

Korea in The Global Innovation Network: Navigating Technological Interdependence

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I. Introduction

As U.S.–China competition intensifies, rivalry is also sharpening within the global knowledge system. This raises a central question: how does deepening U.S.–China tension reshape the global innovation network (GIN)—the cross-border web through which knowledge is created, shared, and recombined?

Governments worldwide have long emphasized the strategic importance of science, technology, and knowledge. Yet science and technology policy has often been approached primarily as a domestic agenda. In today’s global economic environment—marked by heightened strategic competition—this perspective is increasingly incomplete. The key issues are not only how much a country invests in innovation, but also how its position within global knowledge networks is changing, how geopolitical frictions affect knowledge flows, and

what strategic direction policy should take in response.

This study therefore focuses on the cross-country and cross-industry structure of technology and innovation. Traditional policy approaches have tended to prioritize expanding total R&D spending. However, innovation cannot be generated by the R&D efforts of a single country, industry, or firm alone. A defining feature of innovation—often underappreciated in policy debate—is its networked and cumulative nature: advances in one sector shape the trajectory of innovation in others, often with long-run effects. Semiconductor progress, for example, does not remain within the semiconductor industry; it underpins innovation in telecommunications, computing, and automobiles. Conversely, knowledge developed in these downstream industries feeds

back into semiconductor advances. These interactions occur not only within national borders but also across them, as knowledge diffuses through multiple channels linking countries and sectors. Accordingly, effective R&D allocation and innovation strategy require explicit attention to international and intersectoral “network effects.”

Against this backdrop, this World Economic Brief traces how Korea and other major economies—including the United States, China, Japan, and Europe—have evolved within the global innovation network over 2000–2020. Using this network perspective, we examine (i) changing patterns of interdependence and (ii) shifts in countries’ relative positions across key technologies.

II. A New Perspective on Innovation Capacity Building

Traditional economic models of innovation typically begin with a closed-economy benchmark: a single country with no foreign sector. In this setting, the production of new knowledge (innovation) is explained primarily by three factors—(i) the domestically accumulated stock of knowledge, (ii) domestic effort, usually measured by R&D investment, and (iii) a country-specific productivity term that is often treated as time-invariant. Put simply, innovation is modeled as the outcome of building on what a country already knows and adding new R&D, with differences across countries attributed to underlying productivity.

A key limitation of this approach is its implicit assumption that knowledge accumulation is largely self-contained. Even within a single economy, technological progress in one industry can shape innovation opportunities in related industries. In a highly globalized world, the same logic applies across borders: countries learn from, build on, and respond to one another’s advances. It is therefore difficult to understand modern innovation without explicitly accounting for cross-industry and cross-country knowledge spillovers—that is, the network through which ideas circulate and compound over time.

Recent work has made this network perspective operational in economic analysis. Acemoglu, Akcigit, and Kerr (2016) were among the first to embed cross-country, cross-industry linkages in knowledge—measured using patent citations—into a formal economic framework. For empirical implementation, they represented “who cites whom” relationships in a structure analogous to an input–output matrix. Building on this methodology, Liu and Ma (2024) use the same network structure to study the design of optimal national R&D investment policy.

1. Theoretical Background

Building on the approach of Acemoglu, Akcigit, and Kerr (2016) and Liu and Ma (2024), global innovation network (GIN) theory extends conventional innovation frameworks by treating cross-country spillovers as a core input to the production of new knowledge.

Innovation, in this view, is not generated solely through domestic effort. Countries also rely on ideas developed abroad—drawing on external knowledge to complement domestic capabilities.

Because countries differ in technological strengths and specialization, their dependence on foreign knowledge varies. These interdependencies can be summarized systematically in a country-by-country matrix that records “who uses whose knowledge.” From Korea’s perspective, for example, one can quantify (i) the extent to which Korean patents cite knowledge from the United States, Japan, Europe, and other parts of Asia, and (ii) the extent to which those economies cite Korean patents. Together, these two directions of knowledge flows can be assembled into a single, interpretable structure.

To capture these complex interdependencies more fully—across both countries and industries—this study adopts the concept of an innovation network. Formally, the innovation network is represented as a weighted directed graph. Using standard network terminology: Nodes correspond to industries in a closed-economy setting, or to country–industry pairs in an open-economy setting. Directed edges represent the direction and strength of knowledge diffusion—indicating how strongly innovation in one node draws on knowledge generated in another.

This network representation provides a clear and policy-relevant way to describe how innovation is produced through interconnected

knowledge flows, rather than within isolated national or sectoral boundaries.

2. Data

To build the patent-citation network, this study relies primarily on the Google Patents Public Dataset and, for firm-level analysis, links it to the Orbis Intellectual Property & Financial Database. The empirical analysis covers 2000–2020.

Google Patents provides broad global coverage—over 120 million patent documents issued by more than 100 patent offices—making it well suited to tracing cross-border knowledge flows through citations. Orbis complements this with firm-level information, including patent ownership, R&D expenditure, and financial indicators, as well as detailed data on ownership structures and M&A activity through its dedicated intellectual property modules.

A key methodological step is to ensure comparability across data sources. Industry-level analysis requires harmonizing classification systems that are defined on different bases: technology-oriented patent classifications (CPC/IPC), production-oriented inter-country input–output tables (ICIO), and firm-level information from Orbis. Because these systems do not share a common taxonomy, we first translate technologies into industries using an established linking procedure.

Specifically, we adopt the Algorithmic Links

with Probabilities (ALP) approach developed by Nikolas Zolas, which statistically maps patent technology codes to industries by linking CPC codes to NAICS industries. Applying this method, we assign each patent's CPC code to an industry classification and thereby convert a citation network defined at the technology level into an industry-level innovation network.

For the firm-level component, Orbis allows us to connect each firm to the individual patents it owns, each of which carries CPC technology codes. Firms can therefore be mapped to specific technology nodes in the network based on their patent portfolios. This linkage makes it possible to examine where firms are positioned within the broader industry–technology network and how their innovation activity relates to global knowledge flows.

III. The GIN and Korea

This subsection uses patent-citation data for 2000–2020 to document a set of stylized facts on how the global innovation network has evolved. The analysis is organized around five complementary lenses: country's centrality, participation patterns of major economies, changes in cross-country citation linkages, leading technologies and industries, and firm-level evidence from Korean patents.

First, we quantify shifts in countries' positions by computing eigenvector centrality for each country in the global innovation network, tracing how the relative influence of major

economies changes over time. Second, we examine how major economies participate in the network by jointly assessing (i) external dependence—the extent to which a country's patents rely on foreign knowledge—and (ii) international contribution—the degree to which its patents are cited abroad. Combining these two dimensions, we classify country–technology positions into four types: leader, hub, self-reliant, and catch-up. This framework allows us to identify countries that sustain leadership, those that move from catch-up toward self-reliance, and those seeking to join the leading group. Third, we provide a detailed account of network reconfiguration by tracking changes in the shares of cross-country patent citations among major economies. Two patterns are particularly salient: China's citation structure becomes increasingly domestically oriented, while mutual citations between Korea and China rise. Fourth, we identify technologies and industries that drive global innovation by computing eigenvector centrality at the level of country–technology nodes. This reveals how the set of leading technologies and industries has shifted over time and highlights cross-country differences in technological leadership. Fifth, we complement these network-level findings with firm-level evidence by focusing on patents owned by Korean firms and summarizing how their cross-country citation relationships have evolved.

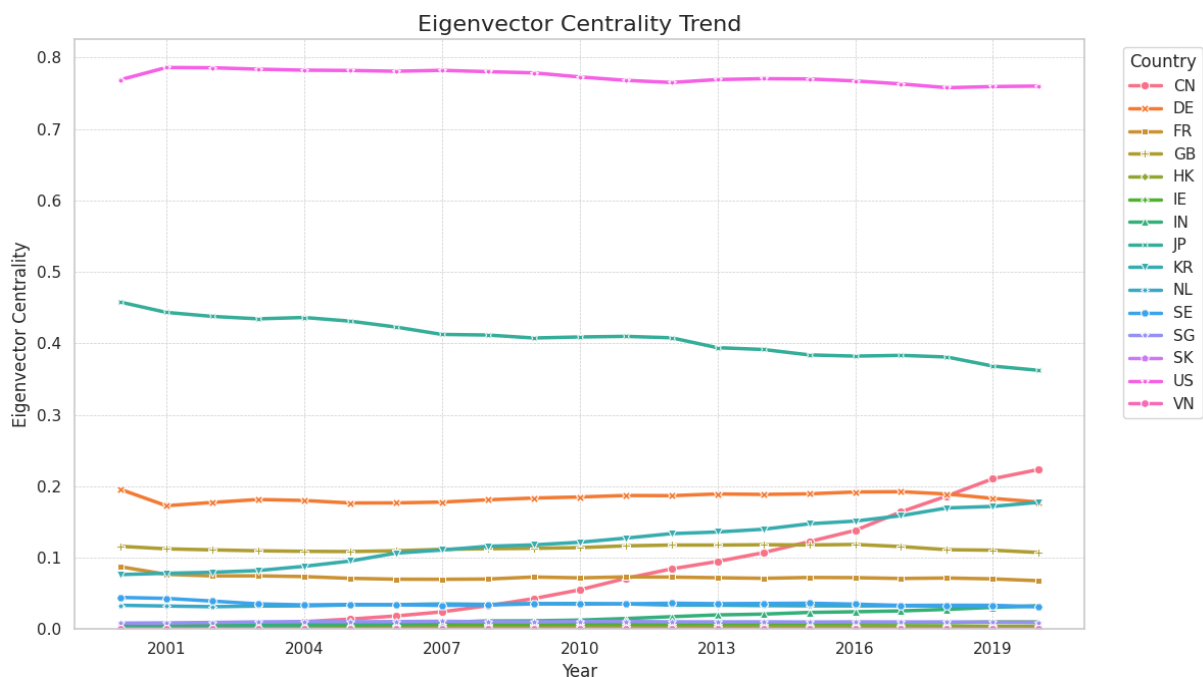
1. Diversification of Major Players

Over roughly the past quarter century, the

global innovation network has become increasingly multipolar. Figure 1 plots eigenvector centrality for the top 15 countries over 2000–2020, providing a clear picture of how each country’s relative influence and contribution within the network has shifted. In the early 2000s, the United States dominated the network by a wide margin, followed—at some distance—by Japan, Germany, the United Kingdom, and Korea. Two longer-run movements then stand out. First, Korea’s centrality rose steadily from the early 2000s. Korea overtook the United Kingdom in 2006 and surpassed Germany in 2018, indicating a gradual but persistent strengthening of Korea’s position in the global innovation system. Second,

China’s ascent was rapid and late-arriving. From the late 2000s onward, China’s centrality increased sharply; beginning around 2010, it sequentially overtook the United Kingdom, Korea, and Germany. Taken together, these patterns point to a diversification of the global innovation network: the United States remains highly influential, but China’s surge and Korea’s steady gains have contributed to a more distributed structure of innovation leadership.

Figure 1. Changes in Eigenvector Centrality among Major Economies (2000–2020, excluding domestic citations)



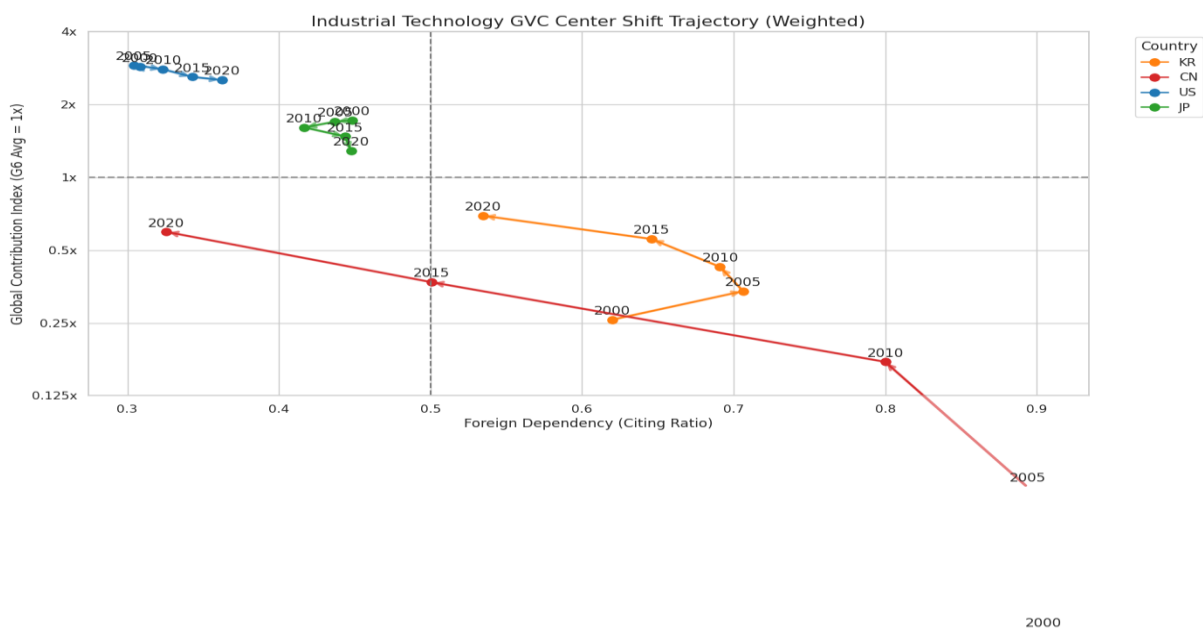
Source: Kim *et al.* (2026). Each country’s two-letter code follows the ISO international standard (ISO 3166). The United States is shown as the top pink dashed line (---); Japan as the second-highest green dashed line (---); Germany as the third-highest orange dashed line (---); and China as the red solid line with dot markers (-•-), ranking third from the top in 2020. China exhibits the fastest growth since the mid-to-late 2000s. Korea is the blue solid line with dot markers (-•-), ranking fourth from the top in 2020. Korea’s centrality has risen since the early 2000s, overtaking the United Kingdom in 2006 and Germany in 2018.

2. China's Rise

Figure 2 maps each country–technology pair into a two-dimensional space to summarize two key features of the global innovation network: reliance on foreign knowledge and international impact. Technologies are defined using CPC codes, and the figure allows comparisons across countries and over time. Horizontal axis (external dependence) represents the share of foreign patents among the patents cited by a given country–technology pair. A higher value indicates greater reliance on knowledge produced abroad. Vertical axis (international contribution) represents the extent to which patents in a given country–technology pair are cited worldwide, expressed as a multiple of the average citation frequency across six major patent-filing economies

(China, the United States, Germany, the United Kingdom, Japan, and Korea). A value above 1 implies above-average global influence. To aid interpretation, the plot is divided into four quadrants using two thresholds: a foreign-citation share of 0.5 and an international-contribution multiple of 1.0. These thresholds yield four stylized categories: 1. Knowledge hub (upper-right): high external dependence and high international contribution; 2. Technology leader (upper-left): low external dependence and high international contribution; 3. Technology self-reliant (lower-left): low external dependence and low international contribution; and 4. Dependent catch-up (lower-right): high external dependence and low international contribution.

Figure 2. Changes in Statuses in the Global Innovation Network (2000–2020)



Source: Kim et al. (2026).

Taken together, the joint evolution of global contribution and external dependence points to a clear structural shift in the global innovation network over the past two decades: China’s rapid ascent has reshaped citation patterns and, in relative terms, has reduced the standing of most incumbent technology leaders—with the United States as the main exception. China shows the most pronounced movement across the two dimensions. Since the 2000s, it has steadily lowered its reliance on foreign knowledge while raising its global citation impact. This trajectory is consistent with a transition toward a more domestically anchored innovation system, approaching what can be described as a “technology self-reliant” stage. Against this backdrop, the United States has largely preserved its role as the network’s core technology leader, maintaining high influence even as China’s weight has increased. Japan, which historically formed the other pillar of the technology-leader group, has continued to exhibit low external dependence, but its global contribution has gradually declined over the past 20 years—suggesting a relative erosion of influence rather than increased reliance on foreign knowledge. Korea follows a different path. Classified as a dependent catch-up economy in 2000, Korea has, over the past two decades, increased technological self-reliance and improved its global contribution, indicating an active push toward the technology-leader group. Nonetheless, as of 2020, Korea still exhibits high external dependence and its global

contribution remains below the average of the six major patent-filing economies.

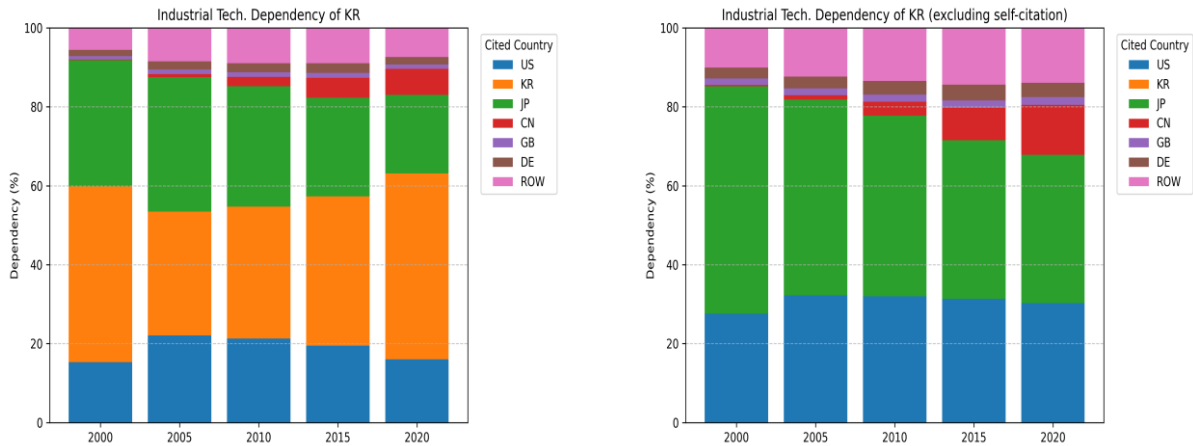
3. Expanding Mutual Citations between Korea and China

Figure 3 tracks how the country composition of Korea’s patent citations has changed, using five-year intervals. The results point to a gradual rebalancing of Korea’s knowledge sources—from heavy reliance on traditional technology leaders toward a mix of stronger domestic foundations and deeper linkages with China. First, domestic citations (citations to Korean patents) fell sharply in 2005, but have increased steadily since then, consistent with Korea’s strengthening internal technological base. Second, the structure of foreign citations has shifted markedly. Japan was the single largest foreign source of cited patents until around 2010, but its share has declined substantially thereafter. U.S. patents show a different pattern: dependence rose in 2005 and then gradually trended downward over time. Third, and most notably, citations to Chinese patents have increased rapidly during the same period. This suggests that Korea’s citation behavior has moved away from a pattern dominated by technology absorption from Japan and the United States, toward a structure in which domestic knowledge plays a larger role and China has become an increasingly important external reference point. Given the growing similarities in the industrial structures of Korea and China, and the strengthening of technological capabilities in both countries, the rise in mutual citations is consistent with

deeper two-way knowledge linkages—implying that each country is becoming more

consequential to the other’s production of new knowledge.

Figure 3. Changes in Foreign Citation Shares of Korean Patents (2000–2020)



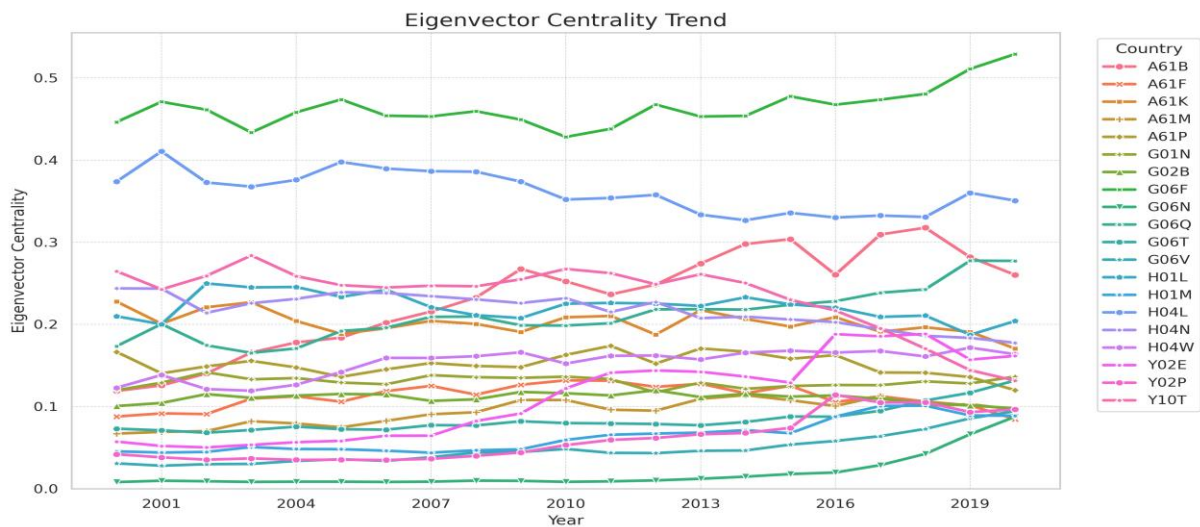
Source: Kim *et al.* (2026). (Left) Including domestic (within-Korea) self-citations; (Right) Excluding domestic (within-Korea) self-citations. United States: blue; Korea: orange; Japan: green; China: red; United Kingdom: purple; Germany: brown; other countries: pink

4. Evolution of Technologies: From Manufacturing-focused to Services-oriented

To identify the technologies that anchor the global innovation network, we select the top 20 CPC technology classes in 2020 and trace the evolution of their network centrality over 2000–2020. Figure 4 shows a clear structural shift in global technological leadership over the past two decades. The main pattern is the

growing dominance of technologies associated with digital transformation (ICT) and bio–healthcare. This reflects a move away from innovation centered on traditional manufacturing processes and hardware alone. Instead, technologies related to data, artificial intelligence (AI), and the life sciences have become increasingly central—emerging as core drivers of change in the global innovation network.

Figure 4. Changes in Foreign Citation Shares of Korean Patents (2000–2020)



Source: Kim et al. (2026). **G06F** (Digital Data Processing, top green) remains the long-standing leader in centrality, followed steadily by **H04L** (Digital Information Transmission, next blue) in second place. AI technology clusters like **G06N** and **G06V** are experiencing significant growth. Meanwhile, health and sustainability-related technologies (**A61**) are seeing a steep surge in prominence.

A central finding is the sustained—and in many cases rising—importance of ICT technologies in the global innovation network. G06F (digital data processing) has remained the most central technology throughout 2000–2020, and its centrality has continued to increase, underscoring its role as a foundational capability in the digital era. H04L (digital information transmission) has consistently ranked second, confirming that data processing and data transmission form the backbone of today’s innovation system. Within ICT, AI-related technologies show especially rapid gains. Centrality rises strongly for categories such as G06N (computing based on specific computational models) and G06V (image recognition). The sharp increase in G06Q (ICT for business and management) is particularly policy-relevant: it signals that competitiveness is increasingly shaped not

only by technological advances themselves, but also by data-driven organizational and business-model innovation. A second, increasingly important pillar is the expansion of technologies linked to health and sustainability. A61B (diagnostic and surgical technologies) records notable growth, suggesting that innovation is shifting toward MedTech, where electronics and medical technologies converge—such as precision diagnostics and medical devices—rather than remaining concentrated in traditional pharmaceuticals centered on chemical preparations (A61K). In parallel, the rising centrality of Y02E (greenhouse-gas reduction technologies) and Y02P (climate-change-mitigation production technologies) highlights the growing prominence of climate-related innovation. At the same time, several traditional technology domains have lost relative influence. Centrality falls

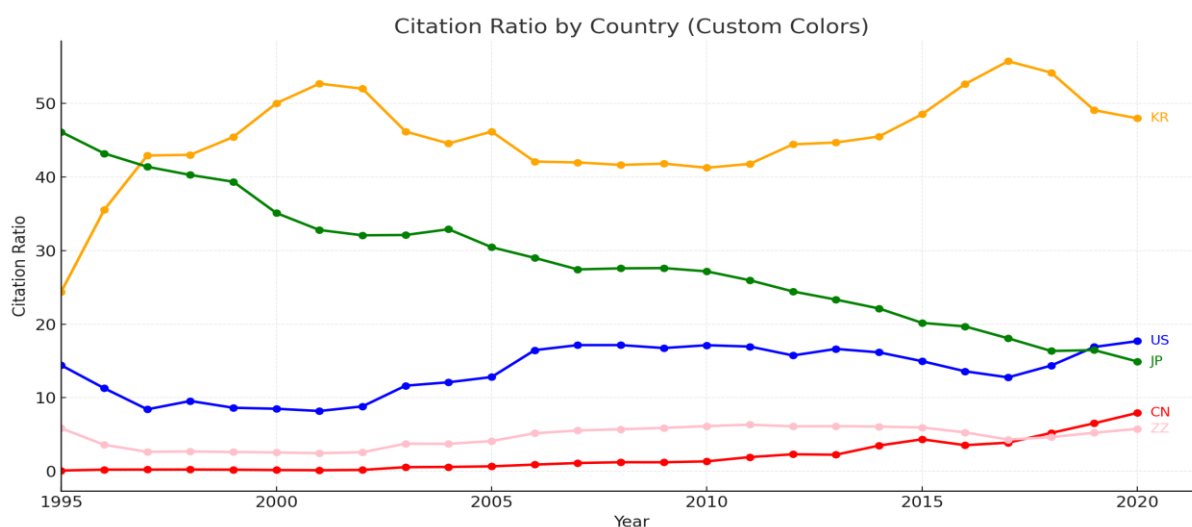
sharply for Y10T (legacy manufacturing technologies), and declines in older media-related technologies such as H04N (video communication/television) reflect broader technological turnover. A particularly informative case is H01L (semiconductor devices). Its modest decline in centrality should not be read as diminished semiconductor importance; rather, it reflects the faster rise of software and AI technologies—such as G06F and G06N—that increasingly build on semiconductor advances. This pattern is consistent with a broader shift in the center of gravity of innovation from hardware toward software and application-layer services. Korea’s trajectory illustrates a distinctive pattern of specialization. Over the past two decades, Korea has pursued a strategy of selection and focus, with sustained leadership in two areas: ICT hardware and digital content. While these pillars remain strong, the evidence also points to gradual diversification. Manufacturing segments such as machinery and electrical equipment have gained momentum, and biomedical and healthcare industries

have emerged as new growth areas—although they still lag global frontier trends.

5. Korean Firms’ GIN Participation Traits

Year-by-year data on Korean firms’ patent citations reveal a clear strengthening of domestic knowledge use. As shown in Figure 5, the share of within-Korea citations rises steadily over the sample period. A particularly notable break occurs in 1996, immediately following Korea’s accession to the WTO (1995) and the OECD (1996). In that year, the domestic citation share jumps by roughly 11 percentage points—the largest single-year increase in the entire period. This surge is consistent with several concurrent developments: tighter enforcement of citation requirements, expanding supply and demand for domestic research, and growing international engagement through joint research and increased overseas patent filings.

Figure 5. Trends in Changes in Korean Firms' Shares of Patent Citations to Major Economies (2000–2020)



Source: Kim et al. (2026).

Meanwhile, Figure 5 also highlights substantial changes over time in where Korean firms source external knowledge, as measured by patent citations. In the case of Japan, until the mid-1990s, citations to Japanese firms accounted for a larger share than Korean firms' domestic self-citations, indicating strong technological dependence on Japan. From the early 2000s, however, the Japanese share begins a sustained decline—consistent with Korea's improving technological capabilities and Japan's relatively reduced weight in parts of the global patent network. As for the United States, citations to U.S. firms remain broadly stable across the period, but with notable short-term fluctuations. One clear episode is a spike in 2006, coinciding with the period when Korea–U.S. FTA negotiations were advancing rapidly. Citations to Chinese firms rise most visibly in more recent years. This pattern

aligns with China's expanded R&D investment, a more assertive overseas patenting strategy, and growing technological influence since the mid-2010s. In addition, citations to firms in other countries—largely European economies such as Germany and the United Kingdom—show a gradual, modest increase rather than sharp discontinuities. Overall, the composition of Korean firms' citations indicates a long-run shift away from heavy reliance on Japan, continued engagement with U.S. technology, and a growing role for China as an external knowledge source.

IV. Takeaways

Policymakers have traditionally sought to strengthen innovation by expanding total R&D expenditure. While domestic investment remains essential, it is no longer sufficient. In

a highly interconnected economy, innovation is produced through cross-border and cross-industry knowledge flows: firms and sectors build on ideas developed elsewhere, and technologies diffuse through multiple channels across countries and value chains. Both research and policy therefore need to treat innovation as a networked process, not a purely domestic outcome. Within this framework, Korea's policy challenge is twofold. Korea should consolidate an economic base centered on "leading core" technologies, while also adopting "future-leading" technologies. At the same time, policy must explicitly recognize a critical constraint: technological dependence can become strategic vulnerability, especially under intensifying geopolitical and trade tensions.

The analysis points to three broad directions for a trade-related innovation strategy.

1. Track global frontier shifts and build domestic capability:

Global innovation networks are anchored by a set of leading technologies, and leadership evolves gradually but persistently over time. Korea has often advanced by following frontier technologies with a lag. Evidence-based policy should therefore focus on identifying where the global frontier is moving, narrowing capability gaps in priority areas, and clarifying national direction.

2. Engage the global innovation network strategically:

Korea's rapid rise in innovative capacity has been supported not only by domestic R&D, but also by effective use of foreign knowledge accessed through global networks. The policy task is to continuously identify—using rigorous analytical methods—which partner countries and which technology domains generate the greatest gains for Korea, and to design instruments that facilitate such collaboration (e.g., joint research, standards cooperation, talent mobility, and targeted international R&D programs).

3. Stabilize the innovation environment through stronger international cooperation:

Korea's growing capabilities and improved network position increase both opportunity and exposure. As a mid-sized leading economy, Korea's long-run innovation prospects depend on a stable, rules-based international order. In an environment where inward-looking and security-driven policies are intensifying, Korea needs sustained monitoring and strategic debate about the international rules and institutions it should support—and with whom, and through what coalitions, those norms can be maintained and shaped. **KIEP**