications in defense, finance, and telecommunications. At KIST's Center for Quantum Technology, R&D spans photon-based quantum communication systems, including the past commercialization of quantum cryptography communication systems. KRISS's Quantum Technology Institute is advancing core enabling technologies such as entanglement generation and control, vital for secure quantum communication platforms and quantum cryptography solutions. Universities are also deeply involved: at KAIST, for example, labs such as the Quantum Device Lab and Quantum Information and Communication Lab are actively researching photon-based quantum repeaters, QKD, and integrated photonic circuits for secure quantum links.

2) Collaboration Opportunities - Communications

Moving forward, the ROK's experience with roll-out and related certification mechanisms could be a first pathway for collaboration. The R&D and deployment expertise in the Netherlands could be coupled with the larger-scale deployments in Korea, aligning existing certification mechanisms; and pushing for international standards in this field.

With this in mind, the Netherlands and the ROK could collaborate in various areas, such as the establishment of a joint testbed or a joint certification process for more advanced (MDI) QKD. In addition, the two countries could explore the development of a potential undersea or satellite-based quantum backbone. Maritime ports in both countries could serve as secure communications testbeds for critical infrastructure – building on existing maritime commercial partnership that already exist today between the Port of Rotterdam and the Busan Port Authority.

The Netherlands has a strong expertise in integration and systems architecture, with particular strengths in advanced quantum networks beyond point-to-point QKD. Using MDI-QKD, the most vulnerable part of 'traditional' QKD systems, namely the detector, is removed from the attack surface. In MDI-QKD, the detector only enables (verifies) the entanglement between qubits from two different sources through a quantum measurement. It never learns the key information. A similar quantum measurement is needed to enable quantum interconnects and a more advanced quantum internet. The ROK, in turn, excels in industrial scaling and telecom deployment capacity, while also taking a lead in the development of certification processes. Moreover, the ROK has successfully embedded QKD within its governmental and military infrastructures. Together, the Netherlands and the ROK offer complementary capabilities that provide a strong foundation for advancing the development of quantum networks.

3) Use Cases & Societal Impact

This way, collaboration between the Netherlands and the ROK would address a number of major security concerns in several critical sectors. In the financial services sector, for example, it would facilitate secure, high-volume transactions and protect sensitive data transfers. For defense-grade and government infrastructures, it would ensure trusted communication, which is essential to safeguarding national security. Critical infrastructure such as electricity networks, waterworks, and power plants would benefit from enhanced protection against cyber threats and disruptions. Strategic ports could serve as secure testbeds to improve logistics and operations and advance the existing bilateral partnership in maritime innovation. Together, these applications would strengthen the resilience of both economies and contribute to the development of international standards for secure communication. The ROK's geopolitical reality of countering systematic cybersecurity threats, coupled with the Netherlands' leadership in cybersecurity governance and privacy standards for protecting digital infrastructure can set a model for cooperating in creating international governance frameworks for transitioning to quantum-safe (digital) infrastructures.

Pathway II – Quantum Computing

1) National Capabilities

The Quantum-in-Korea roadmap defines a progression from high-risk fundamental research (2021–2024), through feasibility demonstrations in academic and industrial settings (2025–2030), toward full industrialization and ecosystem maturity by 2031–2035. This includes multiple institutions with specific focus areas. The Korea Research Institute of Standards and Science (KRISS) is actively developing superconducting qubit technology, including long-coherence qubits, high-fidelity quantum gates, and advanced microwave control and measurement systems. At KIST's Center for Quantum Technology, efforts span foundational research and full-cycle commercialization—ranging from photon-based quantum information processing to solid-state diamond NV-center technologies for quantum computing and sensing. The Electronics and Telecommunications Research Institute (ETRI) houses a dedicated Quantum Technology Division, conducting R&D across quantum computing, communication, and sensing – including quantum machine learning, simulation, hardware/software integration, and fault-tolerance research. Related efforts include activities by POSTECH, the IBS Center for Quantum Nanoscience, KAIST, Seoul National University, KAIST's Quantum Information and Computation Laboratory, Yonsei University's IQIT, and SKKU's Q-Center. All of these institutions are deeply involved in quantum computing R&D – spanning hardware, algorithms, error correction, simulations, and ecosystem development.

These R&D efforts are coordinated under the National Quantum Science and Technology Strategy, targeting domestic development of a 1,000-qubit computer, advancing the quantum network infrastructure, and boosting industrial capacity – guided by a ₩3 trillion investment plan through 2035. In the medium term, the ROK's national programme puts emphasis on real-world use cases: plans to demonstrate 1,000 industrial applications of quantum tech, deploy sector-specific platforms, and boost public awareness of quantum.

In the Netherlands, QDNL's Vision 2035 outlines an ambition to transform the Netherlands into a top-3 global quantum economy, anchored by world-leading science, entrepreneurial culture, and public infrastructure that encourages start-up formation and scaling.

Activities span across various qubit technologies, with major R&D efforts under way in the fields of superconducting, spin qubits and photonic qubits. World renowned research groups in Delft, Eindhoven, Leiden, Twente and Amsterdam (D-E-L-T-A) work on both hardware and software challenges. Since the early days of the national programme, the Netherlands boasts a fast-growing start-up ecosystem, many of whom are market leaders in their specific domain, such as Delft Circuits, Qblox, QUIX, Single Quantum, Orange Quantum Systems or Quantware. These start-ups provide all relevant components of the full quantum computing stack and work intensively within the QDNL programme and with international partners to increase interoperability and emerging standards / benchmarking. QDNL actively supports the scale-up phase of these companies and facilitates international partnerships for their operations.

Alongside the quantum R&D developments, QDNL has also been active in building hybrid quantum-HPC infrastructure and related offerings, with Quantum Inspire and SURF as key partners in Delft and Amsterdam respectively. This will enable integrated quantum-classical algorithms via co-located computing clusters and orchestration tools – an important step towards operational quantum applications and attracting industrial engagement from various sectors. To this end, QDNL's Centre for Quantum & Society is developing sector-specific visuals for non-quantum experts; these help to start conversations with innovation and IT experts in i.e. energy, health or finance sectors.

Moving forward, a ROK-NL partnership in the field of quantum computing could focus on two inter-related aspects. First, a joint testbed facility, bringing together technology from the Netherlands and Korea, could serve as a space for joint validation and mutual learning. It would provide an opportunity to integrate different components and improve interoperability, attract talent and develop new standards for quantum computing.

A second function of such a testbed would be to provide industrial end-users with opportunities to explore pilot projects with a team of Korean and Dutch experts. This would help raise general awareness and push early industrial adoption in the light of Korea's 1000 applications strategy.

2) Use Cases and Societal Impact

There is growing interest from various sectors in exploring the potential value of quantum computing. Prominent examples include healthcare, finance, logistics, chemistry and the wider materials sector. With a joint effort as outlined above, this bilateral partnership could make larger corporations understand the potential impact of this technology and turn them into early adopters.

Enabling Conditions for Collaboration

1) Implementation Models

Funding and implementation could be structured through several mechanisms. One option is to use of Horizon Europe and Horizon ROK joint R&D funding calls. Currently, the open QuantERA call is a possibility for both parties to explore joint projects. In addition, bilateral mechanisms under the NL–ROK Strategic Partnership could be explored in the future. Another option is to establish public–private consortia, for example via the Quantum Flagship framework. Finally, the two countries could pursue joint business propositions for both pathways: communications and computing. This would include bringing together QKD companies and telecom operators through national tenders to build operational quantum networks in both the Netherlands and the ROK; and supporting corporate R&D players to start exploring the potential of quantum computing for their respective sectors. When considering these partnership options, it is important to establish adequate tools to support talent development and enable cross-border mobility. This includes visa procedures and limitations embedded in funding rules. As part of a bilateral partnership (and in view of relevant links to EU programmes), these aspects have to be addressed proactively – and likely within a broader context, not a quantum specific one.

2) Joint Action Areas

Building on the identified pathways for collaboration, the Netherlands and the Republic of Korea could explore a range of concrete actions to strengthen their partnership in quantum technologies. Joint exchange initiatives—such as summer schools, student and researcher mobility programmes, and dual-award PhD or postdoctoral schemes—would help cultivate highly skilled talent, with degrees recognised in both countries and opportunities for industry involvement. Academic and industrial cooperation could be further reinforced through collaborative research projects and training programmes. To raise public awareness and ensure responsible innovation, they could develop initiatives in collaboration with Quantum Delta NL's Centre for Quantum & Society, which has expertise in building frameworks for societal engagement and outreach. Finally, coordinated efforts on quantum-safe cryptography—spanning standardization, certification, and policies to safeguard critical infrastructures—would offer an important avenue for Dutch-Korean collaboration, providing both societal and security benefits.

03

ROK-NL Strategic Cooperation in Energy Security

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Introduction

The concept of energy security has not only evolved but now encompasses geoeconomic pressures. According to the IEA (2025), only a few countries adopted security measures, such as oil stockpiling, before the 1973 oil crisis. Since then, governments have deployed their strategic plans to other energy sources, including LNG and critical minerals. Governments, recommended by the IEA and other initiatives, mainly stock fossil fuel reserves in response to short-term supply disruptions. They also try to suppress demand from fossil-fuel intensive sectors, while diversifying sources remains another main part of their strategy.[60]

However, as geoeconomic pressures rise between hegemonic countries (US-China) and other regional competitors, the traditional landscape in energy security moves toward a higher level of "securitization." Combatting climate change requires an advanced energy mix among renewables, fossil fuels, nuclear, and other sources. Such mixtures complicate the global supply chain, leading to higher exposure to potential economic security risks. For instance, Middle East war's impact on oil prices has been reduced[61] while the blocking risk of the Strait of Hormuz still remains a concern for countries that highly depend on oil imports from the Middle East regions.[62] The US's imposition of reciprocal tariffs provoked China to impose retaliatory export controls on REEs, which led to unexpected shortages of permanent magnets in the US that are essential for wind energy, commercial products, and EV production.[63] Unregistered devices found in solar power inverters raise both cyber and energy security concerns

60 IEA (2025), Are governments better positioned to respond to energy security risks today than in the past?, IEA, Paris https://www.iea.org/commentaries/are-governments-better-positioned-to-respond-to-energy-security-risks-today-than-in-the-past, Licence: CC BY 4.0.

61 https://www.reuters.com/markets/commodities/israel-iran-war-highlights-mideasts-declining-influence-oil-prices-2025-06-25.

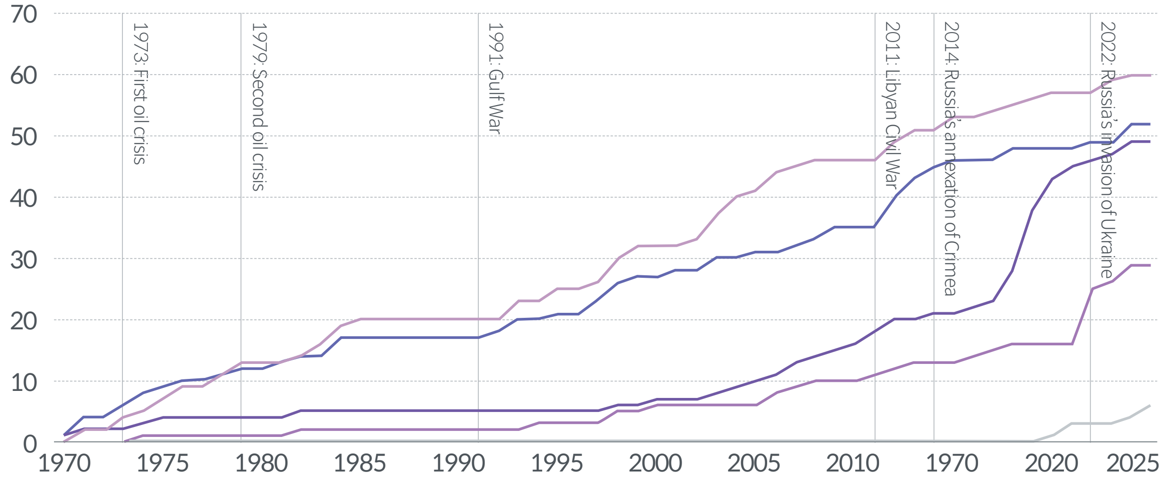
62 https://www.lemonde.fr/en/economy/article/2025/06/25/israel-iran-war-hormuz-the-worlds-oil-chokepoint-is-under-tension_6742691_19.html.

63 https://www.nytimes.com/2025/06/02/business/china-rare-earths-united-states-supplies.html.

simultaneously for the electricity grid.[64] The Iberian power blackout, which began in Spain, alarmed the global community, showing that a transition to 100% renewable energy still poses security risks similar to those of traditional grids.[65] More governments are choosing to deploy additional security measures at their own expense to mitigate these risks.

Strategic cooperation, in this context, is essential both for reducing the risk from a coercive trade environment and subsequently accelerating energy transition. Bilateral cooperation in strategic sectors has received more attention as a means of resolving similar challenges between two countries. The newly established relationship between Korea and the Netherlands in 2023 highlights the importance of bilateral cooperation regarding economic security.[66] Today, such cooperation goes beyond the semiconductor sector. New attempts are being made in energy sector cooperation between Korea and the Netherlands, an area that has not yet been thoroughly investigated so far. This article addresses unexplored agendas arising from the two countries' different industrial structures and positions in global value chains.

Figure 1. Energy Security Measures (1970-2025)



Note: Each line indicates "Oil stockholding policies" (skyblue), "Oil demand restraint policies" (blue), "Gas stockholding policies" (light green), "Gas demand restraint policies" (green), "Critical mineral stockholding policies" (Yellow).
Source: IEA (2025), Are governments better positioned to respond to energy security risks today than in the past?, IEA, Paris https://www.iea.org/commentaries/are-governments-better-positioned-to-respond-to-energy-security-risks-today-than-in-the-past, Licence: CC BY 4.0.

64 https://www.reuters.com/sustainability/climate-energy/ghost-machine-rogue-communication-devices-found-chinese-inverters-2025-05-14/.

65 https://www.reuters.com/business/energy/what-caused-iberian-power-outage-what-happens-next-2025-06-18/.

66 https://www.mofa.go.kr/eng/brd/m_5674/view.do?seq=320931.

ROK-NL Energy Transition Phase

The two countries' energy transition phases show stark differences reflecting their industrial structures. In Figure 1, the Netherlands' share of renewable sources in total electricity output has increased significantly since 2018. Over the past five years, the share of renewables in the Netherlands has reached 47%, while that of fossil fuels has decreased to less than 50%. Total electricity output surpassed 120,000 GWh in 2020 and has shown a slowly decreasing but steady trend since then. The Netherlands has now became a European leader in the renewable sector due to the expansion of solar, offshore wind, and biofuels.[67] In 2025, the Netherlands ranked 8th in the world for energy transition.[68] In 2022, the Netherlands exported its electricity to Belgium, Germany, and the UK while importing it from Denmark and Norway.[69]

In 2023, Korea's electricity output was five times higher than the Netherlands' in 2023, as was its rate of expansion. Unfortunately, this remarkable growth has come primarily from fossil fuels and nuclear energy rather than renewables. Specifically, the share of renewables in electricity output represents around 8%, while the share of fossil fuels and nuclear energy is around 61% and 30%, respectively, in 2023. The regional differences are also substantial in Korea. For instance, Jeju Island leads the energy transition in Korea, which shows more than double phases than the average in mainland Korea.[70] The Netherlands also shows geographic disparities in renewable energy deployment,[71] though it seems not as substantial as in Korea.[72] Korea's electricity grid is completely isolated, with no cross-border connections or interchanges.[73]

67 https://strategicenergy.eu/renewable-energy-share-the-netherlands/.

68 https://www.iamsterdam.com/en/business/netherlands-ranks-among-worlds-top-10-for-energy-transition-progres.

69 https://www.energie-nederland.nl/en/facts-figures/energy-market/.

70 Noh, J., Kim, J., Kim, Y. J., Lee, K. Y., Beak, S. M., & Park, J. W. (2025). Compensation strategies for renewable energy curtailment in South Korea. *Energy Policy*, 199, 114501.

71 Nortier, N., Paardekooper, M., Lucas, C., Blankert, A., van der Neut, A., Luxembourg, S., ... & van Sark, W. (2023). Spatially resolved generation profiles for building, land and water-bound PV: a case study of four Dutch energy transition scenarios. *Advances in Geosciences*, 58, 199-216.

72 Gasparini, Mulder and Bakens (2025) argue that energy transition would widen economic inequality, based on their assessment scores for adaptive capacity across different regions in the Netherlands.
Gasparini, D., Mulder, P., & Bakens, J. (2025). Mapping regional vulnerability to the energy transition: the case of the Netherlands. *Review of Regional Research*, 1-40.

73 https://www.iea.org/articles/korea-electricity-security-policy.

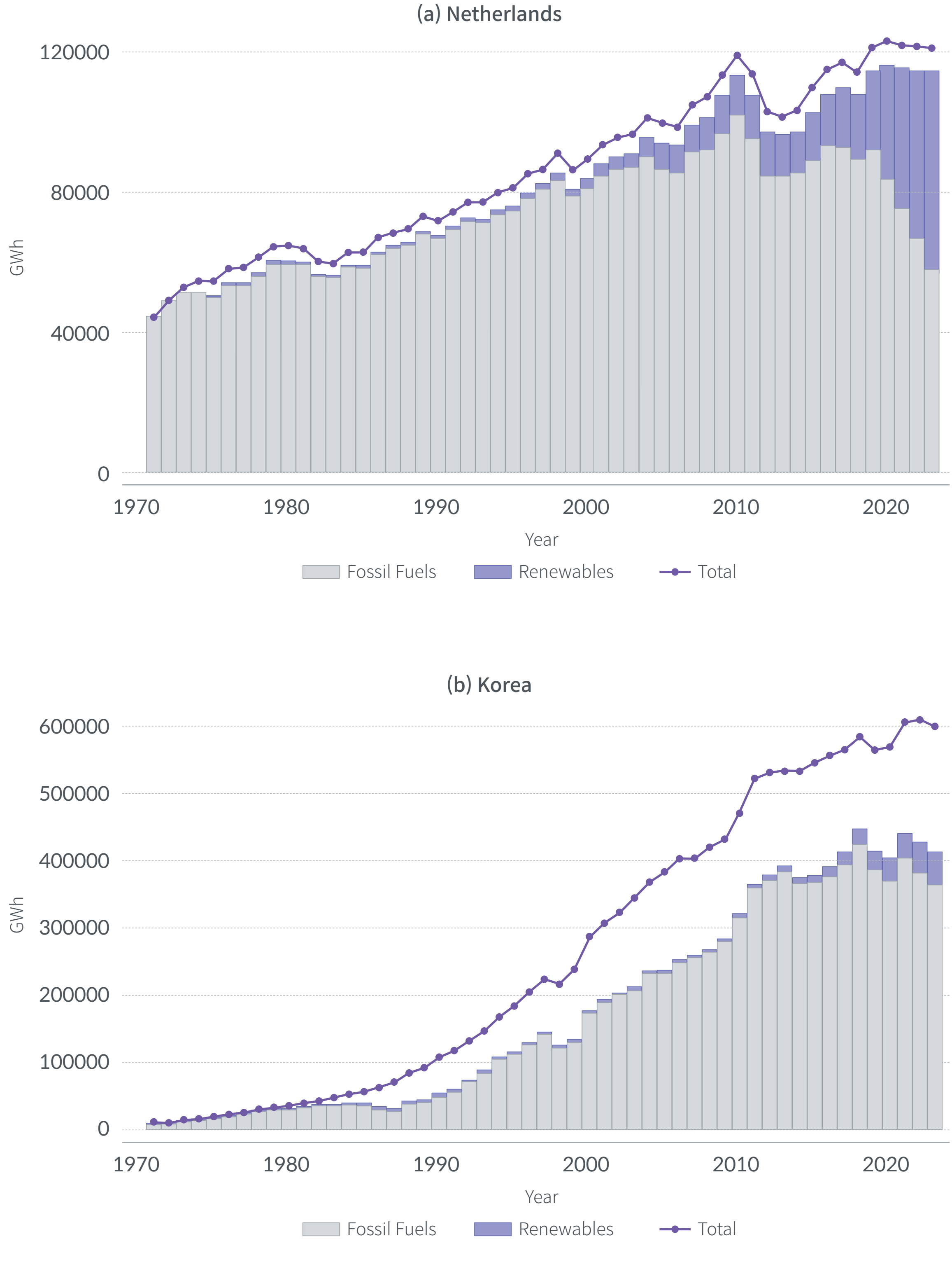
Both nations target a similar level of renewable capacity, despite substantial differences in energy transition phases. The Netherlands' national goal for renewable energy capacity is to reach 86 GW by 2030, while Korea's national target by 2030 is 76 GW.[74] Solar and wind power drive the energy transition for both countries, accounting for 97.1% for the Netherlands and 83.5% for Korea. Compared to the 2030 target, the Netherlands' target gap (49.9 GW) is higher than Korea's (35.5 GW). However, Korea's 2030 target is relatively low considering its current renewable share. Korea's heavy reliance on fossil fuels has long historical disputes.[75] To meet the electricity demands, such as AI and semiconductors in 2030, Kim (2025) argues that Korea needs to triple its renewable energy supply.[76]

74 https://www.iea.org/data-and-statistics/data-tools/renewable-energy-progress-tracker, IEA source for Korea's target is based on 10th Basic Plan on Electricity Supply and Demand; Korea's goal was increased to 78 GW in the final announcement of the 11th Basic Plan on Electricity Supply and Demand, and the Lee administration would raise this target further in the next plan. (https://www.mk.co.kr/en/economy/11396257)

75 https://www.theguardian.com/environment/2025/aug/16/a-structural-dependence-on-heavy-industry-can-south-korea-wean-itself-off-fossil-fuels.

76 Kim, Michelle. 2025. South Korea's Economy Risks Missing Out on Global Transition to Renewables. Report. Institute for Energy Economics and Financial Analysis. p. 33.

Figure 2. Composition of Electricity Output Sources



Source: IEA(2024), World Energy Balances; Author's visualization.

Table 1. Energy Transition Phase between the Netherlands and Korea

	Netherlands		Korea	
	Cumulative Capacity (GW)	Share (%)*	Cumulative Capacity (GW)	Share (%)
PV (Distributed)	41.8	57.5	7.5	10.6
PV (Utility-Scale)	8.8	12.1	40.8	57.3
Wind (Onshore)	7.8	10.8	7.1	10.0
Wind (Offshore)	12.2	16.7	4.0	5.6
Total (PV+Wind)	70.6	97.1	59.4	83.5
Target (2030)	86		76	
Current Phase (2030)	72.7		71.2	
Current Capacity (2023)	36.1		40.5	
Target Gaps**	49.9		35.5	

Note: (*) Each share is calculated as a percentage of "Current Phase (2030)"
(**) This gap represents differences between "Target (2030)" and "Current Capacity (2023)"
Source: https://www.iea.org/data-and-statistics/data-tools/renewable-energy-progress-tracker; Author's calculation.

Energy Transition Framework and Strategy between the Netherlands and Korea

Energy Transition from Fossil Fuel

Since 1959, the Netherlands has relied on gas production from the Groningen field, but concerns about depletion grew significantly during the 2010s. In response, the Dutch government developed alternative strategies by diversifying energy sources and implementing electric heating systems.[77] Finally, gas production in the Groningen field ceased in 2023.[78] This shift transformed the Netherlands into a net energy importer, leading to an increased share of LNG imports from Russia since 2015.[79]

77 https://europeangashub.com/the-rise-and-fall-of-the-dutch-groningen-gas-field.html#:~:text=History of production,of the smaller gas fields.

78 https://europeangashub.com/groningen-gas-field-the-end-of-an-era-but-the-timing-is-unfortunate.html.

79 https://www.cbs.nl/en-gb/news/2025/27/netherlands-now-more-dependent-on-us-for-energy-less-on-russia.

After Russia weaponized its gas supply during the Russia-Ukraine war, the Netherlands, like other EU states, quickly shifted its LNG imports away from Russia to alternative countries. In 2024, the US is the first trading partner, while Norway and the UK are second and third.[80] To improve resilience and accelerate energy transition, the Dutch government is also considering faster permitting on new LNG terminals.[81]

Korea has never been an oil or gas exporter.[82] As a leading energy importer, it has managed various types of external threats to the energy sector. Its long history of government-led industrial policy has also contributed to such strategies. For instance, in 1973, the Korean government announced the "Heavy and Chemical Industry (HCI) Drive," a plan that led to an industrial transformation from low-value to higher value-added sectors.[83] The oil crises in 1973 and 1979 alarmed the Korean government about energy security due to higher prices and shortages. Thus, they tried to diversify energy input sources such as LNG or nuclear energy.[84] Energy security has evolved in tandem with Korea's economic development history.

However, Korea's heavy reliance on fossil fuels remains a major concern for energy transition. Several bottleneck factors have already been identified.[85] With limited resources, Korea's energy transition could slow further due to current geoeconomic pressures and trade conflicts. In 2024, the Special Act on National Resource Security (RSA, hereafter) was passed,[86] incorporating new security agendas in the energy sector that the traditional legal framework did not address. Park (2023, p. 25)[87] indicates that Korea has no basic law for the entire energy sector due to the repeal of the "Framework Act on Low Carbon, Green Growth." The new replacement law, the "Framework Act on Carbon Neutrality and Green Growth for Coping with Climate Crisis," did not incorporate legal provisions for comprehensive energy plans. There

80 *Ibid*.

81 https://www.offshore-energy.biz/permitting-starts-for-netherlands-third-lng-terminal/.

82 Korea produced a small amount of natural gas at offshore sites, "Donghae-1" and "Donghae-2" from 2004 to 2021 (Lee and Ko, 2023, p. 2.)
Lee and Ko. 2023. "South Korea Energy – Oil & Gas." The Legal 500 Country Comparative Guides.

83 See Lane (2025), Kim, Lee and Shin (2021).
Lane, N. (2025). Manufacturing revolutions: Industrial policy and industrialization in South Korea. *The Quarterly Journal of Economics,* 140(1), 403-458.
Kim, M., Lee, M., & Shin, Y. (2021). *The plant-level view of an industrial policy*: The Korean heavy industry drive of 1973 (No. w29252). National Bureau of Economic Research.

84 https://www.kdevelopedia.org/Development-Overview/all/promoting-heavy-chemical-industries--25.do.

85 Kim, Michelle. 2025. Bottlenecks to Renewable Energy Integration in South Korea. Institute for Energy Economics and Financial Analysis.

86 https://www.iea.org/policies/25384-special-act-on-national-resource-security.

87 Park, Ki-Sun. 2023. "Legal Issues to Establish Energy Security in an Era of Energy Crisis." National Public Law Review. Korea National Public Law Association. 19(1).

was a "Framework Act on Energy," but it lost its legal status and was amended to the "Energy Act." In 2023, the 10th Basic Plan for Electricity Demand and Supply, as a master plan in the electricity sector, started addressing a new environment for energy security.

The Netherlands has also passed a new, comprehensive law, called the "Energy Act," replacing the "Electricity Act" and the "Gas Act." The new law embraces changing energy markets and systems in the Netherlands, and modernizes old laws suitable for energy transition.[88] As its name suggests, the Dutch "Energy Act" focuses on regulating the domestic market[89] while Korea's RSA defines critical resources and creates a legal framework for responding to external crises or threats.

Industrial Strategy - Solar, Wind, and Hydrogen

This article examines two key renewable sectors, solar and wind, to identify strategic differences, and further explores hydrogen as a potential area for collaboration between Korea and the Netherlands.

1) Netherlands – Solar

As previously shown, the Netherlands has led energy transitions in Europe over the last five years. There have been steady increases in PV and on/offshore wind deployment since 2018. A significant jump in net additions occurred between 2019 and 2020 when the government modified its subsidy scheme. These subsidy programs, SDE+ and SDE++,[90] have produced highly successful results.[91] As other EU states adopted, these schemes primarily use a feed-in premium mechanism where the government subsidizes cost differences for operators.[92] The Dutch government plans to transition to a Contract for Difference (CfD) scheme by 2026, gradually phasing out the feed-in premium in the process.[93] According to the IEA, the SDE budget was around 10 billion EUR (16 trillion won) during 2016-2019, while it be-

88 https://kvdl.com/en/articles/de-energiewet-wat-verandert-er-vanaf-2026; https://www.energie-nederland.nl/en/energie-nederland-speed-up-the-energy-act-to-accelerate-the-energy-transition/

89 Draft summary provided by https://nedzero.nl/en/news/the-new-energy-law-what-is-it-about

90 Stimulation of sustainable energy production and climate transition (English) or Stimulering Duurzame Energieproductie en Klimaattransitie (Dutch); https://english.rvo.nl/subsidies-financiering/sde

91 https://www.abnamro.com/research/en/our-research/sustainaweekly-how-large-and-effective-are-dutch-energy-transition-subsidies

92 Netherlands Enterprise Agency. 2024. SDE++ 2024 - Stimulation of Sustainable Energy Production and Climate Transition. p. 4.

93 International Energy Agency. 2025. The Netherlands 2024 – Energy Policy Review. p. 12.

came more volatile after 2020 but still maintained a similar or higher level of funding on average.[94]

2) Netherlands - Wind

The SDE++ scheme covers a wide range of technologies, while the Offshore Wind Energy Roadmap has specifically funded offshore wind deployment in the Netherlands. Introduced in 2015, the policy set a target of 4.5 GW capacity by 2023. The target has been achieved, though remaining work continues connecting these offshore installations to mainland grids in 2024.[95]

Behind this success, the government's "one-stop-shop" approach has played a critical role in alleviating business uncertainty. State agencies provide comprehensive services ranging from site selection and environmental impact assessment to grid connections. These guidelines not only build a strong partnership between the private and public sectors but also reduce cost burdens associated with complicated administrative procedures.[96]

With this success, in 2022 the Dutch government increased its 2040 target to 50 GW. However, the current government lowered the target to 30-40 GW due to slow growth of hydrogen demand and rising cost of construction.[97]

3) Netherlands - Hydrogen

[Hydrogen] The majority of the SDE++ subsidy package has been allocated to CCUS and hydrogen. In 2022, more than 50% of the total budget went to CCUS and hydrogen, whereas solar PV and onshore wind received more than 10 out of 12 billion EUR in 2017. This shift aligns with the Dutch government's transition to a Contract for Difference (CfD) scheme as it phases out the current subsidy plan for the solar and wind sectors.

The Netherlands initiated the Dutch Hydrogen Roadmap, leveraging three natural advantages: a long history of hydrogen production in the gas sector, existing transit infrastructure, and potential growth in offshore wind farms.[98] However, the Dutch supply-driven hydrogen strategy has encountered challenges with insufficient investment and uncertain demand. The IEA (2025) recommends that the Dutch gov-

94 IEA (2025), p. 13.

95 IEA (2025), p. 34; In fact, the Roadmap was published following Energy Agreement in 2013 (Netherlands Enterprise Agency. 2025. Development Framework for Offshore Wind Energy. Unofficial Translation. p. 7.)

96 Netherlands Enterprise Agency (2025), pp. 9-12.

97 https://www.offshorewind.biz/2025/07/17/dutch-govt-lowers-2040-offshore-wind-target-50-gw-unrealistic-and-unnecessary/.

98 Nationaal Waterstof Programma (2022), Hydrogen Roadmap for the Netherlands. pp. 5-10.

ernment mandate the adoption of green hydrogen by industry and increase investment across all stages of hydrogen value chains.[99]

4) Korea - Solar

The “Master Plan for Electricity Supply and Demand”[100] and the “Basic Plan for the Promotion of Technological Development, Use, and Distribution of New and Renewable Energy”[101] have driven solar PV deployment in Korea. The 2017 Renewable Energy Implementation Plan 3020 represented a significant shift, establishing a target of 20% renewable energy by 2030.[102]

Korea primarily relies on two key support mechanisms: Renewable Portfolio Standards (RPS) and Renewable Energy Credits (RECs). The RPS replaced the feed-in tariff system in 2012 and mandates that electricity producers meet target renewable energy shares. The RPS replaced the feed-in tariff system in 2012 and mandates that electricity producers meet target renewable energy shares.[103] Producers can receive RECs for their renewable electricity generation, with different weights assigned to various sources. The Korean government assigns higher weights to electricity produced from solar, wind, and energy storage systems, while assigning lower weights to biomass and waste. This has led to increased renewable energy adoption through advanced technology.[104] To meet these requirements and avoid penalties, producers must purchase RECs on the market if they cannot generate sufficient renewable energy themselves.[105]

Unlike the Netherlands, Korea has reduced its budget scale following political changes. In 2020, the Moon administration announced the Green New Deal as part of the broader Korea New Deal package. This stimulus package promised 42.7 trillion won,[106] averaging about 8 trillion won (4.9 billion EUR) annually through 2025. In 2023, the Korean government implemented the Greenhouse Gas Reduction Cognitive Budget System. Under this system, the energy transition budget in the 2025 government proposal is just 1.2 trillion won (0.74 billion EUR),[107] less than one-tenth of the Dutch budget. Yoon’s administration reinstated nuclear power and gas for

99 IEA (2025), pp. 55-66.

100 https://elaw.klri.re.kr/kor_service/lawViewTitle.do?hseq=68118, updated every two years.

101 https://elaw.klri.re.kr/kor_service/lawView.do?hseq=33632&lang, updated every five years.

102 International Energy Agency (2020), Korea 2020 – Energy Policy Review. p. 82.

103 IEA (2020), p. 85.

104 IEA (2020), pp. 85-86.

105 IEA (2020), pp. 85-86.

106 IEA (2020), p. 24

107 National Assembly Budget Office (2024), Evaluation of the Carbon Neutral Energy Transition Policy. p. 24.

energy security matters which the Moon administration had phased out during his presidency.[108] Several experts have raised concerns and inconsistencies over national energy transition plans due to these political backlashes.

5) Korea - Wind

Like the Netherlands, Korea has focused on offshore wind power development. This strategic direction stems from Korea's geographic limitations for onshore wind generation, with mountainous terrain and low wind speeds creating natural disadvantages.[109] This subsequently led to an interest in offshore sites for wind generation, as the first offshore generator was deployed in Jeju,[110] and Jeju Hallim wind farm is now the biggest site.[111] However, Korea's deployment phase is still far below the targets announced in the RE 3020 plan and its subsequent announcements. Current capacity is only 0.2 GW, whereas the 2030 target is 14.3 GW.[112] The long lag in permitting procedures, social licensing issues, supply chain issues, and grid connections have been identified as causes for the underdeveloped wind power sector.[113]

To overcome these challenges, the Korean government passed the Offshore Wind Promotion Act.[114] The government will use auction mechanisms to determine optimal site locations for future offshore deployments.[115] Additionally, the act takes a "one-stop-shop" approach that streamlines permitting procedures, which previously took more than eight years.[116] Along with Germany's initiative, Korea's new bill was recognized as one of two leading practices.[117]

6) Korea - Hydrogen

Korea has emerged as a leader in promoting the full hydrogen economy cycle.

108 Kustova, Sauvignon, and Dietz (2025), pp. 12-19.
Kustova, I., Sauvignon, F., & Dietz, C. (2025). *From Partnership to Leadership: Energising EU-Korea Cooperation on the Road to Net Zero.* CEPS.

109 Seo *et al*. (2024), p. 384.; IEA (2020), p. 77.
Seo, H., Park, S., Yun, D., Yu, J., & Jung, S. P. (2024). Korean Offshore Wind Electrical Power Generation: Current Status and Prospects. *J Korean Soc Environ Eng*, 46(7), 382-394.

110 IEA (2020), p. 83.

111 GWEC (2025), p. 47.
GWEC. 2025. Global Wind Report 2025.

112 GWEC (2025), p. 53.

113 Seo *et al*. (2024)

114 https://www.yulchon.com/en/resources/publications/newsletter-view/39645/page.do; As in this article, the full title is "Special Act on the Promotion of Offshore Wind Power Distribution and Industry Development."

115 GWEC (2025), p. 52.

116 GWEC (2025), p. 86.

117 GWEC (2025), p. 51.

Starting with the Hydrogen Economy Roadmap, its first national-scale strategy, in 2019,[118] the Korean National Assembly later enacted the Hydrogen Economy Promotion and Hydrogen Safety Management Law.[119] This legislation provided Korea with a strong legal foundation early on and represented a milestone for the global hydrogen sector.[120] Interestingly, Yoon's administration incorporated hydrogen initiatives within his carbon-neutral policy framework.[121] However, the current hydrogen economy relies primarily on grey or blue hydrogen, mainly co-firing with fossil fuels. This differs from the green hydrogen that Moon's government had targeted.[122]

Table 2. Industrial Strategy and Initiatives between the Netherlands and Korea (Summary)

Key Focus Area	Netherlands	Korea
Energy Transition	- Post-Groningen transition - Infrastructure improvement for LNG import	- Reduce high dependency on fossil fuels - Regulatory bottlenecks
Solar	- Leading PV deployment through SDE subsidies - Sizable budget (10 billion EUR), shift from FiP to CfD in 2026	- Lagging deployment due to political shifts (and backlash) - Insufficient budget (4.9 to 1 billion EUR), shift from RPS+REC to CfD (forthcoming)
Wind	- Offshore Wind Energy Roadmap - Single window approach	- Offshore Wind Promotion Act - Benchmarking North Sea projects
Hydrogen	- National Hydrogen Strategy - Supply-driven approach, awaiting for demand	- Hydrogen Economy Promotion and Hydrogen Safety Management Act - Leading industrial use in hydrogen

Source: Based on author's findings in the main text.

118 IEA (2020), p. 104.

119 IEA (2020), p. 107; https://elaw.klri.re.kr/eng_mobile/viewer.do?hseq=60917&type=sogan&key=13.

120 https://www.investkorea.org/ik-en/bbs/i-308/detail.do?ntt_sn=490772.

121 Kustova, Sauvignon, and Dietz (2025), pp. 19-20.

122 *Ibid.*, pp. 45-46.

Future Agenda for Strategic Cooperation

Paradoxically, the clean energy transition demands a multi-dimensional approach to energy security. While fossil fuel-based economies during the 1970s encountered new security challenges, today's emerging energy resources are redefining security priorities across energy sectors. Current national frameworks and industrial strategies often fail to address all the complexities involved in accelerating the shift from fossil fuels to renewables. Thus, the Netherlands and Korea should establish strategic partnerships across various sectors to tackle these emerging challenges.

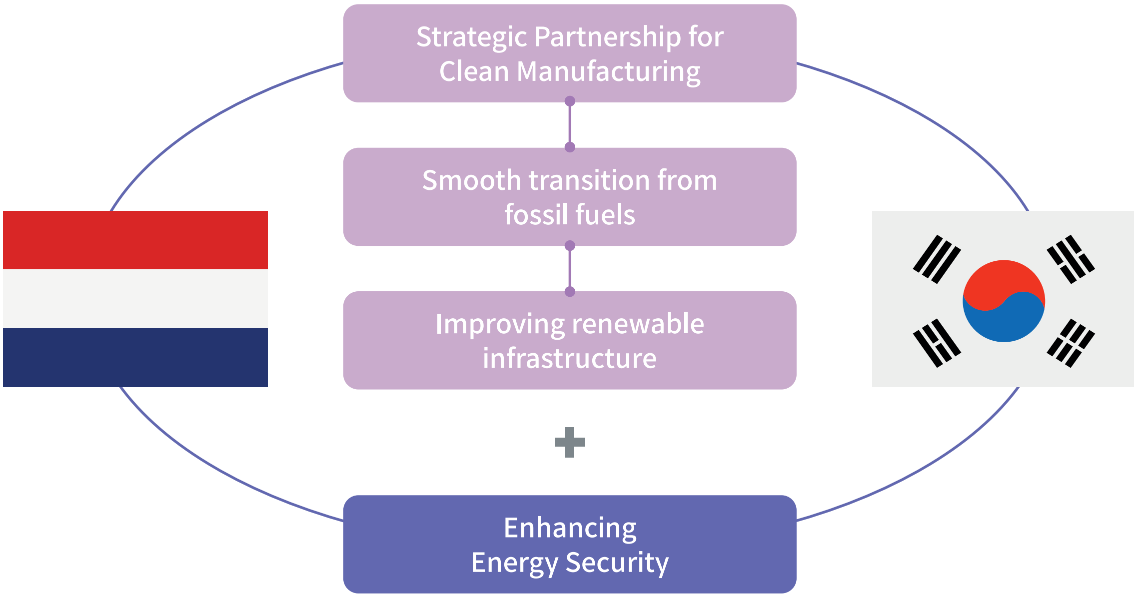
This partnership should focus on how the Netherlands and Korea can accelerate the transition to clean energy. The data clearly shows that the Netherlands is more advanced than Korea in terms of overall implementation. Both governments are expanding public-led initiatives and roles across multiple sectors. The Netherlands has effectively driven domestic energy transitions but lacks national legal frameworks to address external threats. Korea lags in its transition phase but has developed robust security measures against supply chain disruptions. These nations could collaborate on creating a framework that both accelerates clean energy transitions and implements active measures against external threats.

The Netherlands and Korea share common interests in clean manufacturing. Both countries prioritize clean and innovative industrial manufacturing bases in their initiatives. They could strengthen their relationship in mutually beneficial ways across several sectors.

First, the transition from fossil fuels remains a major concern for both countries, though they also prioritize stabilizing fossil fuel sourcing before completing the transition. Both nations need to modernize their industrial strategies in the LNG sector. Korea could be a strategic partner in increasing LNG shipping capacity and improving infrastructure in the Netherlands.

Dutch expertise in distributed solar PV systems and North Sea offshore wind development could help the Korean government and industry players accelerate their transition. For hydrogen, both countries could collaborate on stimulating market demand from manufacturers. This collaboration would help prepare them for the rising clean energy demands of AI and other advanced manufacturing sectors in the near future.

Figure 3. Future Agenda between the Netherlands and Korea



04

Key technologies for Open Strategic Autonomy in Korea and the Netherlands: Critical Raw Materials for Defense

Irina Patrahau, Benedetta Girardi
The Hague Centre for Strategic Studies

Strategic context: Dutch and Korean defense supply chains in a changing security environment

The Netherlands and the Republic of Korea (ROK) share structural characteristics that make them natural partners. Both are export-oriented economies reliant on open sea lanes and rules-based trade. They both host globally competitive firms in semiconductors, advanced manufacturing, maritime engineering, sensors, and digital infrastructure. Additionally, both countries are middle powers navigating increasing geopolitical and geoeconomic tensions worldwide while aiming at achieving open strategic autonomy. The return of war on the European continent in 2022 pushed the Netherlands to increase its defense spending and accelerated the defense industrialization process in Europe. The ROK faces an increasingly unstable regional environment, driven by heightened great power competition, maritime territorial disputes, and the ever-present nuclear threat of its northern neighbour.

Having a robust defense industry is thus currently as pressing a concern as ever for both the Netherlands and the ROK. Dutch defense capabilities have traditionally reflected measured and selective investments, but the government has recently placed increasing attention on boosting its defense industry and spending on military and dual use technologies. In comparison, the ROK has a much more developed defense industry that combines the sophistication and scale of its advanced, diversified industrial base with rapid production capabilities.

Both countries depend on critical raw materials (CRM), which hinders the secure development of their defense sectors as well as their open strategic autonomy. CRM underpin the technologies that power both advanced economies and modern defense industries. Lithium, cobalt, nickel, rare earth elements, tungsten, and gallium are examples of materials indispensable in batteries, semiconductors, radars, precision munitions, or communications equipment. Neither the Netherlands nor the

ROK possess significant domestic reserves of these materials.

Both countries rely almost entirely on imports from a few supplier states. This shared vulnerability is exacerbated by the strategic weaponization of CRM in the current geopolitical landscape. China's restrictions on exports of gallium and germanium, Indonesia's evolving policies on nickel exports, and recurrent instability in cobalt-producing regions of Africa are some of the instances illustrating the risks of concentrated supply chains.

For small, open economies like the Netherlands and ROK, this creates a structural exposure: industries central to national security, such as defense, are subject to external vulnerabilities. At a time when defense demand is accelerating in Europe and instability is increasing in the Indo-Pacific, blind spots in the supply chains of the defense sector come at increasing costs. Thus, the pursuit of open strategic autonomy and national security also involves reducing external dependencies. Yet, autonomy does not mean isolation: there are many cooperation venues between Seoul and The Hague that can lead to the increased security of their defense supply chains. This brief will examine these opportunities, with a specific focus on CRM in the defense industry.

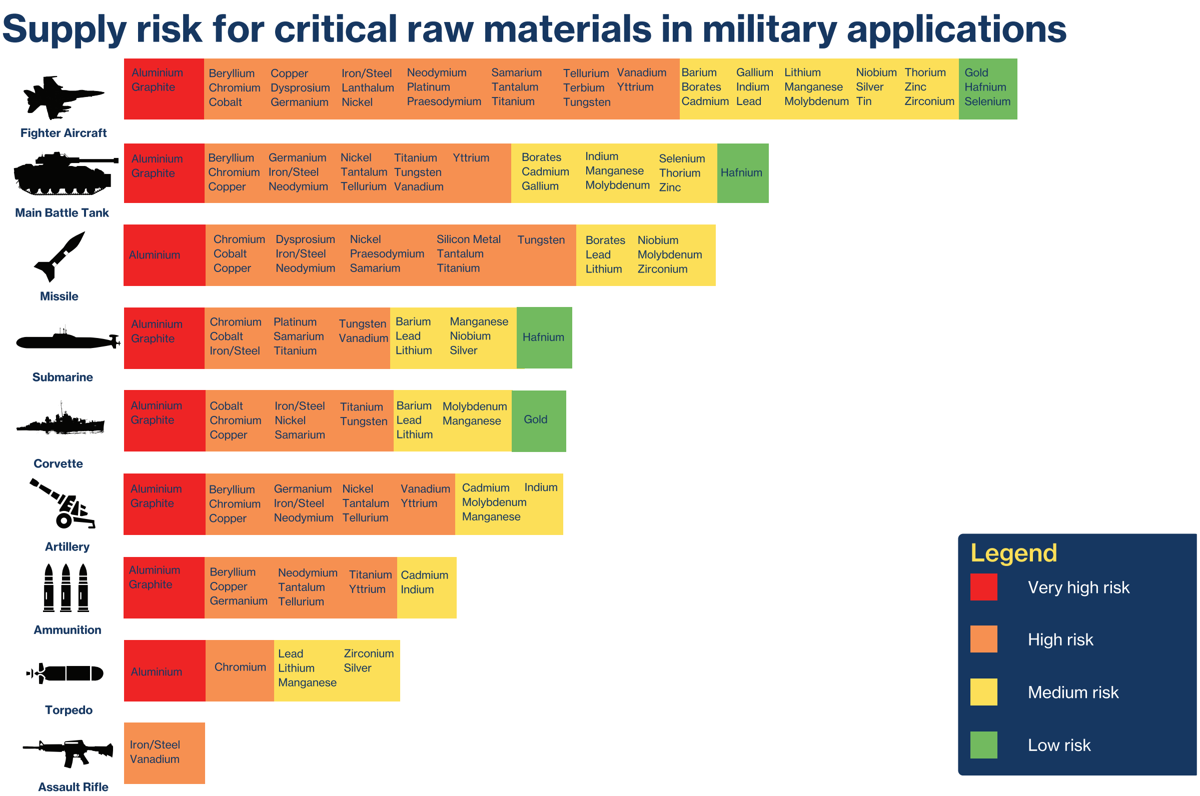
Critical Raw Materials: A fundamental vulnerability of defense supply chains

CRM are materials of high economic importance and high supply risk for a country. In the EU, 34 materials are considered critical. The Korean government considers 33 core critical minerals. These materials are heavily used in the energy, digital, health, defense and space sectors, all of which are sectors of vital national importance in both the Netherlands and the ROK.

For a long time, the defense sector's dependency on CRM received less attention than in the energy and digital ones. The fastest-growing demand for CRM comes from the energy transition, as clean energy technologies are highly mineral-intensive. In a 'business as usual' policy scenario, clean tech demand for lithium and graphite could grow more than 10 times between 2021 and 2030. Moreover, digital technologies have been central to the trade conflict between the United States and China, which brought urgency to policymakers to try to mitigate the negative effects. Several chip and chip-making technologies have been affected by export restrictions in the form of licensing requirements or temporary export bans. These restrictions have had adverse effects globally, including on the Netherlands and ROK. Policymakers have thus been focusing their attention on de-risking energy and digital supply chains, without a specific focus on defense.

Yet the defense sector is equally dependent on secure supplies of CRM. From fighter aircraft to battle tanks and ammunition, every single military application contains a range of CRM (Figure 1). Aluminium and graphite are the most widely used CRM in military systems, including aircraft (fighter, transport, maritime patrol, and unmanned), helicopters (combat and multirole), aircraft and helicopter carriers, amphibious assault ships, corvettes, offshore patrol vessels, frigates, submarines, tanks, infantry fighting vehicles, artillery, and missiles. Cobalt, for instance, is used in superalloys for jet engines and in the propulsion, arming and firing of missiles. Tungsten is found in propulsion systems of aircraft and helicopter carriers, amphibious assault ships, corvettes, offshore patrol vessels, and frigates.

Figure 1. Supply risk for critical raw materials in military applications



Since 2021-2022, the geopolitical context and heightened security tensions have brought the defense industry's CRM vulnerabilities to the forefront of policy developments. Tensions surrounding CRM supply chains have reached unprecedented levels. China's dominance in mining and processing most of CRM allows it to weaponize CRM export against the US and other countries, including the Netherlands and the ROK. This could negatively affect defense supply chains. The main risks of these export restrictions are material price spikes and delays in the delivery of components that make use of these materials. While many companies reportedly had inventories to overcome the short-term disruptions, significant issues could arise if material exports are reduced for a longer term. The Netherlands, for instance, was the largest importer of Chinese antimony, used in a variety of applications from plastics to lead-acid batteries, ammunition and the semiconductor industry. Between 2023 and 2024, China's exports to the Netherlands decreased by two thirds, followed by a complete halt in October 2024. In light of these geopolitical and security tensions, CRM supply chain disruptions have become commonplace.

Vulnerability at the material level adds complexity to the already complex and opaque defense supply chains. A submarine, for instance, uses 600,000 components. These components consist of several layers of subcomponents, many of which rely on CRM. No single industry player has full visibility of such vast, fragmented supply chains, which can involve thousands of subcontractors. As such, it is very difficult for defense suppliers of complex systems, such as submarines, to mitigate supply chain risks at the material level. A supply chain approach involving mining companies, component manufacturers, and system assemblers is necessary.

Securing defense supply chains in ROK and the Netherlands

Against this backdrop, the ROK and the Netherlands are working to address the CRM-related vulnerability of their defense supply chains. Korea, with a rapidly expanding defense industry and growing arms exports, is seeking to safeguard production against CRM dependencies and increase its strategic autonomy. The Netherlands, after decades of underinvestment, is rebuilding its defense industrial base while aligning with European CRM initiatives to promote diversification and enhance economic security. A closer look at each country's defense and CRM developments shows how these contexts shape Seoul and Amsterdam's approaches to securing defense supply chains.

The Republic of Korea

Thanks to the continuous modernization efforts undergoing in the country since the 1970 creation of the Agency for Defense Development, the ROK currently ranks among the top 5 global military powers and top 8 arms exporters worldwide. The last few years have been particularly significant for the development of the Korean defense sector, with a growth in market share percentage of arms exports between 2013-2017 and 2018-2022 of 74%. With Korean arms exports growing from 2 billion USD in the late 2010s to 20 billion in 2024, the ROK is positioning itself as a global leader in this field.

Notable growth has been spurred in particular by the development and solidification of the national defense industrial base, which is undergoing an unprecedented boom. In 2024, the combined sales of the 31 listed defense companies in the ROK was of 30.3 billion USD, 16% more than in 2023. The top 5 defense companies alone registered an operating income of 1.4 billion USD operating profit in 2024. Hanwha Aerospace, Korea Aerospace Industries (KAI), LIG Nex1, Hyundai Rotem and Hanwha Systems are at the forefront of Korea's defense industrial exponential growth thanks to the in-house production of defense capabilities such as the K2 tank, the K9 self-propelled howitzer, and the Cheongung II surface-to-air missile interception system.

Although the Korean defense industry has gone global in its exports, with significant agreements concluded with Poland, Romania, Australia, and Saudi Arabia, production remains local. Most of the exported systems are produced on Korean territory, primarily in South Kyungsang Province, Daejeon City, North Kyungsang Province, and South Chungcheong Province. The Korean government supports local production and global export efforts with R&D subsidies and industrial policies that seek to couple the growth of the defense sector with overall economic development and high-tech industry diversification.

Despite its forward-looking, comprehensive approach, the Korean defense sector still suffers from one main vulnerability: the procurement of CRM needed in its defense production. Recent reports shows that South Korea relies on overseas sources for 79% of its supply of 10 critical defense materials, such as heat-resistant alloys and titanium alloys that are made using CRM. In 2022, the ROK spent a total of 620.7 million USD on procuring 10 types of key defense materials, of which 489.7 million USD (78.9%) was allocated to imports. Often these materials are imported from countries that weaponised critical resources in the past, such as China, making the supply unstable, especially given the growing export controls and restrictions on CRM.

The Korean government has been aware of these vulnerabilities for decades and has a long history of industrial policies and strategies aimed at boosting mineral security. Korean industry saw a period of rapid growth in the 1970s-1980s. Soon after, it became clear that domestic resources were insufficient to satisfy the Korean market. As a consequence, the Korean government decided to expand abroad, provide informational and technical support for exploration efforts, and stockpile. KOMIR, the main body implementing CRM policies of the Korean Ministry of Trade, Industry, and Energy (MOTIE), led these efforts. KOMIR provided significant financial support for exploration projects abroad and invested in exploitation projects. KOMIR also provided information, networking opportunities, and capacity building. After a very active period in the 1970s and 1980s, these efforts have declined over time, but picked up again since 2010.

Most recently, the Korean government put CRM in the spotlight by announcing its Critical Minerals List in 2023 and by allocating 35.7 billion USD to a supply chain stabilization fund for key minerals. The central point of Seoul's derisking strategy is to reduce import dependencies from 80% to 50%, and to increase recycling rates from 2% to 20% by 2030. To this end, the ROK has boosted its stockpiling capacity, acquired new mining and refining concessions abroad, and inaugurated the Critical Mineral Investment Council to stimulate annual public-private investments. When it comes to the defense sector, Seoul is reportedly planning to invest 288.7 million USD in developing the advanced materials and components necessary for defense production.

The ROK is also open to International cooperation. Participation to and chairing of the Mineral Security Partnership (MSP) demonstrate the ROK's commitment to strengthen the global supply chain for critical raw materials. Seoul is exploring cooperation opportunities with Japan and the United States. The ROK also closely cooperates with resource-rich African countries by providing technology for resource exploration in exchange for critical raw materials. These initiatives underscore the ROK's openness to international cooperation regarding CRM supply chains.

As the ROK defense industry rapidly matures into a global powerhouse, the sector's long-term resilience will depend on how effectively Seoul mitigates its reliance on imported CRM, making its current push for diversification, innovation, and international cooperation a decisive factor in sustaining future growth. This creates many opportunities for cooperation with other countries.

The Netherlands

The Dutch government, like all NATO members, pledged to increase its defense spending towards 2035. The pledge made during the 2025 NATO Summit to increase defense spending to 5% of GDP implies a renewal of Dutch capabilities. After several decades of underinvestment, upgrades are required in all military domains in the Netherlands: maritime, air and space, and land.

Some of the new defense funds will be spent to strengthen the domestic defense industry, but there are significant gaps that could be filled by other NATO members and partners. The Dutch defense industrial base consists of about 850 companies, 500 of which are active in the land domain. The land domain is also the profitable sector in the Netherlands, together with the maritime sector. Across the defense industry, most companies present in the Netherlands are Original Equipment Manufacturers (OEM) that supply finished products. The rest of the supply chain in the Netherlands is fragmented: there are a few tier-one suppliers that provide the subsystems, as well as relatively many tier-two suppliers that manufacture semi-finished goods, but few tier-three suppliers that provide materials and basic components. Some of these capabilities, especially in robotic and autonomous systems, and the maritime and land weapons technology sector, will grow in the Netherlands according to policy ambitions and industry prospects. The Defense Industry Strategy, the Shipbuilding Sector Agenda, and other plans being developed around the 5% spending pledge point in that direction. Others will have to be fulfilled through partnerships with like-minded countries.

Like Korea, the Netherlands is also aware of the supply chain vulnerabilities that could hinder its military preparedness. Unlike Korea, though, its efforts to de-risk and build resilience, especially at the material level, only began in 2022. In line with the European Critical Raw Materials Act, the Netherlands has launched its National Raw Material Strategy (Nationale Grondstoffenstrategie, NGS) in 2022. The NGS aims to secure CRM supplies by acting on five pillars: circularity and innovation, sustainable European mining and refining, diversification, greater sustainability of international supply chains and knowledge building. In other words, the NGS focuses on domestic resilience and cooperation with other actors.

To support domestic resilience, the NGS led to the establishment of the Netherlands Materials Observatory (Nederlands Materialen Observatorium, NMO) in 2025 to map and analyse CRM supply chains. The NMO runs projects that aim to improve knowledge on CRM and providing timely information on potential disruptions or supply issues. Additionally, the Dutch government announced a plan in October 2024 to start assessing the prospect of building strategic stockpiles of critical raw materials in the Netherlands and/or the EU. First, a feasibility study was commissioned to assess how national reserves could be set up. Based on further engagement with stakeholders, plans for stockpiling for the defense and healthcare sectors are being developed in 2025.

The Dutch government is following European initiatives when it comes to international cooperation. The EU has developed 14 agreements with countries in Europe, Central Asia, Africa and Latin America. The EU is also active in multilateral forums such as the International Energy Agency, the G7, and the Minerals Security Partnership.

Avenues for ROK-NL cooperation on defense supply chains

As like-minded states that share security concerns and a push for the revitalization of their military capabilities, the Netherlands and ROK should cooperate to reduce their common vulnerabilities. Both countries face strategic challenges that motivate defense modernization. The Netherlands seeks to strengthen its economic security, reduce strategic dependencies, and fulfill its NATO alliance commitments. Korea is diversifying its supply chains and expanding its defense industrial footprint in Europe. A key challenge that the ROK and the NL share is the dependence of their defense industries on insecure supply chains, especially at the material level. By partnering, they can overcome these obstacles more efficiently.

To increase the open strategic autonomy of their defense industries, the ROK and the Dutch governments could pursue cooperation on the following three domains. This will also contribute to the creation of closer ties at the defense industry level, which can open new markets and foster innovation.

Collaborate on risk mitigation strategies for defense supply chains

The ROK has been active in the risk mitigation sector for decades, whereas the Netherlands has made progress in this field in recent years. Collaborating on risk mitigation strategies would increase the span of control of the two middle powers by enhancing the effectiveness of risk mitigation measures. This could be achieved in several ways:

- Enhance intelligence sharing at the governmental level – including agencies like KOMIR and NMO – on risk mitigation strategies for CRM supply disruptions. This includes exchanges on methodologies for identifying and monitoring supply chains, but also early warning and action plans for supply chain disruptions.
- Explore options for a shared stockpiling system for CRM and components for the defense sector. The ROK already has a well-established CRM stockpiling sector, while the Dutch government is investigating stockpiling for the naval military sector. As two countries with major shipbuilding industries and naval capabilities, the two could not only exchange best practices but also establish jointly managed programmes for stockpiling where relevant. These programs could take the form of physical stockpiles or price floors to protect strategic industries.

Facilitate collaboration between dual-use and defense industries

The defense supply chain consists not only of defense-specific sub-components but also of dual-use products like batteries, magnets and drones. These sub-components, in turn, depend on CRM. To more efficiently address vulnerabilities, the governments in the ROK and the Netherlands should facilitate dialogue and collaboration between companies. This could include the following actions:

- Organize periodic industrial exchanges along supply chains to discuss shared challenges and potential solutions. This could be organized between companies active along a defense system supply chain like frigates or submarines to support both countries' de-risking efforts. Alternatively, they could be organized between companies in both dual-use and defense supply chains, such as between batteries and frigates, since dual-use technology suppliers tend to be more advanced in supply chain risk mitigation than the defense sector.
- Develop professional 'exchange' programmes so that staff can learn from each other. Companies in the ROK and the Netherlands face similar challenges, and each of them has innovative ways of dealing with these challenges. Acknowledging business confidential issues, industrial actors could partner up on specific CRM challenges and develop programmes for their employees to learn from one another over the course of six months to one year. Since cooperation on semiconductors is already ongoing, it could be expanded to other components or systems that depend on CRM, like drones or sensing equipment, in order to share learnings of common challenges.
- Invest in materials and manufacturing innovation for the defense sector. By identifying shared vulnerabilities in defense supply chains, companies from the two countries, supported by their governments, could fund scientific research on physical or functional substitution of at-risk materials.

Cooperate in the creation of secure and sustainable supply chains

The ROK and Dutch governments could work together upstream to establish more secure and sustainable supply chains outside of China, the main global supplier. This would de-risk mining and processing, creating alternative supply lines for defense industries to use in their manufacturing. There are different ways this could be done:

- Promote a ROK-EU strategic partnership on CRM. Given that the Netherlands tends to follow European initiatives in its external engagements on CRM, an EU-wide partnership with the ROK would be beneficial. The ROK and the EU would be able to, for instance, jointly develop infrastructure projects and other conditions that enable emerging mineral producers to establish up- and mid-stream responsible CRM supply chains. One example is the Lobito Corridor, a transportation network connecting Angola's Atlantic Coast with Zambia and the Democratic Republic of Congo to boost (mineral) trade and economic integration in the region.

- Engage in multilateral trade agreements and promote global cooperation on CRM via the Minerals Security Partnership. The ROK's leadership of the MSP offers strategic entry points to push for de-risking CRM supply chains. Since all MSP members are either NATO members or partners, there is an opportunity to focus on the defense sector in collaboration with other international actors.

Conclusion and Policy Recommendations:

This volume has examined how the Netherlands and the Republic of Korea (ROK) are seeking to strengthen their industrial open strategic autonomy in an era of deep economic interdependence and geopolitical competition. Both countries are highly innovative, export-driven economies whose prosperity and security depend on cross-border supply chains. However, both face mounting exposure to external shocks, technological concentration, and economic statecraft.

The chapters collectively demonstrate that strategic autonomy for such open economies cannot mean self-sufficiency or disengagement. Rather, it entails managing interdependence: remaining globally integrated, and developing national resilience and adaptability. Throughout the volume, the authors show that achieving this balance requires three complementary capabilities: strategic intelligence, technological leadership, and resilient supply chains. Each of which offers a domain for bilateral cooperation.

Seungjoo Lee shows how Korea's experience with 'triple vulnerabilities' (high trade dependence, supplier concentration, and exposure in critical nodes) has driven institutional reforms to enhance supply chain resilience and technological sovereignty. Richard Ghiasy situates the Dutch approach within Europe's broader economic security agenda, arguing for calibrated tolerance of dependency, informed by empirical measures rather than broad protectionism. Myong Hwa Lee illustrates that both countries now treat science, technology, and innovation (STI) as central instruments of economic security. This is exemplified by Korea's participation in Horizon Europe and the Netherlands' National Technology Strategy.

Joris Vierhout and Amber Geurts stress that autonomy must rest on detailed knowledge of value chains and potential vulnerabilities rather than abstract policy rhetoric. Seokjoon Kwon identifies opportunities for cooperation in AI-driven semiconductor design and production, while Anna Grashuis and co-authors highlight the case for joint quantum testbeds and shared infrastructure. Sunghun Cho underscores the convergence of energy and security policy, showing complementarities in hydrogen, renewables, and grids. Irina Patrahau and Benedetta Girardi demonstrate that similar coordination could strengthen both nations' positions in critical raw materials and defense supply chains.

Together, these contributions show that the Netherlands and the ROK are confronted with converging structural pressures but at the same time hold complementary strengths. Both combine technological sophistication with global openness, and both face the challenge of ensuring that interdependence remains a source of strength rather than vulnerability.

In this concluding section, we summarize the authors' key takeaways in three main recommendations that suggest potential pathways for ROK-Netherlands cooperation on open strategic autonomy.

First, establish a shared economic security foresight mechanism.

Both Lee and Ghiasy both highlight that the effectiveness of economic security policies depends on continuous monitoring of dependencies, vulnerabilities, and emerging technological shifts. Korea is already developing supply chain mapping systems and legal frameworks, whilethe Netherlands is advancing analytical capacities in this field. Still, these efforts remain nationally bounded. Vierhout and Geurts remind us that autonomy is relational: no single economy can map interdependence in isolation.

The two countries could therefore establish a structured but flexible mechanism for economic security foresight. Rather than creating new institutions, this would connect existing national bodies through regular exchanges of data, methodologies, and early-warning assessments. Annual or biannual foresight meetings could compare sectoral analyses in semiconductors, energy, quantum technologies, and critical materials.

Second, expand innovation cooperation in enabling technologies.

As demonstrated by Myong Hwa Lee, Kwon, and Grashuis et al., innovation is now the linchpin of both industrial competitiveness and strategic resilience. The Netherlands and the ROK have compatible strengths: Dutch excellence in equipment, photonics, quantum, and sustainable manufacturing complements Korea's scale and expertise in semiconductors, AI, and digital infrastructure. Yet most cooperation remains fragmented.

The two governments could build a more cohesive framework for joint innovation in a several key areas: AI-driven semiconductors, quantum technologies, sustainable energy systems, and circular materials. Rather than launching large-scale programmes, collaboration should focus on pragmatic mechanisms, such as joint research calls under Horizon Europe, coordinated innovation missions, and co-funded pilot projects involving universities, research institutes, and firms from both countries.

An annual bilateral innovation forum could bring together policymakers, industry, and researchers to identify emerging opportunities and coordinate funding streams. Exchanges of early-career scientists and engineers embedded within existing clusters such as Quantum Delta NL, Brainport Eindhoven, KAIST, and Pangyo Techno Valley would foster long-term professional networks.

Lastly, coordination in international standard-setting bodies for AI and quantum technologies would allow the Netherlands and Korea to shape governance principles and interoperability standards. Their combined reputations for responsible innovation and digital excellence would give their positions credibility and influence beyond their relative size.

Third, coordinate sustainable supply chain resilience.

As Cho, and Patrahau and Girardi emphasise, the sustainability and security of supply chains are now inseparable. The green transition intensifies demand for critical raw materials and new energy carriers, while defense modernization puts a strain on similar supply bases. Korea's experience with stockpiling and diversification, and the Netherlands' growing role in implementing the EU Critical Raw Materials Strategy, make cooperation both feasible and mutually beneficial.

A bilateral supply chain coordination initiative could begin with periodic consultations on sourcing strategies for critical minerals and components essential to defense and clean energy. Shared criteria for environmental, social, and governance (ESG) performance in overseas mining and processing would strengthen both countries' credibility as responsible investors. Joint feasibility studies could explore shared stockpiling arrangements or reciprocal access to reserves in emergencies.

Further collaboration could focus on circularity and substitution. Dutch expertise in recycling technologies and circular manufacturing complements Korea's industrial capacity in batteries and electronics. Pilot projects in recycling of lithium, cobalt, or rare earths, possibly co-financed by the private sector, could advance both resilience and sustainability goals. Regular industry exchanges between defense and dual-use manufacturers, as proposed by Patrahau and Girardi, could institutionalise mutual learning on risk management and supply diversification.

Together, these recommendations translate the findings of the authors into three actionable steps. By developing shared foresight, expanding targeted innovation cooperation, and coordinating sustainable supply chain resilience, the Netherlands and the ROK can reinforce their economic security while maintaining an open economy.

This cooperative approach offers not only mutual benefit but also an example of how intelligent interdependence anchored in transparency, innovation, and sustainability can serve as a durable foundation for industrial open strategic autonomy in an ever-evolving geoeconomic landscape.

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