

Mapping Supply Chain Power in the Age of Economic Security: Introducing Supply Chain Dominance Index

Trade Power Network in 2020



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Introducing SNU IFS Economic Security Cluster

Economic security has emerged as a crucial keyword in international politics, determining not only economic relations between countries but also security and diplomatic relationships. The Institute for Future Strategy (IFS, <https://ifs.snu.ac.kr>) at Seoul National University (SNU), established with the critical mission of developing national future strategies, launched its Economic Security Cluster (<https://ifs.snu.ac.kr/cluster/economic-security>) in spring 2022 to research national future strategies in economic security.

Through internal research team meetings and consultations with external experts, we became convinced that accurate analysis of economic relationships between countries is essential for developing economic security strategies, and understanding these relationships from an economic security perspective is the most important foundational work.

1 Executive Summary

Economic security has emerged as a crucial keyword in international politics, determining not only economic relations between countries but also security and diplomatic relationships. The Institute for Future Strategy at Seoul National University, established with the critical mission of developing national future strategies, launched its Economic Security Cluster in spring 2022 to research national future strategies in economic security. Accurate analysis of economic relationships between countries is essential for developing economic security strategies, and understanding these relationships from an economic security perspective is the most important foundational work. Accordingly, the Economic Security Cluster set its first-year objectives to develop scientific, objective, and intuitive indices that can explain economic security while conducting various data collection and analysis efforts.

Economic security remains an ambiguous and complex concept, encompassing vast areas including trade, investment, resources, policy, and technology. We defined **supply chain dominance** as the core concept for our first-year focus. Supply chain dominance is defined as (1) a country's ability to control or influence global supply chains through the dominant position of major export companies or export products, and (2) a country's ability to protect its economy from disruptions in global supply chains. From perspective (1), countries can pursue the ability to disrupt supply chains through influence over trade flows, major industries and technologies, and other countries' policy decisions. From perspective (2), countries can take measures such as protecting core industries, safeguarding intellectual property rights, promoting domestic innovation, and strategic stockpiling of essential resources to protect their economies from external threats and vulnerabilities. Supply chain dominance differs from other commonly used terms in economic security (e.g., weaponization of interdependence, weaponization of resources, resilience, strategic autonomy/indispensability, chokepoints) in terms of conceptual clarity and measurability through empirical data.

Key Concepts in Economic Security

- **Supply Chain Dominance (SCD):** Measure of a country's ability to control or influence global supply chains
- **Export Power:** Capacity to leverage export position for strategic advantage
- **Import Vulnerability:** Degree of dependence on specific countries for critical imports

Let's take Saudi Arabia as an exporting country, South Korea as an importing country, and oil as the product. Looking at bilateral dependency, South Korea's oil import share from Saudi Arabia in 2021 was 0.293, meaning Saudi Arabia exports 29.3% of South Korea's imported oil. The higher this proportion, the stronger influence the exporting country has over the importing country, and conversely, the greater vulnerability the importing country has. In terms of global dependency, Saudi Arabia accounts for 12.2% of global oil production in 2021. Thus, Saudi Arabia's share of oil production as an exporting country is 0.122. The higher this figure, the greater dominance the exporting country has over that product's supply chain. Conversely, the higher this figure, the greater vulnerability importing countries

face. Additionally, oil is an essential resource for industrial production and economic activity, with above-average product complexity in international trade networks. Therefore, we can say that Saudi Arabia has export power over South Korea regarding oil, while South Korea has import vulnerability to Saudi Arabia regarding oil.

To estimate supply chain dominance from real-world data, we use bilateral trade data from UN COMTRADE at the HS 6 level. Key findings from the supply chain dominance analysis can be summarized as follows:

Key Findings

- **China's Supply Chain Dominance:** China's rise in export power rankings is most notable. China pushed the US to third place in 2004, then surpassed Germany to become first in export power in 2007. China's export power increased without corresponding increase in import vulnerability
- **US Supply Chain Dominance Weakening:** US started at 18th in import vulnerability in 1995 and steadily rose to 9th in 2021. Despite its large economy, US shows significant dependence on few countries for imports
- **Korea and Japan's Vulnerabilities:** Both countries have economic structures dependent on imports from a small number of countries. They have been the two most import-vulnerable countries since the 2000s. As of 2021, Korea ranks 1st in import vulnerability and Japan 2nd. In export power, Korea started at 12th in 1995, fell to 15th, then rose to 11th in 2021. Japan fell from 4th to 7th during the same period
- **Hong Kong's Decline:** Hong Kong was a strong small country ranked 9th in export power in 1995 but fell to 19th in 2021. Import vulnerability rose from 13th in 1995 to 7th in 2021
- **India's Rise:** India rose from 15th in 1995 to 5th in 2021, becoming a significant export power. Netherlands similarly rose from 11th to 6th
- **Vietnam and Thailand's Increasing Import Vulnerability:** Vietnam entered the rankings at 18th in 2011 and steadily rose to 3rd by 2021. Thailand shows similar trends, with both countries following growth patterns similar to Japan and Korea's import vulnerability-based high growth

Among traded goods, high-tech items expected to play important roles in the upcoming era of technological competition are receiving particular attention from an economic security perspective. To analyze their trade structure, we focused on 9 areas closely related to the Fourth Industrial Revolution among the 12 new industries designated by the government and Korea International Trade Association in March 2017 (electric vehicles, robotics, biohealth, aerospace, premium consumer goods, new energy industries, advanced materials, next-generation displays, and next-generation semiconductors). The analysis revealed these characteristics in new industry trade:

Key Findings fro 12 New Industries

- **Structural Changes in New Industry Export Power:** The five-power structure of Germany, China, US, Japan, and Korea has changed to a four-power structure excluding Japan since 2018
- **Korea's Potential:** While Korea shows top import vulnerability in new industries, its supply chain dominance turned positive after 2017, reaching 4th in export power by 2021. Though Korea's situation in the upcoming technology competition era is challenging, it has established a foothold in new industry competition

From these findings, we suggest the following policy recommendations:

Immediate Actions Required:

- Develop strategic industry resilience programs
- Strengthen technological sovereignty in key sectors
- Diversify supply chain dependencies
- Enhance international cooperation frameworks

The Economic Security Cluster has published the supply chain dominance analysis results as interactive visualization materials on the Future Strategy Institute website (<https://snu-economic-security.vercel.app>) and plans to update them annually.

2 Motivation



Figure 1: The 2017 National Security Strategy

After U.S. President Donald Trump officially declared “Economic security is national security” in the National Security Strategy (NSS) in 2017, economic security became a key concept symbolizing the transformation of world order (NSS 2017, 17). Subsequently, not only China, which was the direct target of U.S. economic security policy, but also Japan and European countries have been accelerating the revision of their foreign strategies and related laws centered on economic security. The world is now transitioning into “the age of economic security” (Lee Seung-joo 2021; Drezner et al. 2021; Congressional Research Service 2022; Kim Yang-hee 2022).

Let’s look back at the world before 2010. Economic globalization that began in the 1990s broke down national boundaries in economic activity, and countries rushed to pursue open economic policies to grow faster in this wave of globalization. Due to the revolution in information technology and the development of microelectronics, trade, investment, inter-firm cooperation and exchange, and technology diffusion proceeded at an astonishing pace, making it unimaginable to pursue closed and self-sufficient strategies against these changes. China’s accession to the World Trade Organization on November 10, 2001, as a socialist country can be seen as the most dramatic event of globalization. When asked “How might China exercise its influence if it grows through WTO membership?” Robert Zoellick, who headed the U.S. Trade Representative’s office in 2001, responded with the normative answer that China should become a “responsible stakeholder” in the world economic order, which became frequently cited as a representative optimistic view of China’s transformation.

Donald Trump, who defeated Democratic candidate Hillary Clinton while championing “America First,” regarded China, along with Russia, as the most significant threats to national security.

“China and Russia challenge American power, influence, and interests, attempting to erode American security and prosperity. They are determined to make economies less free and less fair, to grow their militaries, and to control information and data to repress their societies and expand their influence” (NSS 2017, 2).

On February 7, 2018, Trump imposed 30% and 20% tariffs respectively on solar panels and washing machines mostly imported from China using Section 201 of the Trade Act of 1974. On March 23, 2018, using Section 232 (national security clause) of the Trade Expansion Act of 1962, which was considered virtually obsolete, he imposed 10% and 25% tariffs on aluminum and steel imports from China. On April 3, 2018, following Section 301 of the Trade Act of 1974, he conducted investigations into unfair trade practices regarding technology

and intellectual property rights, and imposed 25% tariffs on 1,333 Chinese products based on evidence of technology theft and intellectual property rights violations. On September 24, 2018, and May 10, 2019, he imposed 10-25% tariffs on Chinese textiles and clothing products. China retaliated by imposing countervailing duties on U.S. products and filed a complaint with the WTO. The Trump administration continued to refuse WTO Appellate Body appointments after 2017, leaving the WTO paralyzed due to lack of quorum.

As the WTO's function, which symbolized the rule of law in trade, was suspended and the two powers of the U.S. and China rushed into economic warfare through unilateral trade measures, the global international trade order regressed into a chaotic state without norms. A prime example is Japan's strong protest against the Korean Supreme Court's ruling on compensation for forced labor victims in 2019, after which Japan announced export restrictions on three items crucial for semiconductor manufacturing (hydrogen fluoride, photoresist, and fluorinated polyimide) and excluded Korea from its whitelist.



Source: nikkei.com



Source: Yonhap News

China, which grew into an economic power after joining the WTO, also did not act like the responsible stakeholder that Zoellick had expected. It took economic sanctions such as rare earth export restrictions in response to the Senkaku-Diaoyu dispute with Japan in 2010, and did not hesitate to retaliate or warn through economic sanctions against countries that implemented policies against China's interests, including Norway, the Philippines, Taiwan, Mongolia, South Korea, Canada, Australia, and Lithuania. Particularly in response to South Korea's decision to deploy THAAD (Terminal High Altitude Area Defense) in 2016, China revealed its intention to use coercive power through its rapidly grown economic strength by implementing extensive sanctions against Korean businesses, products, and tourism.

The Biden administration, which succeeded the Trump administration, promised changes from Trump's foreign policy by claiming "America is back." However, Biden's economic policy was directed not at reviving the liberal international order but at strengthened and more sophisticated technological nationalism and protectionism. Through the Inflation Reduction Act of 2022 and the CHIPS and Science Act, the Biden administration's domestic goal is to adopt technological protectionism as its core industrial policy and foster large-scale manufacturing industries like automobiles and high-tech industries like semiconductors within the United States. Externally, the core of the Biden administration's economic security strategy is to create and manage an Asia-Pacific economic cooperation framework excluding China through the Indo-Pacific Economic Framework (IPEF).

On October 7, 2022, the Bureau of Industry and Security (BIS) under the U.S. Department of Commerce, the most important agency actually implementing U.S. economic security policy, announced additional export control policies to limit China's advanced semiconductor chip production capabilities and implemented various measures including amendments to Export Administration Regulations (EAR). The announcement was directed not only at

China but also at U.S. allies and partners who had been trading with China. The U.S. BIS warned that it could conduct end-use checks on U.S. goods to other countries at any time, and if there was interference such as inspection refusal, non-cooperation, or delays, those countries would be included in the Unverified List or Entity List for sanctions.



Figure 2: Alan F. Estevez, Under Secretary of Commerce

Alan Estevez, Under Secretary of Commerce for Industry and Security, stated,

“As I told Congress last July, my north star at BIS is to protect our security and prevent sensitive technologies with military applications from being acquired by China’s military, intelligence, and security services... The threat environment is constantly changing. Accordingly, we are continuously updating our policies to ensure we address the challenges posed by China and are continuously supporting and coordinating with allies and partners.”

Additionally, Thea D. Rozman Kendler, Assistant Secretary of Commerce for Export Administration, said,

“China has poured resources into developing supercomputing capabilities and aims to become a global leader in artificial intelligence by 2030. China is using these capabilities to monitor, track, and surveil its citizens and accelerate its military modernization... Our actions will protect U.S. national security and foreign policy interests while sending a clear message that U.S. technological leadership is about values as well as innovation.”

Furthermore, Matthew S. Axelrod, Assistant Secretary of Commerce for Export Enforcement, warned,

“Our core principle is to determine whether other actors comply with U.S. export control rules... If a foreign government prevents timely completion of BIS end-use checks, we will add that government to the Unverified List, and if the delay is sufficiently serious, to the Entity List to prevent the risk of diversion of U.S. technology that could undermine our national security interests” (Bureau of Industry and Security, 2022).

Through these actions, the Biden administration adopted a ‘small yard, high fence’ strategy to isolate China from the United States and its allies and partners in advanced industry areas such as semiconductors, artificial intelligence, quantum computing, batteries, and biotechnology.

3 Objectives

Facing this global transformation of economic order, the Economic Security Cluster of the Institute for Future Strategy set the indexation of economic security as its first-year task. As the first step, it defined economic security as a national security strategy that uses economic means to promote and defend national interests, and established supply chain dominance (SCD) as the foundational concept underlying current economic security strategies. In today's interconnected world, global supply chains have profound impacts on a country's economic growth and national security. Economic globalization that accelerated after the 1990s created such interdependence that no country or company can produce advanced products using only domestic supply chains. In this interdependent world, the ability to maintain safe and robust supply chains against external attacks and the capacity to cause significant disruptions to other countries' supply chains constitute foundational concepts of economic security.

Based on this perspective, this study defines supply chain dominance as (1) *a country's ability to control or influence global supply chains through the dominant position of major export companies or export products*, and (2) *a country's ability to protect its economy from disruptions in global supply chains*. From an offensive perspective, a country can pursue the ability to disrupt supply chains through influence over trade flows, major industries and technologies, and other countries' policy decisions. From a defensive perspective, countries can take measures such as protecting core industries, safeguarding intellectual property rights, promoting domestic innovation, and strategic stockpiling of essential resources to protect their economies from external threats and vulnerabilities.

Supply chain dominance is closely related to concepts long discussed in economics and international politics, such as asymmetric interdependence (Hirschman 1978; Keohane and Nye 1989; Brooks 2002; Lektzian and Souva 2003,2007; Allen 2008; Flores-Macas and Kreps. 2013; Kastner 2014) and weaponization of interdependence (Copeland 2015; Farrell and Newman 2019; Drezner, Farrell and Newman 2021; Park Jong Hee 2022). For example, one of the key concepts of weaponization of interdependence presented by Farrell and Newman (2019) is the "chokepoint," which refers to critical technologies or products that provide countries complete control over information and resource flows. Technologies or industries that can maximize the offensive aspect of supply chain dominance can be considered chokepoints. However, the concept of weaponization of interdependence has limitations in fully explaining the defensive aspect of economic security. In the defensive aspect, a concept similar to supply chain dominance is "resilience." Resilience is connected to the defensive concept of supply chain dominance, and an economic system with strong resilience can be considered to have high defensive supply chain dominance. Additionally, Japan's core economic security concepts of strategic autonomy (略的自律性) and strategic indispensability (略の不可欠性) correspond to the defensive aspect (import vulnerability) and offensive aspect (export power) of supply chain dominance, respectively.

The document that most clearly shows the importance of supply chains in U.S. economic security strategy is the supply chain report (The White House, 2021b). The supply chain

report was prepared following Executive Order 14017 (The White House, 2021a) issued on February 24, 2021, shortly after the Biden administration took office, ordering a comprehensive review of U.S. supply chains. The report involved National Security Advisor Jake Sullivan, White House and administration officials, and key private sector stakeholders such as the U.S. Semiconductor Industry Association. The report summarizes that “More secure and resilient supply chains are essential for our national security, our economic security, and our technological leadership” (The White House, 2021b, 6).

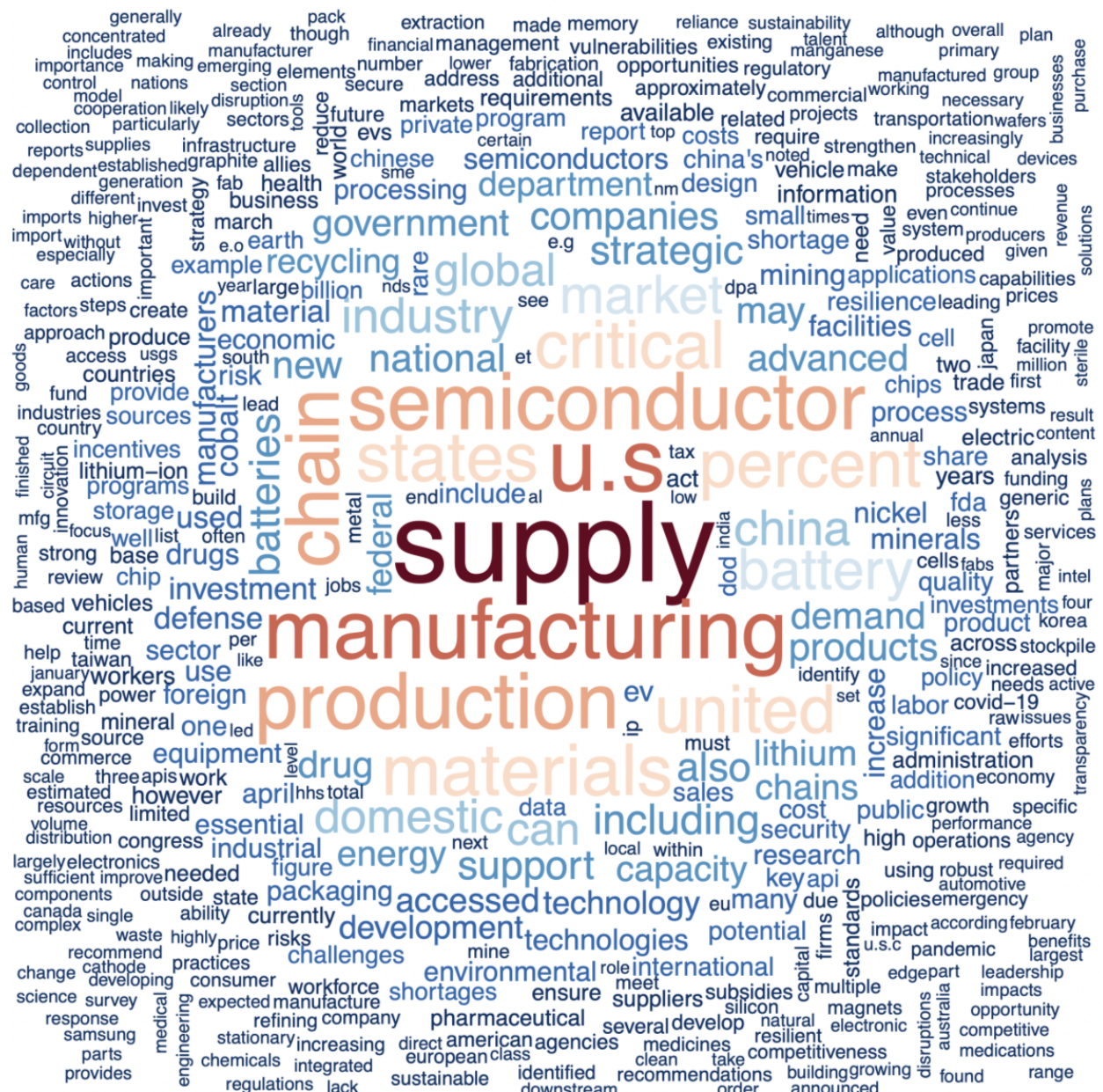


Figure 3: Supply Chain Report (The White House 2021b) Unigram Word Cloud

Figures 3 and 4 show word cloud visualizations of one-word and two-word terms extracted from the supply chain report. The one-word analysis shows the most frequently appearing

words, while the two-word analysis shows how frequently appearing words were specifically used in phrases.

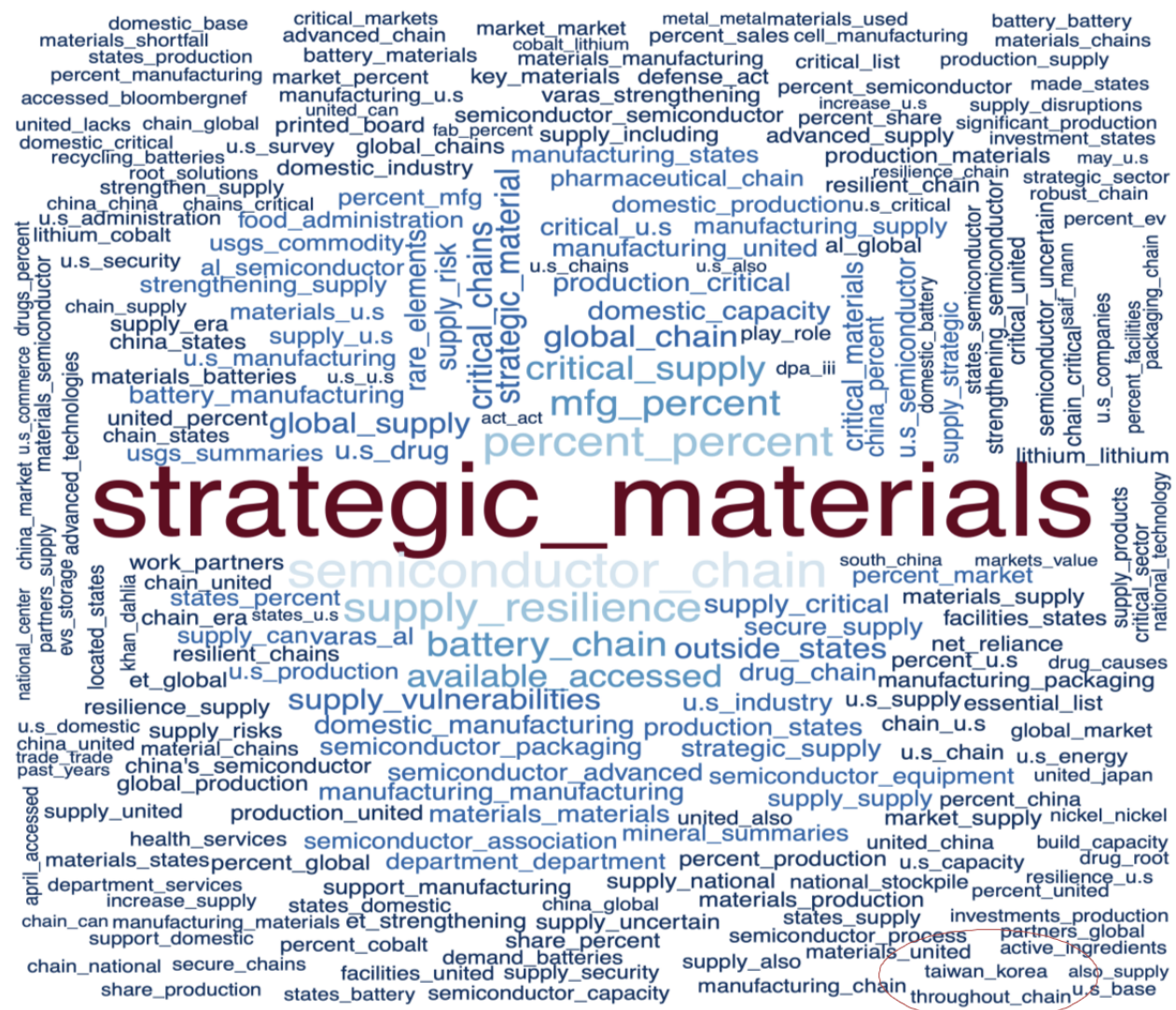


Figure 4: Supply Chain Report (The White House 2021b) Bigram Word Cloud

Looking at one-word terms, supply, manufacturing, U.S., production, semiconductor, resources, chain, battery, China, market, nickel, enterprise, pharmaceuticals, and capability appear most frequently. Interestingly, “percent” appears as a key word alongside these supply chain-related terms, indicating that the report’s core focus was an empirical investigation of supply chain dependencies.

Figure 4 shows the frequency of two-word terms. The most notable point is the high interest in “strategic resources.” The report’s important content includes U.S. dependence on strategic resources in supply chains for batteries, semiconductors, pharmaceuticals, etc. After strategic resources, the most important terms are semiconductor supply chain, supply chain resilience, and battery supply chain.

4 Supply Chain Dominance Index

4.1 Power and Vulnerability in Global Supply Chain

This study defines supply chain dominance through two key capabilities: (1) *a country's ability to control or influence global supply chains through the dominant position of major export companies or export products*, and (2) *a country's ability to protect its domestic economy from disruptions in global supply chains*. The first capability is conceptualized as “export power,” while the second is conceptualized as “import vulnerability.”

Both export power and import vulnerability are relational concepts, defined within bilateral national relationships. The difference between export power and import vulnerability represents a country's supply chain dominance. Countries with export power exceeding their import vulnerability possess positive supply chain dominance, while those with lower export power than import vulnerability have negative supply chain dominance, meaning they are exposed to other countries' supply chain control. Export power and import vulnerability are mirror concepts - Country A's export power over Country B equals Country B's import vulnerability to Country A.

To measure export power and import vulnerability at the bilateral-product level, we employed the following methodology:

- Products were defined using 6-digit HS codes, the most granular international trade product classification currently in use
- For industry aggregation, we additionally used first digit, first two digits, and first four digits of HS codes
- Export-import data for 6-digit HS products was collected annually through UN COMTRADE (<https://comtradeplus.un.org/>) from 1995 to 2021 (27 years total)
- To resolve inconsistencies between export and import data records, we implemented a comprehensive approach where all import data was converted into equivalent export data format and merged with the existing export dataset. After eliminating duplicate entries, we utilized all remaining data points, thereby minimizing data loss that could occur from incomplete reporting.

The proposed export power (or import vulnerability) is defined by four conditions:

- **Major Economic Player:** Countries accounting for $\geq 0.1\%$ of global exports. This addresses the problem of smaller economies being overrepresented when normalizing by ratios due to extreme economic size disparities.
- **Bilateral Dependence:** As an importing country's dependence on specific products from a particular exporting country increases, vulnerability to supply chain disruptions also increases. The importing country's dependence grows with the import share of specific products and the number of dependent products.
- **World Dependence:** As an exporting country's global export share of specific products increases, their irreplaceability grows, as does their influence over product pricing, technology, distribution, standards, and inter-firm cooperation. Control over supply chain disruptions proportionally increases with world market share.
- **Product Complexity:** Products that play crucial roles in national economic growth, are essential to global economic function, or are highly technology and capital-intensive carry significant supply chain dominance. We used Tacchella et al. (2013)'s method for complexity calculations.

When these four conditions are met, we define an exporting country as having export power over importing countries. The formulas presented show:

- Formula 1: Measures export power at product and bilateral country level
- Formula 2: Aggregates product-level measurements to bilateral relationship level
- Formula 3: Further aggregates to individual country level
- Formula 4: Defines supply chain dominance (SCD) as the difference between export power and import vulnerability

product export power

$$\begin{aligned}
 \text{product export power}_{ijkt} &= \overbrace{\mathbf{1}\left(\frac{\sum_{jk} y_{ijkt}}{\sum_{ijk} y_{ijkt}} > 0.01\%\right)}^{\text{Major Economic Player}} \overbrace{\mathbf{1}\left(\frac{y_{ijkt}}{\sum_i y_{ijkt}} > \tau_a\right)}^{\text{Bilateral Dependence}} \quad (1) \\
 &\quad \underbrace{\mathbf{1}\left(\frac{\sum_{ij} y_{ijkt}}{\sum_{ij} y_{ijkt}} > \tau_b\right)}_{\text{World Dependence}} \underbrace{\mathbf{1}(\text{PCI}_{kt} > \text{median}(\text{PCI}, t))}_{\text{Product Complexity}} \quad (2)
 \end{aligned}$$

Note that $\text{product export power}_{ijkt}$ is a binary measure of four components. We consider all four components to be necessary conditions for country i 's export power over country j in the global supply of product k at year t .

Since our measure of **product export power**_{*ijkt*} is disaggregated at the product and dyad levels, it can be aggregated to the dyad and country levels. First, we aggregate **product export power**_{*ijkt*} at the dyad level.

dyadic export power

$$\text{dyadic export power}_{ijt} = \sum_k \text{product export power}_{ijkt}. \quad (3)$$

dyadic export power_{*ijt*} is a directed measure of export power from country *i* to country *j*. One convenient property of our measure is the symmetry. That is, the export power of country *i* to country *j* for a product corresponds to the import vulnerability of country *j* to country *i* for the same product. Thus, the import vulnerability of country *j* on country *i* for the supply of product *k* is defined as follows:

dyadic import vulnerability

$$\text{dyadic import vulnerability}_{jit} = \sum_k \text{product export power}_{ijkt}. \quad (4)$$

It is straightforward to compute country-level aggregates.

export power

$$\text{export power}_{it} = \sum_j \text{dyadic export power}_{ijt}. \quad (5)$$

import vulnerability

$$\text{import vulnerability}_{jt} = \sum_i \text{dyadic import vulnerability}_{jit}. \quad (6)$$

Last, we compute supply chain dominance (SCD) by subtracting **import vulnerability**_{*it*} from **export power**_{*it*}. Since both are count measures, subtraction maintains the count property and hence it is easy to interpret SCD as a country's export power relative to its import vulnerability. SCD of a country is calculated as the gap between the country's offensive capacity and its defensive capacity with regard to economic security.

SCD

$$\text{SCD}_{it} = \text{export power}_{it} - \text{import vulnerability}_{it}. \quad (7)$$

Note that we need **import vulnerability**_{*it*}, not **import vulnerability**_{*jt*}, to compute **SCD**_{*it*}.

4.2 On Product Complexity

Product complexity is calculated based on two principles: diversification (products made by countries that export diverse products have higher complexity) and uniqueness (products made by few countries have higher complexity) (Tacchella et al., 2013). The uniqueness principle aligns with the concept that products important for calculating export power and import vulnerability are produced by a limited number of countries. For comparison with other well-known complexity indicators (Hidalgo and Hausmann, 2009), refer to Tacchella et al. (2013). Figure 5 shows an example of country-product export network. Node colors indicate complexity degree in order of red-yellow-green-blue.

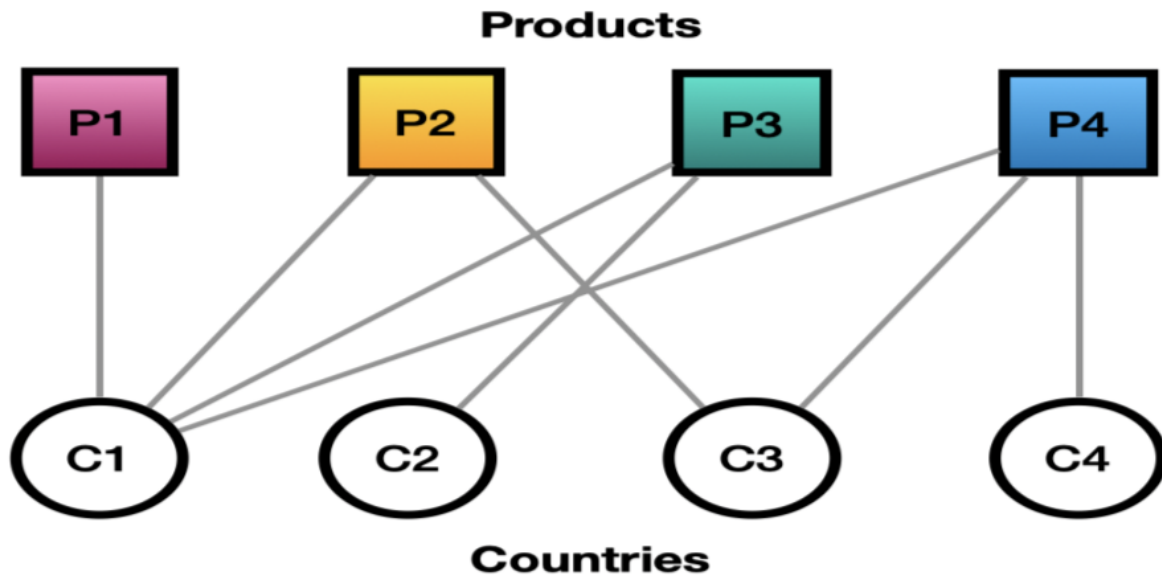


Figure 5: Example of country-product export network. The node colors indicate the degree of complexity in the order of red-yellow-green-blue.

For example, in the network showing production relationships of four countries (C1, C2, C3, C4) and their products (P1, P2, P3, P4), product complexity decreases in order from P1 (highest) to P4 (lowest). Specifically, based on the diversification principle, between two products made by the same number of countries, a product (P3) made by countries with lower average production diversity has lower complexity than a product (P2) made by countries with higher diversity. Based on both diversification and uniqueness principles, a product (P1) made by a single country with the highest production diversity has the highest complexity.

Figure 6 shows export-import relationships for three types of products among three major trading countries. Product 3, belonging to the lower 50% in product complexity, is excluded. Among bilateral export-import relationships by product, C3's export of Product 1 is excluded because it doesn't exceed τ_b , the World Dependence threshold of the export country's share in global trade volume. C2's export of Product 1 to C3 is excluded because it doesn't exceed τ_a , the bilateral dependence threshold. Consequently, export power is calculated in order of C1, C2, C3. Applying the same calculation to each country's import relationships shows C3

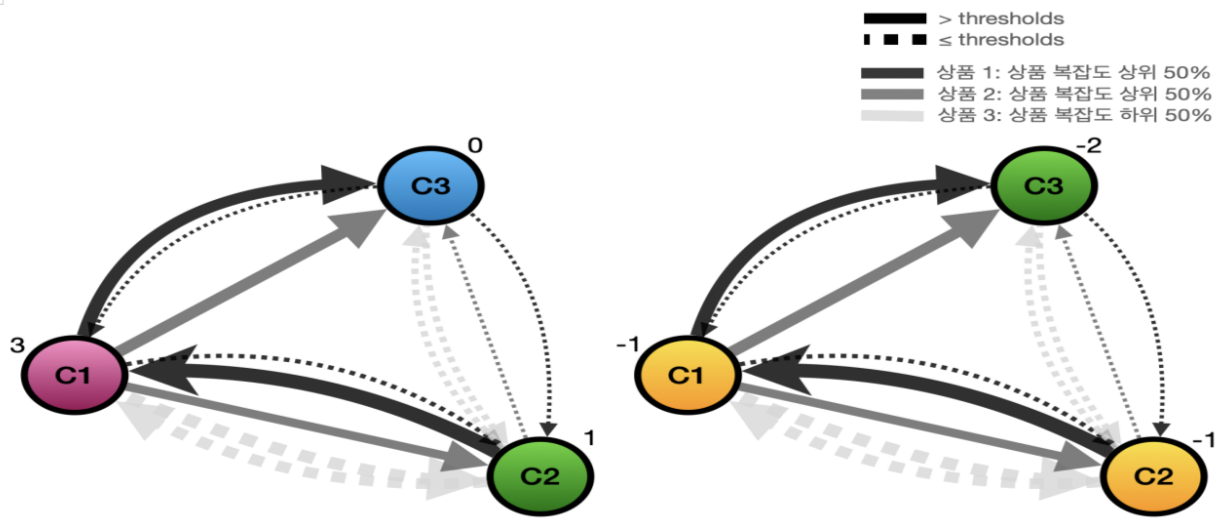


Figure 6: Calculation of export power and import vulnerability in the example network. Thresholds indicate the introduced threshold values, and the numbers above country nodes represent the country-level values of the respective indicators. Left) Colors indicate the degree of export power in the order of red-yellow-green-blue, with red representing countries with the highest level of power. Right) Numbers represent -import vulnerability, and colors indicate the degree of vulnerability in the order of red-yellow-green-blue, with blue representing the most vulnerable countries.

is more vulnerable than C1 and C2, which show equal vulnerability levels. Therefore, supply chain dominance is measured highest for C1, followed by C2 and C3.

Illustration: Saudi Arabia's Oil Export to South Korea

Let's consider Saudi Arabia as an exporting country, South Korea as an importing country, and oil as the product. Looking at bilateral dependency, South Korea's oil import share from Saudi Arabia in 2021 was 0.293, meaning Saudi Arabia provides 29.3% of Korea's oil imports. The higher this proportion, the stronger the exporting country's influence over the importing country, and conversely, the greater the importing country's vulnerability. In terms of global dependency, Saudi Arabia accounts for 12.2% of global oil production in 2021. Thus, Saudi Arabia's oil production share as an exporting country is 0.122. The higher this figure, the greater dominance the exporting country has over that product's supply chain, and conversely, the greater vulnerability importing countries face. Oil, being essential for industrial production and economic activity, has above-average complexity in international trade networks. Therefore, Saudi Arabia has export power over Korea regarding oil, while Korea has import vulnerability to Saudi Arabia regarding oil.

When an exporting country maintains both a very high global production share of a specific product and a very high export share to a specific importing country, it possesses strong export power. Saudi Arabia produces 12.2% of global oil and provides 29.3% of Korea's oil imports. If Saudi Arabia, producing 12.2% of global oil, unilaterally stops exports to Korea, while we could find alternative oil suppliers, they would likely have smaller production shares than Saudi Arabia, potentially increasing costs in terms of price and supply stability. If Saudi Arabia's global oil production share were to increase significantly, securing alternative suppliers during an export suspension might become impossible.

The fact that 29.3% of Korea's oil imports come from Saudi Arabia means more than just receiving large oil supplies; it indicates structural dependence of Korean industries (e.g., refining industry) that use oil as a main input on Saudi Arabian oil imports. This implies significant asset specificity in terms of shipping routes, contractual relationships, business relationships, insurance, price predictability, and refining technology. Asset specificity can lead to the hold-up problem in political economy, potentially resulting in disadvantages like breach of promises or changes in initial contract terms using dependency relationships. Therefore, Saudi Arabia's export suspension or threats thereof can translate into significant political influence. If the product contains core technology determining future economic growth and success in international competition, the importance of export power and import vulnerability becomes even greater.

4.3 Supply Chain Dominance Index

In this chapter, we will introduce the results of applying the previous discussions to bilateral trade data provided by UN COMTRADE. Figure 7 shows histograms of export power, import vulnerability, and supply chain dominance calculated for bilateral dependency of 0.4 and world dependency of 0.1. First, the distribution of export power shows a highly unequal pattern similar to a power-law distribution. International trade can be characterized by an asymmetric and unequal structure divided between a small number of countries with powerful export power and many countries with almost no export power. On the other hand, import vulnerability (middle of Figure 7) shows a relatively symmetrical pattern like a normal distribution. This means that there are few countries with extremely high or extremely low import vulnerability, and most countries are concentrated around the average level of import vulnerability. Noting that these indicators are all values not normalized for the economic size of countries, the mean-centered distribution of import vulnerability is more notable than the concentration of export power. In other words, it can be seen as a structural characteristic of the international trade order that even a small number of countries with large economic scale and powerful export power have similar levels of import vulnerability as countries that do not. The right figure in Figure 7 well illustrates this characteristic. The distribution of supply chain dominance is concentrated in a small number of powerful countries, and most of the remaining countries have negative values.

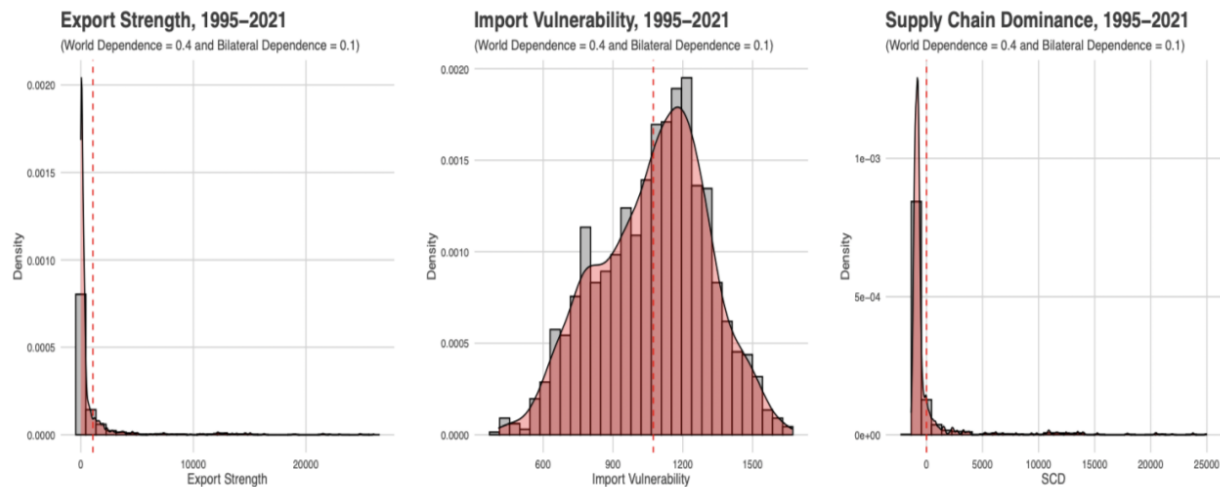


Figure 7: Export power, import vulnerability, and supply chain dominance histogram, 1995-2021

Figure 8 visualizes the temporal changes in export power and import vulnerability for nine major trading countries. The flow of time is distinguished by the shade of the dots, with more recent data having darker shades. China's change is most noteworthy. China's export power is rapidly rising without a significant increase in import vulnerability. In contrast, the United States and Germany experienced relative decline in export power during the same period. Interestingly, unlike Germany, the United States' relative decline was accompanied

by an increase in import vulnerability. South Korea and Japan share the commonality of rapidly increasing import vulnerability, but while Japan's export power declined, South Korea's export power appears to have slightly increased or remained stagnant.

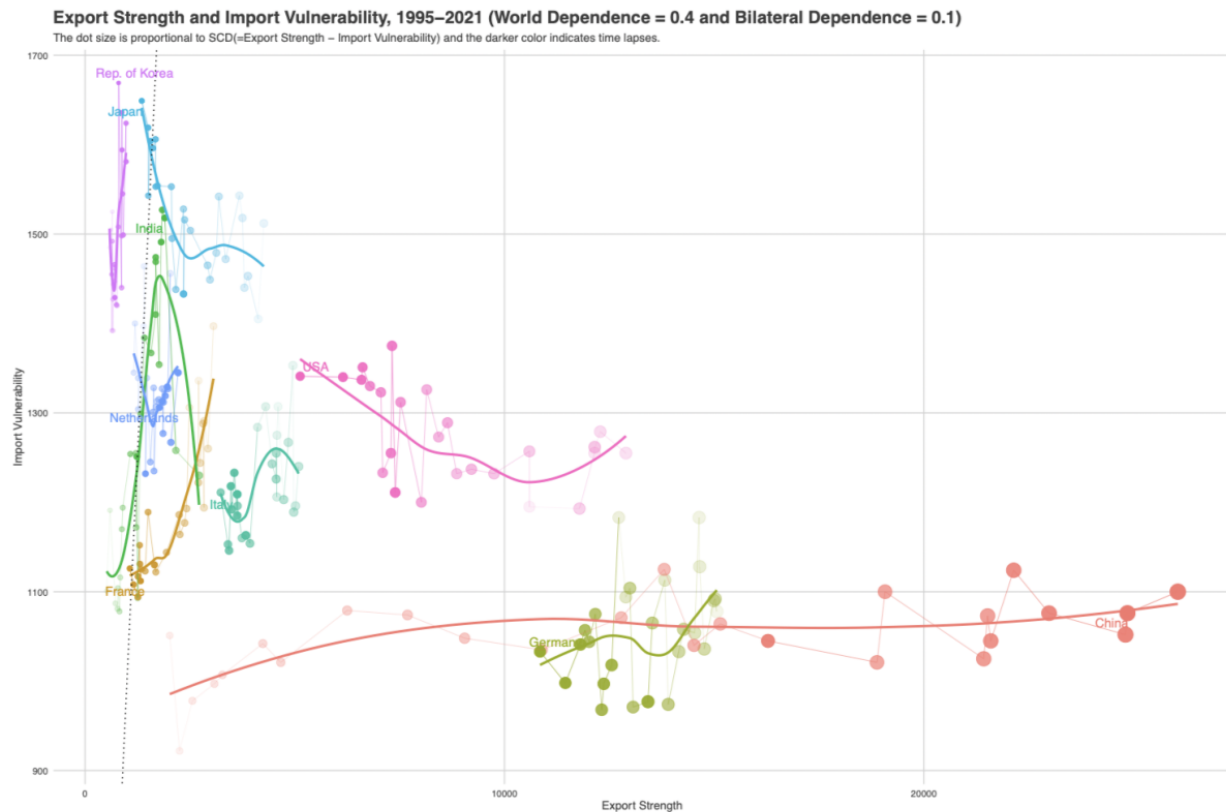


Figure 8: Changes in export power and import vulnerability for China, United States, Germany, Japan, Italy, Netherlands, France, and South Korea: The size of dots is proportional to the Supply Chain Dominance (SCD). The shading of dots represents the flow of time, with more recent data appearing darker.

Figure 9 visualizes the changes in countries excluding China, United States, Germany, Japan, Italy, Netherlands, France, and South Korea. The fact that most countries are located above the 45-degree dotted line indicates that these countries mostly have import vulnerability greater than their export power. In other words, most trading countries except China, United States, Germany, Japan, Italy, Netherlands, and France maintain a state where import vulnerability is greater than export power, and can be seen as being exposed to the supply chain dominance of countries with strong export power.

Figures 10 and 11 visualize the ranking changes of the top 20 countries in export power and import vulnerability. While ranking information has the problem of showing gaps between ranks as if they were equal since it is relative information rather than absolute magnitude, it has the advantage of easily grasping the dynamics of power in the economic security domain.

The rankings of the top 10 countries in export power can be summarized as follows:

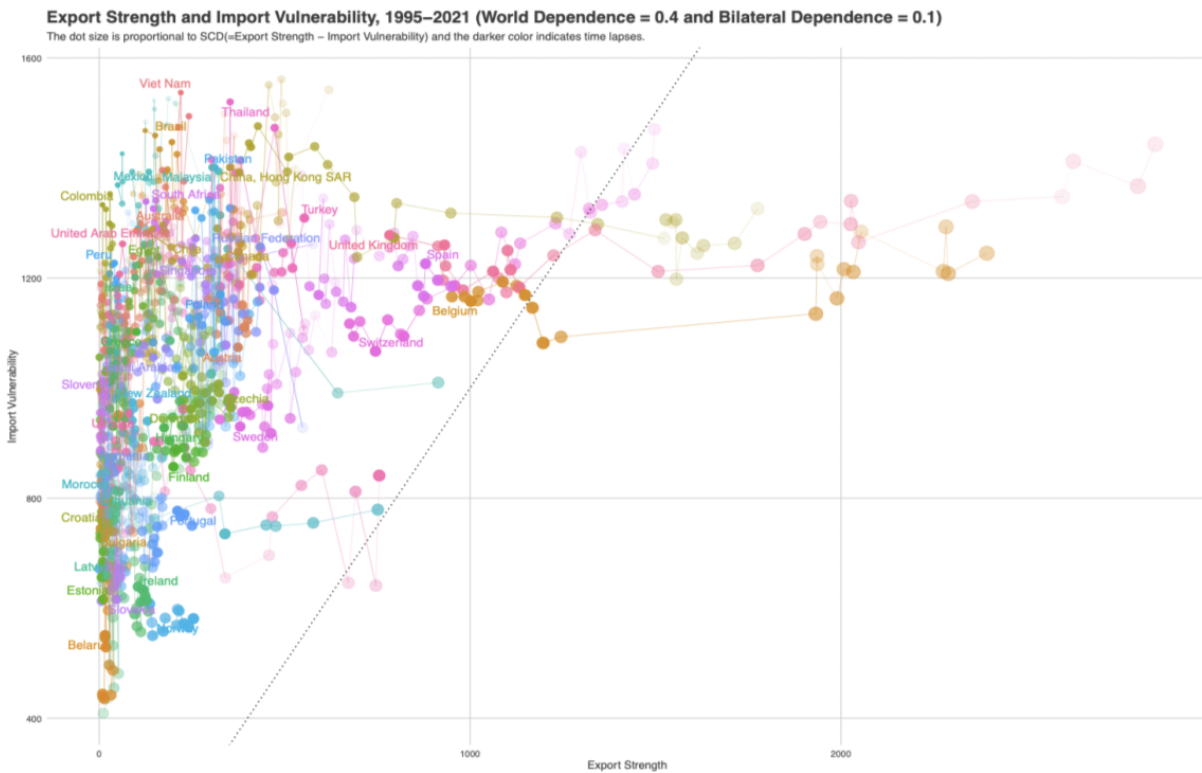


Figure 9: Changes in export power and import vulnerability for countries excluding major nations

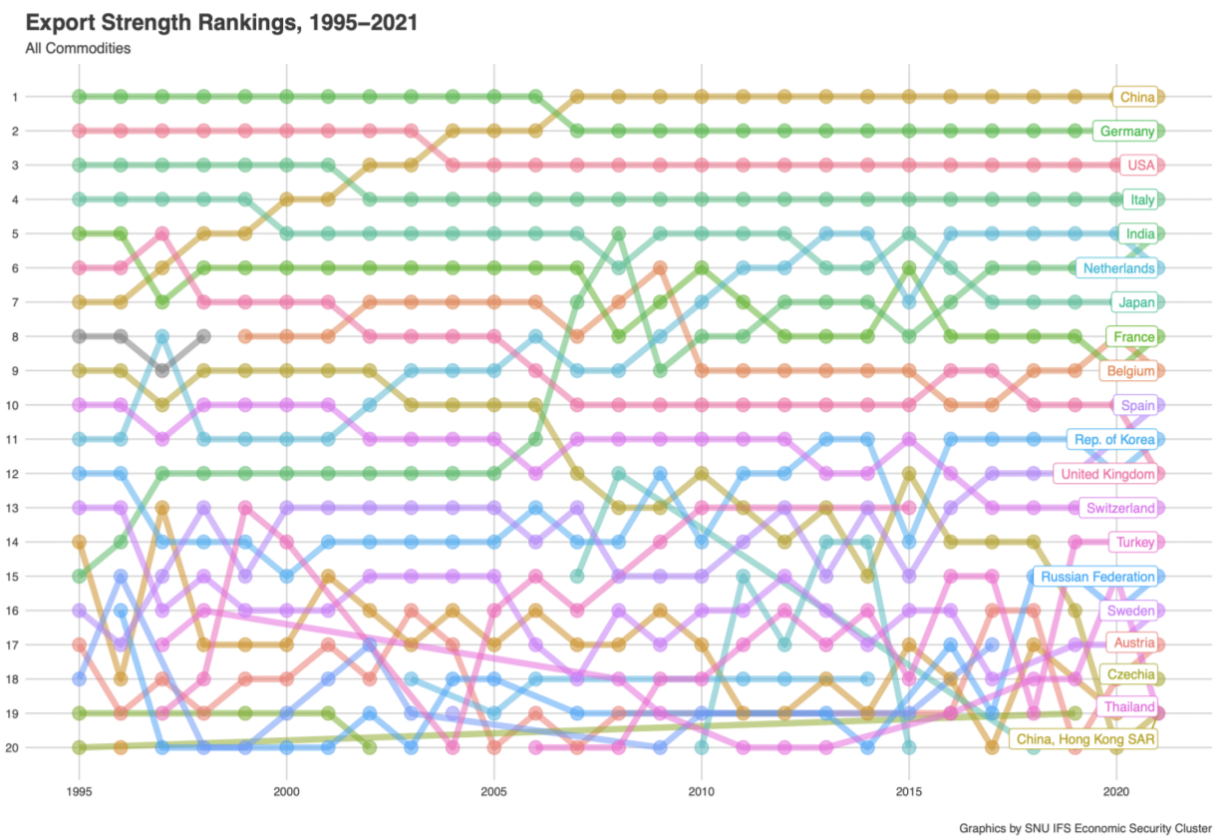


Figure 10: Temporal changes of top 20 countries in export power

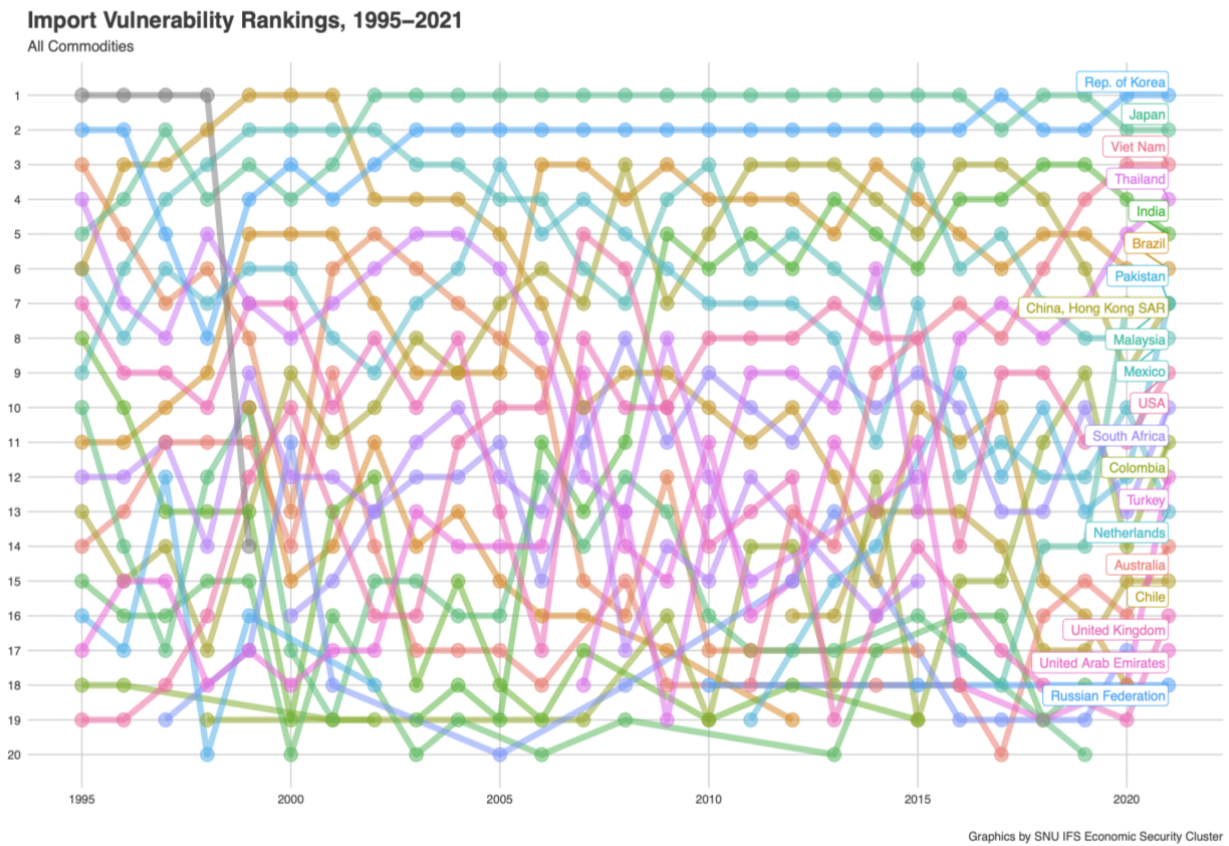


Figure 11: Temporal changes of top 20 countries in import vulnerability

Key Findings from Top 10 Countries

- China pushed the United States to third place in 2004, and then overtook Germany to become the country with the highest export power in 2007. Along with China's rise, Hong Kong's decline is noticeable. Hong Kong was a strong small country with the 9th highest export power in 1995, but its ranking dropped to 19th in 2021.
- India's upward trend is noteworthy. India, which remained at 15th place in 1995, rose to 5th place in 2021, becoming a country with significant export power. The Netherlands also rose from 11th place in 1995 to 6th place in 2021.
- South Korea started at 12th place in 1995, dropped to 15th, and then rose again to 11th place in 2021. During the same period, Japan fell from 4th to 7th place.
- The ranking changes in import vulnerability are much more dynamic. South Korea surpassed Japan in 2020 to become the country with the highest vulnerability. The United States started from 18th place in import vulnerability in 1995 and steadily increased in import vulnerability. It shows 9th place in import vulnerability in 2021. This shows that the United States, despite having a large economic scale, depends on a small number of countries for a considerable portion of its imports.
- Vietnam, which was outside the rankings, emerged with import vulnerability at 18th place from 2011, and then steadily increased in import vulnerability to become the country with the 3rd highest import vulnerability in 2021. Thailand shows a similar upward trend to Vietnam, suggesting that the economic growth of Thailand and Vietnam shows a pattern of high growth based on import vulnerability similar to the growth patterns of Japan and South Korea.
- Russia emerged at 18th place in import vulnerability in 2010 and has remained in a similar position.
- Hong Kong's import vulnerability rose from 13th place in 1995 to 7th place in 2021.

4.4 Supply Chain Dominance Network

The expressions "chokepoint" and "supply chain," most frequently mentioned in economic security, suggest that power in economic security operates through networks that govern economic relationships. In other words, while the sources of power that determine economic security stem from national attributes such as corporate technological capability, productivity, human resource excellence, and technological and economic policies, the way this fundamental power operates is greatly influenced by the network to which that country belongs. This is because advantages or disadvantages from bilateral relationships can be offset or amplified by relationships with actors outside those bilateral relationships. Therefore, it is necessary to examine supply chain dominance patterns at the global network level along with country-specific characteristics and bilateral relationships.

Figure 12 visualizes the supply chain dominance network using data from 1995 and 2021. Arrows indicate the direction of export power, and their thickness is proportional to the magnitude of that power. Node size represents the export power of the corresponding country. Information about import vulnerability can be checked in the reverse direction of the arrows, and node information about import vulnerability is omitted due to visualization limitations.

The 1995 supply chain dominance network is divided into two clusters: Europe and Asia-Pacific. The European cluster is centered around Germany and consists of Italy, the UK, France, Netherlands, etc., while the Asia-Pacific cluster is centered around the United States and consists of Japan, Hong Kong, China, etc. The figure clearly shows that Germany and the United States had powerful dominance over almost the entire world's supply chains.

The 2021 supply chain dominance network is also divided into two clusters of Europe and Asia-Pacific, but compared to 1995, the two clusters have become more integrated, and the center of the Asia-Pacific cluster has changed significantly. It is centered around China and consists of the United States, Japan, India, South Korea, etc. While the United States and Germany have strong local supply chain dominance, China has now become the country with global supply chain dominance. China has become a country with considerable export power not only to Asia-Pacific countries but also to European, African, and Middle Eastern countries.

This can be summarized as follows:

Node size and edge width are proportional to export power.
Observations with edge strength over 10 and ego strength over 25 percentile are present.



Node size and edge width are proportional to export power.
Observations with edge strength over 10 and ego strength over 25 percentile are present.



Figure 12: Supply Chain Dominance Network, 1995 and 2021

Key Findings of Supply Chain Dominance Network

- **China's Supply Chain Dominance:** China's rise in export power ranking is most notable in the overall data. China pushed the United States to third place in 2004, then overtook Germany to become the country with the highest export power in 2007. China's increase in export power proceeded without an increase in import vulnerability.
- **Weakening of US Supply Chain Dominance:** The US started from 18th place in import vulnerability in 1995 and steadily increased in import vulnerability. It shows 9th place in import vulnerability in 2021. This shows that the US, despite having a large economic scale, depends on a small number of countries for a considerable portion of its imports.
- **Vulnerability of Korea and Japan:** Korea and Japan have economic forms that grow by depending on a small number of countries for imports in extensive areas. Korea and Japan have been the two countries with the highest import vulnerability since the 2000s. As of 2021, Korea ranks 1st in import vulnerability and Japan ranks 2nd. In export power, Korea started at 12th place in 1995, dropped to 15th, and rose again to 11th place in 2021. During the same period, Japan fell from 4th to 7th place.
- **Hong Kong's Decline:** Hong Kong was a strong small country with 9th place export power in 1995, but its ranking dropped to 19th place in 2021. Import vulnerability rose from 13th place in 1995 to 7th place in 2021.
- **India's Rise:** India, which remained at 15th place in 1995, rose to 5th place in 2021, becoming a country with significant export power. The Netherlands also rose from 11th place in 1995 to 6th place in 2021.
- **Increase in Import Vulnerability of Vietnam and Thailand:** Vietnam, which was outside the rankings in import vulnerability, emerged at 18th place from 2011 and steadily rose to 3rd place in 2021. Thailand shows a similar upward trend to Vietnam, suggesting that the economic growth of Thailand and Vietnam shows a pattern of high growth based on import vulnerability similar to the growth patterns of Japan and Korea. Thailand and Vietnam, like Korea and Japan, experienced rapidly rising import vulnerability during the same period.

4.5 Supply Chain Dominance in 12 New Industries

Let's narrow our focus to examine supply chain dominance in core industries of next-generation technology competition, looking at 9 areas (electric vehicles, robotics, bio-health, aerospace, premium consumer goods, new energy industry, advanced new materials, next-generation displays, next-generation semiconductors) among the 12 new industries designated by the government and Korea International Trade Association in March 2017 that are closely related to the Fourth Industrial Revolution. The product codes used in the analysis were referenced from Moon Byung-ki and Lee Do-hyung (2017).

As shown in Figure 13, export power in new industries shows powerful Germany and China competing for first place, with the United States, South Korea, and Japan competing for 3rd-5th places behind them. Import vulnerability shows even more dynamic patterns. As of 2021, import vulnerability rankings are South Korea (1st), Japan (2nd), Netherlands (3rd), Hong Kong (4th), and the United States (5th).

It is particularly noteworthy that while South Korea shows the highest import vulnerability in new industries as well, its supply chain dominance in new industries has risen to positive values since 2017, with export power ranking 4th in 2021. With this, unlike in overall industries, South Korea's export power in new industries has begun to slightly surpass its import vulnerability. Although the reality facing South Korea in the upcoming era of technological competition is not easy, this well demonstrates that the Korean economy has established a certain foothold in new industry competition.

The analysis of new industries can be summarized as follows:

Key Findings of Supply Chain Dominance in 12 New Industries

- Structural changes in new industry export power: The structure of five major powers (Germany, China, US, Japan, South Korea) has been changing to a structure of four major powers excluding Japan since 2018
- South Korea's potential: While South Korea shows the highest import vulnerability in new industries as well, its supply chain dominance in new industries has risen to positive values since 2017, with export power ranking 4th in 2021. Although the reality facing South Korea in the upcoming era of technological competition is not easy, the Korean economy has established a certain foothold in new industry competition



Figure 13: Changes in export power and import vulnerability in new industries

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