An industry's international connectedness and knowledge-sourcing behavior: a study of the Korean case

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Abstract

Purpose – The purpose of this study is to investigate the impact of an industry's connectedness to foreign countries on knowledge sourcing.

Design/methodology/approach – The authors examine the research model through probit regression techniques to the 472,303-patent data across 16 industries derived from the United States Patent and Trademark Office.

Findings – The results suggest that international connectedness increases the accessibility of foreign knowledge and helps the accumulation of technological capability. Thus, this paper provides a better understanding that international connectedness can be critical for exploiting knowledge dispersed worldwide and influencing intra- and interindustry knowledge-sourcing behavior in the home country.

Originality/value – While prior studies have mainly paid attention to the relationship between parents and subsidiaries in foreign countries for international knowledge sourcing, the authors attempt to analyze international and local knowledge sourcing with a broader set of knowledge sourcing channels at an aggregate level. By considering an industry's export intensity and inward foreign direct investment, this study reveals specifically how the extent of an industry's international connectedness influences knowledge sourcing from both abroad and locally.

Keywords South Korea, Foreign direct investment, Export, International knowledge sourcing, Interindustry knowledge sourcing, International connectedness, Intraindustry knowledge sourcing

Paper type Research paper

Introduction

Knowledge sourcing is crucial for inventing and developing new technology. The complexity of technology and the global dispersion of technological knowledge make firms to seek knowledge internationally (Cantwell and Piscitello, 2015). Technological activities of firms from many Western European countries have become decentralized to foreign subsidiaries (Cantwell and Kosmopoulou, 2002). Thus, previous studies on international knowledge sourcing have primarily emphasized the relationship between the parent firm and its subsidiaries in foreign countries, as well as the role of subsidiaries in the MNC

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network (Buckley *et al.*, 2022; Cantwell and Mudambi, 2011; Frost, 2001; Kim and Cho, 2021; Song *et al.*, 2011).

However, some countries have developed strong technological capabilities primarily through other modes of international knowledge sourcing rather than relying on the technological activities of subsidiaries in foreign countries or MNC networks (Choi and Cho, 2022; Elia *et al.*, 2020). Japan has created and accumulated strong technological knowledge with relatively limited internationalization of R&D. More recently, South Korea has also developed remarkable technological capabilities, relying mainly on channels other than the technological activities of subsidiaries in foreign countries. However, there is a lack of research on the patterns of knowledge sourcing when most R&D activities are concentrated in the home country market. (Cho and Cantwell, 2024). Therefore, analyzing the knowledge sourcing behavior of South Korea can potentially enrich and provide a more balanced perspective on the literature concerning knowledge sourcing and international business, broadening our understanding of the nature of knowledge sourcing.

After the Korean War (1950–1953), South Korea, once one of the world's poorest nations, has rapidly transformed into one of the most advanced emerging economies. This transformation relies on extensive international business connections, not limited to multinational corporations' internal networks. South Korea's industrialization process shares similarities with Japan's, as Ozawa (2009) suggests a "flying geese theory," where less developed countries learn and imitate from more advanced economies. In the second half of the 20th century, Japan's advanced status in Asia, coupled with its geographic proximity and historical ties to South Korea, facilitated the transfer of Japanese management and technology practices, which South Korea adapted and innovated upon. Similar to Japan's experience, some of South Korea's highly competitive industries have become internationally connected, while domestically oriented sectors remain relatively protected and less efficient.

South Korea's substantial economic growth has been accompanied by significant technological knowledge generation (Hannigan *et al.*, 2013). In contrast to other countries at a similar development level, South Korea historically concentrated its technological development domestically, with limited internationalization of research and development (R&D) activities through foreign subsidiaries. Despite the absence of an extensive foreign subsidiary network and endogenous technological knowledge, South Korea has successfully built internal technological capabilities by sourcing innovation-related knowledge from abroad (Wang and Tsai, 2010) through diverse international channels and modes of knowledge acquisition, going beyond intrafirm relationships.

The form of international connectedness that emerged during South Korea's industrialization presents a unique context for investigating knowledge-sourcing behavior. While several recent studies have focused on parent–subsidiary relationships and their influence on knowledge sourcing (Liu and Li, 2022; Scott-Kennel and Saittakari, 2020), such relationships have not been critical in South Korea. Instead, we can observe and examine knowledge-sourcing behavior in a more general sense by considering diverse channels at an aggregate level because South Korean firms have depended on a wider range of knowledge-sourcing channels. This approach addresses a broader set of issues related to knowledge sourcing (Lee and Lim, 2001; Miao *et al.*, 2018).

South Korean industry sectors reveal two distinct types of international knowledge connectedness. In advanced industries like electronics, shipbuilding and semiconductors, strong international connections foster high technological capability (Cho and Lee, 2003; Hwang and Choung, 2014). Conversely, less advanced industries exhibit weaker international ties. Although Smith (2014) explored the effects of imports and exports on technological innovation between leading and following industries, it did not address knowledge transfer

within a specific home country. This context is ideal for studying international knowledge sourcing as it allows us to directly examine how the international connectedness of specific industries influences knowledge sourcing. South Korean industrialization relies on connections with foreign countries, with international links playing a vital role in knowledge acquisition and capability development. The degree of connectedness to foreign countries distinguishes internationally connected industries from domestically oriented ones and can significantly impact an industry's knowledge sourcing behavior, both internationally and domestically. Thus, our central research question is as follows:

RQ1. How have the international connectedness of South Korean industries influenced their international knowledge sourcing and knowledge sourcing across industries within the home country?

With this study, we consider two distinctive features of an industry's international connectedness: its export intensity and the extent of inward foreign direct investment (FDI) penetration. Considering these two factors, we investigate South Korean industries' international knowledge sourcing and relative reliance on intra versus interindustry knowledge sourcing within the home country.

In the next sections, we review background literature and develop our hypotheses with theoretical arguments. We then describe our data, models and measures. After outlining the results of the empirical analysis, we conclude with a discussion of the results, their implications and some research directions.

Literature review

In our research, we embrace the perspective of the knowledge-based view (KBV). As KBV suggests, knowledge is a critical resource for a firm's success and competitive advantage (Conner and Prahalad, 1996; Eisenhardt *et al.*, 2000; Grant, 1996; Oliva *et al.*, 2019). To achieve success, firms need to develop and expand their technological knowledge to adapt to evolving environmental conditions (Mu *et al.*, 2008; Santoro *et al.*, 2020). Consequently, the continuous creation of knowledge and the maintenance of repositories for knowledge sources emerge as key activities (Cantwell and Fai, 1999). It is important to note that knowledge possesses geographical specificity, with countries varying in terms of their technological knowledge (Cantwell, 1989). Moreover, firms often encounter challenges in developing and attaining a high level of technological knowledge and innovation solely through their internal resources (Papa *et al.*, 2018; Santoro *et al.*, 2020). Therefore, the integration of both internal and external knowledge typically becomes a necessity for achieving successful product innovation (Iansiti and Clark, 1994).

Creating new knowledge through sourcing and combining knowledge can allow firms to experience complementarities between internal and external knowledge (Cassiman and Veugelers (2002), which in turn can become a source of competitive advantage (Argote *et al.*, 2000; Conner and Prahalad, 1996). Therefore, successful firms increasingly source and acquire knowledge to develop their capabilities and knowledge (Kim, 1998; Lane and Lubatkin, 1998). Firms' capabilities to source external knowledge, including technological knowledge, is critical for innovative activities (Chesbrough, 2003; Laursen and Salter, 2006) because such external knowledge can upgrade and get integrated with existing technological knowledge (Birkinshaw, 2001). Firms actively try to use and source external knowledge to engage in innovative activities with the aim of ultimately succeeding in product market competition (Arora and Gambardella, 2010; Leone and Reichstein, 2012).

Sourcing knowledge internationally is a notable trend in knowledge flows (Amin and Cohendet, 2005). Because countries differ significantly in their innovation systems, including

educational systems, trade policies and intellectual property, foreign countries can serve as potential sources of new knowledge, as well as new markets (Dunning, 1994). A given home country has a limited stock of knowledge, so sourcing knowledge from abroad can be a strategy to catch up with competitors (Cantwell, 1989; Kuemmerle, 1999). To seek new technologies, supplement existing technologies and develop complex and more advanced technologies, international knowledge sourcing is necessary (Cantwell and Janne, 1999; Cho and Cantwell, 2024; Choi and Cho, 2022). In particular, it allows firms to access and obtain new technology or knowledge that then can serve them in both home and global markets (Ambos *et al.*, 2006), and influence the capabilities to develop local knowledge sources (Cantwell and Zaman, 2018). Chung and Yeaple (2008) suggest an additional motivation for international knowledge sourcing: Firms can reduce their R&D costs by sourcing knowledge from foreign countries and combining it with their own.

Connectedness to external knowledge is beneficial for innovation (Chesbrough, 2003; Laursen and Salter, 2006; Leiponen and Helfat, 2010), and these connections also encourage further connections. Searching for external knowledge widely can facilitate the recombination of diverse knowledge, which in turn helps firms strengthen their product innovation (Laursen and Salter, 2006). The value of external knowledge connectedness stems from its potential to stimulate creativity and improve the quality of innovations (Powell, 1998). This connectedness can also increase accessibility to technological knowledge located outside the firm (Leiponen and Helfat, 2010; Niosi, 1999). Because knowledge depends on location-specific factors (Cantwell, 1989), international connections are necessary to determine the most suitable sources of globally dispersed knowledge. Firms and industries can become more internationally connected by expanding their business in foreign countries, such as by exporting (Branstetter, 2001; Salomon and Shaver, 2005) or receiving investments from foreign actors in the form of FDI (Sinani and Meyer, 2004).

Several studies show a positive relationship between exporting and innovation. For example, Salomon and Shaver (2005) proposed "learning by exporting" model shows that exports can facilitate innovation in the home country, and Castellani and Zanfei (2007) discovered a positive relationship between exporting and innovation. Internationalization through exporting can help firms acquire technological knowledge for innovative activities. In terms of process innovation, exporting can provide a positive impact (Damijan *et al.*, 2010). Şeker (2012) shows that export-oriented firms perform better in terms of improving production processes and introducing new products. Cho and Kim (2017) argue that adapting a firm's resources and capabilities to the international environment can positively influence the firm's domestic technological activities.

Previous studies also show a positive relationship between FDI and innovation. For example, as foreign firms' business activities in the host country increase, domestic firms' innovative activities in the same industry also increase (Bertschek, 1995; Blind and Jungmittag, 2004). Other studies identify a positive impact of FDI spillovers on local firms' productivity (Sinani and Meyer, 2004; Damijan and Knell, 2005); for example, Brambilla *et al.* (2009) find a positive relationship between FDI and domestic firms' introduction of new products.

Another research stream delves into South Korean and other Asian countries' catch-up and knowledge-sourcing strategies. Hannigan *et al.* (2013) find that technological specialization and concentration in relevant industries have been critical factors in South Korea's successful catch-up efforts. Jung and Lee (2010) examine the impact of several industry-level variables (e.g. explicitness of knowledge, embodied technology transfer, degree of dominance) on South Korea's catch-up with Japan. Some comparative empirical works investigate different patterns of innovation between South Korea and Taiwan (Wang and Tsai, 2010) or distinct international knowledge flow between these countries according

to patent citations (Hu and Jaffe, 2003). Miao *et al.* (2018) suggest research agendas for external/foreign knowledge and learning channels, such as reviewing extant research on East Asia's technological catch-up. However, though several studies have established that knowledge sourcing is a critical factor for technological development and catch-up, few of them address how an industry's international connectedness influences knowledge-sourcing behavior. To address this research gap, we investigate the role of an industry's international connectedness in international knowledge sourcing in an emerging market context and the relationship between international knowledge sourcing and local knowledge transfer across industries in the home country.

Theoretical development and hypotheses

Traditionally, industries engage in knowledge sourcing to access new knowledge and to further develop their existing knowledge. Therefore, in what conditions have South Korean industries behaved differently in terms of knowledge sourcing? Our focus is on the effect of the international connectedness of an industry on South Korean firms' knowledge sourcing from abroad and on relationships of knowledge sourcing between South Korean industries. We consider two distinctive features of an industry's international connectedness – the degree of export intensity and the degree of inward FDI – to investigate industries' knowledge-sourcing behavior.

Export and international knowledge sourcing

Sourcing technological knowledge from abroad is one of the forms of learning for developing new technology. One international trade research stream posits a "learning-by-exporting" effect, in which exporting can be associated with innovation and productivity (Andersson and Lööf, 2009; Cassiman *et al.*, 2010; Cassiman and Golovko, 2011; Salomon, 2006). Exporting firms in industries can learn from foreign contacts by accessing and adopting new and diverse technological knowledge that is not obtainable in their home country (Salomon and Shaver, 2005). In addition, exporting enables industries to gain a deeper understanding of the foreign counties in which they distribute their goods (Freixanet and Federo, 2023; Wang and Tao, 2019). But domestically oriented industries have fewer opportunities to understand foreign markets because their main focus is likely limited to the home country market. Export-oriented industries must analyze their foreign market competitors' products and, in so doing, are likely to recognize and become more familiar with technological knowledge beyond their home country environment. The more industries engage in exports, the more exposure to foreign knowledge resources they gain. Because export-oriented industries have more opportunities to recognize and become aware of diverse sources of foreign technological knowledge, they are more likely to source technological knowledge from abroad.

However, firms may also engage in foreign export markets because they are more productive (Greenaway and Kneller, 2007; Wagner, 2007). When firms have more capabilities, they tend to expand their business (Hymer, 1976); if they expand to foreign markets, they often rely on exporting as a prevalent form of international expansion. Export-oriented industries have more technical efficiency than import-substitution-oriented industries because they face a higher level of competition in the world market (Chen and Tang, 1987). Because export-oriented industries have stronger technological capabilities, they need more advanced and diverse technological knowledge to develop their own technology continuously. If searching for technological knowledge is limited in the home country, it is difficult for industries to improve and maintain their technology base continuously, which can lead to a loss of foreign market share. In some markets, export orientation may not need

much international knowledge sourcing if exports were mainly standardized products or commodities. However, exporting requires continuous improvement through external knowledge to compete in world markets (Acikdilli *et al.*, 2022; Ferreras-Méndez *et al.*, 2019). Export-oriented industries typically are eager to source the more advanced and diverse knowledge that exists in foreign countries. Moreover, their wider experience in foreign countries means that export-oriented industries have more opportunities to encounter potentially useful knowledge abroad than their domestically oriented counterparts.

Previous studies have investigated the effect of international trade on knowledge spillovers (Branstetter, 2001; Grossman and Helpman, 1991). When export intensity is high in an industry, familiarity with and recognition of advanced foreign technological knowledge in the industry also increases. Export-oriented industries' foreign knowledge recognition can be shared and dispersed through spillover effects. It naturally leads export-oriented industries to source knowledge internationally. In contrast, if an industry is more domestically oriented, it has a restricted search for foreign knowledge resources because it has fewer opportunities to encounter such resources. Thus, export-oriented industries tend to source knowledge internationally because they have greater recognition of and familiarity with advanced and diverse foreign technological knowledge. Moreover, these industries have a greater motivation to obtain advanced knowledge from foreign locations to maintain their leading technological position and develop their technology further. Accordingly, we propose:

H1. The more export-oriented an industry is, the more likely it is to source knowledge internationally.

Inward foreign direct investment and international knowledge sourcing

Existing research on knowledge spillovers suggests the importance of interactions between actors (e.g. firms, universities and government R&D centers) in the same location (Griliches and Hjorth-Andersen, 1992; Jaffe *et al.*, 1993; Maurseth and Verspagen, 2002). Knowledge spillover increases when these interactions occur between actors in close proximity because knowledge is partially tacit. The actors are more likely to know and understand the other parties' products and technology when they interact with one another in the same location (Cantwell and Santangelo, 1999). They interact both directly (e.g. cooperation or competition between firms) and indirectly (e.g. through the impact of FDI on local firms in an industry).

Theoretical and empirical research provides evidence that FDI is one of the primary channels for knowledge spillovers (Blomström and Kokko, 1998; Liu and Wang, 2003; Sinani and Meyer, 2004; Xu, 2000). Branstetter (2006) demonstrates that FDI plays an important role in bilateral knowledge spillovers between investing and indigenous firms. Meyer and Sinani (2009) suggest that FDI can provide positive spillovers, but its effects differ according to a country's institutional framework, human capital and level of development. If inward FDI was mainly directed to host country enclaves, such as export processing zones, in which foreign-owned firms and domestic firms do not directly interact much, the FDI may not lead to much direct knowledge spillovers and international knowledge sourcing. Nonetheless, the influence of inward FDI extends beyond just direct knowledge transfer; when interactions take place through FDI, recognition of and familiarity with foreign knowledge also increase. (Kano *et al.*, 2020). The inflow of FDI into a given country's industry naturally helps other firms in that industry become familiar with foreign products and technologies. In contrast, when an industry in a given country receives less FDI, it has limited opportunities to encounter foreign knowledge. If the knowledge acquired through inward FDI is diffused, with some recognition of the knowledge originated (Wu *et al.*, 2023), then the industries in the home country are inclined to source knowledge from the corresponding foreign

locations, as they recognize those locations as potential knowledge sources. Industries with more inward FDI are more adept at recognizing the sources of knowledge and its diverse origins, thus, becoming increasingly familiar with foreign knowledge sources (Wu *et al.*, 2023). This familiarity with foreign sources increases international knowledge sourcing of an industry in a given country and creates more opportunities to obtain diverse technology from foreign countries. In contrast, industries with less inward FDI have fewer chances to become familiar with foreign knowledge resources. Because they have fewer knowledge spillover effects and interactions with foreign subunits, exposure to foreign knowledge is also limited, which makes it difficult to access foreign knowledge resources. If an industry in a country receives more inward FDI, the industry in the home country is more likely to source knowledge from foreign countries, because it gains familiarity with the foreign knowledge resources and is able to access the more diverse range of technology that exists internationally. Thus, we propose:

H2. The more inward FDI an industry receives, the more likely it is to source knowledge internationally.

Thus far, we have discussed how the degree of export intensity and inward FDI in an industry can influence its international knowledge sourcing. In what follows, we turn our attention to local knowledge sourcing in the home country. By only considering knowledge sourcing within the home country, we can investigate the relationships between South Korean industries and their intra or interindustry patterns of local knowledge sourcing.

Export and intra versus interindustry knowledge sourcing in the home country

As we discussed in the development of *H1*, export-oriented industries have more international connectedness than domestically oriented industries. International connectedness through exporting can be beneficial to export-oriented industries in at least two ways, in terms of technological knowledge. First, export-oriented industries can learn more about foreign countries (Salomon and Shaver, 2005) and become more familiar with diverse and advanced technological knowledge in these countries. Second, export-oriented industries have more competitors in foreign countries. Although this heightened competition might cause short-term challenges for export-oriented industries, these industries are also likely to develop enhanced capabilities as a result of the more intense competitive pressures. By sourcing necessary technological knowledge from abroad and competing with competitors in foreign countries, export-oriented industries tend to be associated with higher rates of internal capability development.

What patterns of knowledge sourcing can be observed when industries engage in local knowledge sourcing? South Korea is a natural resource-constrained country, in which exporting is concentrated in manufacturing and knowledge-intensive services. More export-oriented industries are competing in world markets with rivals that have a wider range of capabilities, and they are also more likely to serve a wider range of high-income consumers or capable clients; therefore, they must be more knowledge-intensive to compete effectively and survive. These factors can encourage the sourcing of knowledge from the same industries or other export-oriented industries, rather than domestically oriented industries that possess relatively weak knowledge.

In contrast, domestically oriented industries are relatively protected or sheltered in character and compete with a narrower range of foreign firms, if at all. Firms in these industries have less need to build up their domestic knowledge base to compete effectively. The lack of international connectedness and a low level of internal capabilities make it difficult for domestically oriented industries to source knowledge from abroad compared

with export-oriented industries. They tend to be relatively more reliant on knowledge that can be acquired from more knowledge-intensive firms or partners in other industries. Because domestically oriented industries' knowledge sourcing abroad is limited, and they tend to have greater internal capabilities, they often engage in intraindustry knowledge sourcing from export-oriented industries. Thus, we propose:

H3. The more export-oriented an industry is, the more likely it is to engage in intra rather than interindustry knowledge sourcing in the home country.

Inward foreign direct investment and intra versus *interindustry knowledge sourcing in the home country*

With *H1* and *H3*, we propose that exporting can increase international connectedness and competitiveness. Similar arguments can be applied to inward FDI, which can offer benefits of both international connectedness and competitive pressure. That is, when an industry receives FDI, it likely acquires capabilities through international connectedness. Such an industry can recognize and use advanced resources available from foreign countries (e.g. capital, technological knowledge, innovation processes; Aitken and Harrison, 1999). By accessing and using those advanced resources, the industry becomes more capable. An industry with more capabilities also could become a target location for inward FDI, such that the more capable an industry is, the more inward FDI the industry receives. Even in this case though, the industry still can develop further and become more capable as a result of the benefits of inward FDI (Liang, 2017). Furthermore, inward FDI increases competitive pressure, which likely drives the industry to invest in capability development and in-house innovation. When an industry sources knowledge from abroad to get necessary and more advanced technological knowledge, its internal capabilities grow stronger, and it accumulates more technological knowledge stock. A more knowledge-intensive industry has more knowledge available collectively across actors in the industry, which creates a greater opportunity and greater imperative to engage in cross-firm knowledge exchanges within the industry at home. Therefore, South Korean industries with more inward FDI are more likely to search and source technological knowledge from the same industries to enjoy the benefits of high-level capabilities and technological knowledge stocks from within the local industry.

In contrast, an industry with a low level of inward FDI cannot enjoy the benefits of international connectedness and competitive pressures. It would have relatively fewer opportunities to access and use advanced knowledge in foreign countries; in turn, that industry's internal capabilities and technological knowledge stocks are likely to be relatively weak compared with those of industries with more inward FDI. Such an industry also is likely to have weak internal capabilities and technological knowledge stocks. Thus, it is more likely to source knowledge from industries with more inward FDI, in an effort to access better resources in the case of local knowledge sourcing (Figure 1). Therefore, we predict:

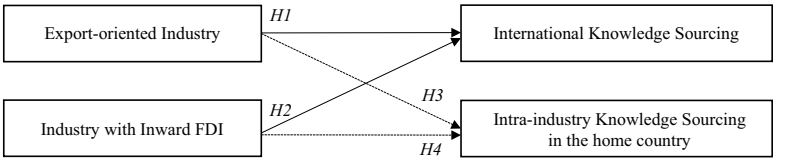


Figure 1.
Research model

Source: Figure by authors

H4. The more inward FDI an industry receives, the more likely it is to engage in intra rather than interindustry knowledge sourcing in the home country.

Research methodology

Data

This study investigates how the international connectedness of South Korean industries affects their knowledge-sourcing decisions, internationally and domestically. To test our hypotheses, we use data on patents granted in the USA but invented in South Korea and their citations to earlier patents (knowledge sources). A patent document contains the location of the inventor(s), assignee information, technological classification and citations to earlier patents. Even though knowledge flows are not visible, patent citations provide information on how new technological knowledge builds on existing knowledge (Singh, 2005). Therefore, many studies have used patent citations to measure patterns of knowledge flows and sourcing (Almeida, 1996; Cantwell and Mudambi, 2011; Kim and Cho, 2021; Song *et al.*, 2011).

We obtained our patent samples by selecting from a pool of USPTO patents originating from South Korea, registered during the years 2005 to 2013. South Korea exhibits a unique blend of features that place it somewhere between emerging and developed nations. However, there is considerable evidence to suggest that as of 2015, South Korea was still considered an emerging market. According to the World Bank's 2016 data [1], South Korea's gross domestic product per capita remained lower than that of fully developed nations. Furthermore, it is worth noting that Morgan Stanley Capital International continued to categorize South Korea as an emerging market during this period [2]. In a similar vein, UNCTAD only reclassified South Korea as a developed country from July 2021 onwards [3]. In light of this information from various reputable sources, the 2005 to 2013 timeframe is deemed to be a period that accurately captures South Korea's characteristics as an emerging market.

In the USPTO system, the primary field of technological activity of each patent is categorized into classes between 002 and 987. However, this categorization is too specific, so we must group these fields into fewer technological fields for this empirical research. Previous studies have regrouped primary technological fields of the US patent class system into 56 technological fields (Cantwell and Andersen, 1996: Cantwell and Piscitello, 2015); we similarly use these regrouped classifications for our sample (Appendix 1, Cantwell and Piscitello, 2015). Our study refers to whether knowledge flows are intra or interindustry, such that the 56 technological fields must be matched with industries. Therefore, we classify the primary technological fields of each industry, as shown in Table 1. We obtained the data on an industry's export intensity and its annual level of investment by foreign capital between 2005 and 2013 from the Industrial Statistics Analysis System website operated by the Korea Institute for Industrial Economics and Trade and the Ministry of Trade, Industry and Energy of South Korea.

Variables and measures

Dependent variables

We define *international knowledge sourcing* as access to knowledge and new ideas developed in foreign countries. To measure this variable, we used the first-named inventor location of cited patents and coded a cited patent as 1 if it was invented in a foreign country and 0 if it was invented in South Korea.

Industry	Primary technological fields
Food, drink and tobacco	1,15
Chemicals	2,3,4,5,7,8,9,10,11,16,55
Pharmaceuticals	12
Metals	13,14,17
Mechanical engineering	20,21,22,28,29
Electrical equipment	24,32,33,34,35,36,37,38,39,40
Office equipment	30,41
Motor vehicle	42,43,47
Aircraft and other transport equipment	31,44,45,46
Textile	25,48
Paper products, printing and publishing	18,26,27
Rubber products	49
Nonmetallic mineral products	19,50
Coal and petroleum products	23,51
Professional and scientific instruments	6,52,53
Other manufacturing	54,56

Source: Qiu and Cantwell (2017)

Table 1. The primary technological fields of each industry

We operationalize *intraindustry knowledge sourcing* by the focal patent's citations of patents within the same industry. Using Table 1 as a basis, we coded an observation as 1 if a technological field of cited patent belongs to the same industry as the citing patent and 0 if not.

Independent variables

We use two independent variables, the export intensity of an industry and the inward FDI of an industry, to proxy the international connectedness of an industry. We operationalize the degree of *export intensity* using the ratio of total exports to total sales in each industry, a widely used measurement in management and international business research (Boehe and Jiménez, 2016; Majocchi *et al.*, 2005). To analyze the influence of *inward FDI* on each industry in South Korea, we examine the intensity of investment in an industry, rather than the absolute volume of inward FDI in each industry. The size and level of activity in each industry should be considered together. Thus, we measure the ratio of the total volume of inward FDI to the total level of all investments in each industry.

Control variables

Prior capabilities in a relevant field in South Korea may serve as alternative knowledge resources, relative to knowledge from foreign locations. Thus, we must allow for the accumulated *South Korean knowledge stock* to analyze *H1* and *H2*. We measured South Korean knowledge stock as the share of South Korea–invented cited patents in each of the 56 technological fields. Our sample covers all patents invented in South Korea, so patents invented by foreign-owned firms in South Korea are also included. Although the percentage of patents by foreign-owned firms in our data is very low (around 6%), some effect of foreign-owned firms' citing patents could be present on international knowledge sourcing. Therefore, we include the accumulated *knowledge stock of foreign-owned firms in South Korea* as a control variable. We coded items as 1 if patents were invented by a foreign-owned firm located in South Korea and 0 if the patents were invented by South Korean firms located in South Korea. Lastly, our sample includes 16 industries, and there might be some

industry-specific effects associated with them. Thus, we include *industry dummies* to minimize the effect of industry heterogeneity.

Samples and model. Because the dependent variables (international knowledge sourcing and intraindustry knowledge sourcing) are dichotomous, we use a probit regression to investigate the effects of international connectedness on both knowledge sourcing abroad and intraindustry knowledge sourcing in the home country. Our sample for *H1* and *H2* is composed of 472,303 observations, such that we analyze the effects of the international connectedness of an industry and its knowledge sourcing abroad. For *H3* and *H4*, we consider only the 66,065 South Korea-invented citations to analyze the patterns of local knowledge sourcing under the impact of the international connectedness of an industry.

Results

Main findings

Table 2 contains the descriptive statistics for all the variables included in the model. Tables 3 and 4 display the correlation matrix of variables for *H1* and *H2* and then *H3* and *H4*, respectively. Although interpreting the size of a correlation coefficient does not follow a specific criterion, in general, multi-collinearity is not a concern if the absolute value of the

Variable	Mean	SD	Min	Max
International knowledge sourcing	0.8541	0.3530	0	1
Intraindustry knowledge sourcing	0.9496	0.2187	0	1
Korean knowledge stock	13.7325	3.5374	0	17.4
Knowledge stock by foreign-owned firms in South Korea	0.0663	0.2489	0	1
Export-intensity	40.2759	5.2894	1.38	74.32
Inward FDI	2.5096	0.6951	0	6.19

Source: Table by authors

Table 2. Summary of descriptive statistics

Variable	1	2	3	4	5
International knowledge sourcing	1.000				
Korean knowledge stock	−0.101***	1.000			
Knowledge stock of foreign-owned firms in South Korea	0.034***	−0.010***	1.000		
Export-intensity	0.032***	−0.060***	−0.018***	1.000	
Inward FDI	0.033***	−0.106***	−0.060***	0.430***	1.000

Notes: $N = 472{,}303$; *$p < 0.10$; **$p < 0.05$; *** $p < 0.01$
Source: Table by authors

Table 3. Correlations for variables for *H1* and *H2*

Variable	1	2	3
Intraindustry knowledge sourcing	1.000		
Export-intensity	0.049***	1.000	
Inward FDI	0.050***	0.476***	1.000

Notes: $N = 66{,}065$; *$p < 0.10$; **$p < 0.05$; *** $p < 0.01$
Source: Table by authors

Table 4. Correlations for variables for *H3* and *H4*

correlation coefficient is less than 0.5. In Tables 3 and 4, no variables exceed 0.5. To confirm the absence of multi-collinearity, we also measure the strength of the correlation between independent variables through variance inflation factor (VIF) test. As a rule of thumb, VIF of 10 or greater is a cause for concern. However, all the VIF values are below 2, which indicates that we do not have a multicollinearity problem in our data.

Table 5 contains the results of the probit regression models, in which the dependent variable is international knowledge sourcing for *H1* and *H2*. Model 1 in Table 5 includes control variables (South Korean knowledge stock and knowledge stock of foreign-owned firms in South Korea, and industry dummy). We include an export-intensity variable in Model 2 to test *H1*. Then Model 3 tests the effects of inward FDI in an industry on its international knowledge sourcing. Model 4 includes all the control and independent variables and is the full model.

In Model 1, the coefficient estimate for the South Korean knowledge stock is negative and significant, and the coefficient on knowledge stock by foreign-owned firms in South Korea is significant and positive. The coefficient for export intensity in Model 2 is positive and significant (Model 2: $\beta = 0.010$, $p < 0.01$), which suggests that an industry with greater export intensity is more likely to source knowledge internationally, in support of *H1*. Model 3 examines *H2*, which predicts a positive relationship between inward FDI in an industry and knowledge sourcing abroad. The coefficient estimate for inward FDI is positive and significant (Model 3: $\beta = 0.085$, $p < 0.01$), so an industry with greater inward FDI is more likely to source knowledge abroad, in support of *H2*. We confirm that the effects of both export intensity and inward FDI on international knowledge sourcing show consistent results in our full model, Model 4.

Table 6 provides the results for *H3* and *H4*. We ran probit regression models with a dependent variable, intra versus interindustry knowledge sourcing within South Korea. Model 1 in Table 6 shows the effects of export intensity on intraindustry knowledge sourcing locally. We include the inward FDI variable in Model 2, because we predict a positive association between inward FDI in an industry and the degree of intraindustry knowledge sourcing within South Korea (*H4*). We include both independent variables in Model 3.

Model 1 tests *H3*, which proposes the existence of positive effects of export intensity on intraindustry knowledge sourcing locally. The coefficient of export intensity is positive and significant (Model 1: $\beta = 0.017$, $p < 0.01$), in support of *H3*. That is, export-oriented industries are more likely to engage in intraindustry knowledge sourcing than domestically

Table 5.
Probit regression models of international knowledge sourcing

DV: International knowledge sourcing	Model 1	2	3	4
Industry dummy	Included	Included	Included	Included
Korean knowledge stock	−0.052 (0.001)***	−0.052 (0.000)***	−0.051 (0.001)***	−0.051 (0.001)***
Knowledge stock of foreign-owned firms in South Korea	0.230 (0.010)***	0.236 (0.010)***	0.241 (0.010)***	0.242 (0.010)***
Export-intensity		0.010 (0.000)***		0.007 (0.001)***
Inward FDI			0.085 (0.004)***	0.059 (0.005)***
Chi^2	6,045.61***	6,533.92***	6,518.56***	6,706.97***
Pseudo R^2	0.0854	0.0866	0.0866	0.0871
Observations	472,303	472,303	472,303	472,303

Notes: *$p < 0.10$; **$p < 0.05$; *** $p < 0.01$
Source: Table by authors

oriented industries within the home country. In Model 2, the results for the effects of inward FDI show that the relationship between inward FDI and intraindustry knowledge sourcing is positive and significant (Model 2: $\beta = 0.206$, $p < 0.01$). Thus, *H4* is also supported. These results also are confirmed in the full model (Model 3).

The results in Tables 5 and 6 do not indicate the magnitude of impact (economic importance) of these effects, though they suggest statistical significance. Thus, we provide the estimates of linear effects for each pair of independent and dependent variables in each hypothesis to analyze the effect sizes of the results. As the export intensity of an industry changes, we find (1) approximately a 16% change (between 77% and 93%) in international knowledge sourcing (Figure 2) and (2) approximately a 10% change (between 81% and 91%) in intraindustry knowledge sourcing within South Korea (Figure 3). In addition, as inward FDI in an industry changes, we observe (1) approximately a 10% change (between 81% and 91%) in international knowledge sourcing (Figure 4) and (2) approximately a 14% change (between 80% and 94%) in intraindustry knowledge sourcing within South Korea (Figure 5).

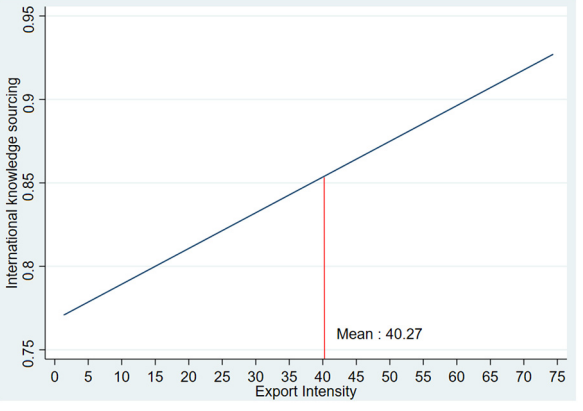
Robustness checks

To ensure the robustness of our results, we ran several additional analyses. First, we conducted a subperiod analysis. The sample period includes the financial crisis of 2007–2008,

DV: Intraindustry knowledge sourcing	Model 1	2	3
Industry dummy	Included	Included	Included
Export-intensity	0.017 (0.002)***		0.010 (0.002)***
Inward FDI		0.206 (0.019)***	0.166 (0.020)***
Chi^2	83.74***	125.76***	154.91***
Pseudo R^2	0.0632	0.0648	0.0659
Observations	66,065	66,065	66,065

Notes: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$
Source: Table by authors

Table 6. Probit regression models of intra versus interindustry knowledge sourcing



Source: Figure by authors

Figure 2. The effect size of the export intensity of an industry on international knowledge sourcing

which had different economic conditions than other years in the sample. Thus, we re-checked the results after we excluded 2007 and 2008 (Appendices 2 and 3) and found consistent results. Second, we also checked whether our estimates were driven by firm heterogeneity in each industry by controlling for firm effects (Appendices 4 and 5). The results of the additional tests are very similar to our main results in Tables 5 and 6.

Discussion

We advance and find empirical support for critical related arguments, which considerably enhances understanding of the role of international knowledge sourcing in emerging market contexts, including the relationship between international knowledge sourcing and domestic knowledge transfer across industries in the home country. Internationally connected industries that lead technological development in areas of South Korea's greatest accomplishments not only increasingly combine the knowledge that comes from home country and international sources but also become vital knowledge reservoirs for domestically oriented industries. That is, whereas internationally connected industries rely mainly on intraindustry sources in their domestic knowledge sourcing activities, domestically oriented industries rely mainly on interindustry knowledge sourcing at home.

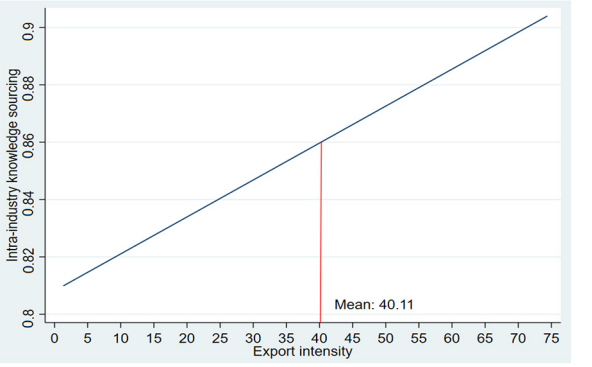


Figure 3.
The effect size of the export intensity of an industry on intraindustry knowledge sourcing within Korea

Source: Figure by authors

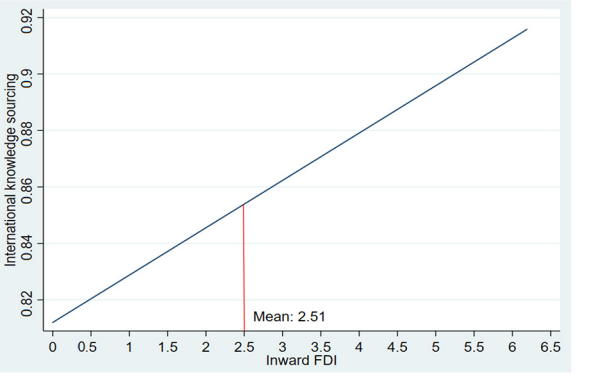


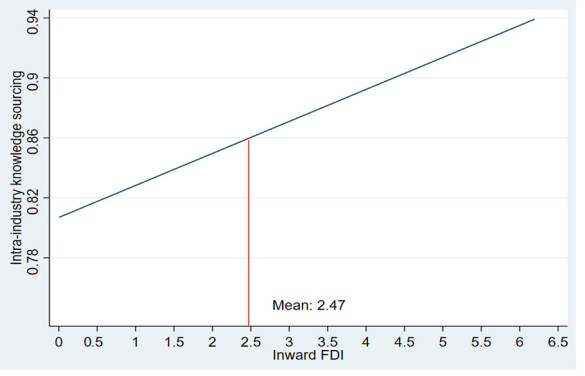
Figure 4.
The effect size of inward FDI in an industry on international knowledge sourcing

Source: Figure by authors

These findings yield two significant theoretical implications. First, this study provides a theoretical foundation for understanding the interplay between international knowledge sourcing, the accumulation of technological capabilities and intraindustry knowledge sourcing within a domestic industry. International connectedness plays a pivotal role in facilitating the flow of knowledge and its subsequent development (Wang and Tao, 2019). International connectedness through exports and inward FDI is critical because it provides a more extensive basis of knowledge that is dispersed around the world (Liu and Wang, 2003; Salomon and Shaver, 2005) and thereby allows firms to accumulate stronger technological capabilities in local industries. While previous studies have underscored the significance of exporting and inward FDI for knowledge acquisition (Andersson and Lööf, 2009; Sinani and Meyer, 2004; Xu, 2000), our research extends these findings by providing a more comprehensive theoretical framework for understanding the relationship between international and local knowledge sourcing. Industries can enhance their technological knowledge by sourcing it from foreign countries through increased international connectedness. This, in turn, fosters the development of stronger technological capabilities in their respective sectors, affecting their inclination to seek knowledge from their own industry rather than relying solely on passive knowledge reception.

Second, our study elucidates the resulting dynamics of knowledge-based relationships among industries, particularly concerning knowledge flows within the home country. Internationally connected industries can serve as domestic conduits or connectors to foreign knowledge resources for domestically oriented industries. They are more inclined to source knowledge both internationally and locally within their own industries, with the objective of continually enhancing their technological capabilities. In contrast, domestically oriented industries, characterized by lower export intensity and limited inward FDI, are more prone to local knowledge sourcing as opposed to international sourcing. They rely on the absorption of knowledge from other industries, as their capacity for direct international knowledge sourcing is inferior to that of internationally connected industries. Consequently, domestically oriented industries leverage the superior technological knowledge of internationally connected industries to catch up.

This research also provides practical implications. Firms in internationally connected industries should consider exporting not only for international sales but also as a means to acquire valuable knowledge. When selecting foreign markets for export, they should also evaluate these markets as potential sources of advanced knowledge. This approach can lead to the accumulation of a higher level of technological knowledge, which, in turn, can further



Source: Figure by authors

Figure 5.
The effect size of inward FDI in an industry on intraindustry knowledge sourcing within Korea

boost their exports in other foreign markets. Moreover, this study offers insights for firms in domestically oriented industries on how to leverage internationally connected industries for technology catch-up. Managers within domestically oriented industries should formulate strategies that foster closer relationships with internationally connected industries to access the necessary knowledge. Through local knowledge sourcing from internationally connected industries, domestically oriented industries may be able to accumulate technological knowledge and thereby open an indirect door for international knowledge sourcing.

Conclusions, limitations and future research

The international connections of an industry can exert an influence on its international knowledge sourcing and knowledge sourcing within the home country's various industries. International connectedness, facilitated by industry export intensity and inward FDI, can have positive associations with an industry's international knowledge acquisition. Both an industry's export and inward FDI activities can play critical roles in sourcing knowledge from overseas, as they serve to establish connections with foreign nations and foster greater international ties. Exporting activities enable industries to identify and access novel technological knowledge available exclusively in foreign countries, while inward FDI fosters increased engagement with foreign resources and knowledge within the industry. In essence, exporting endeavors in foreign markets and interactions with foreign resources through inward FDI enhance an industry's awareness of foreign technological knowledge, which can be used for their own knowledge advancement.

Industries with a strong export focus and those with more inward FDI tend to possess stronger capabilities through their international connectedness. Firms within these industries have greater opportunities to source technological knowledge from foreign countries and bolster their competencies through competition with foreign firms. Consequently, industries with higher levels of export activities and increased inward FDI are more inclined to engage in local intraindustry knowledge sourcing, using the abundant technological knowledge reservoirs within their own sector. In contrast, domestically oriented industries lack foreign connections, rendering it challenging for them to access international knowledge, which results in a lower level of international capabilities. Given their limited technological knowledge resources within their industry, domestically oriented industries are less likely to engage in intraindustry knowledge sourcing by exploiting knowledge from other industries with more robust internal capabilities, such as export-oriented industries or those with higher inward FDI.

This study presents several limitations that offer avenues for future research. First, we focused on examining the influence of certain industry-level factors on knowledge-sourcing behavior, while we did not delve into the examination of firm- or country-level factors. Future researchers should consider incorporating firm-level factors, such as technological capabilities and specialization, to analyze the knowledge-sourcing behavior of firms situated in South Korea, a country historically characterized by limited internationalization of R&D. Second, our investigation was limited to a single country, and as such, we advise against generalizing the findings to other nations. While South Korea is unique in its historical weak internationalization of R&D, there are countries like Japan and Taiwan that exhibit similar characteristics. Consequently, it would be beneficial to conduct comparative research to assess the applicability of our findings in diverse contexts. Third, another comparative approach could encompass a broader sample of countries with varying degrees of internationalization of R&D and knowledge sourcing. The distribution of R&D activities in European countries differs significantly from those of South Korea, and its R&D activities and knowledge sourcing differ from those of China and India. In addition, even within the category of European countries, there is substantial diversity. Ongoing research could

explore and compare the patterns of R&D activities and knowledge sourcing across various categories of countries, shedding light on the distinct trends and patterns, ultimately enhancing our understanding of the reasons behind these differences.

Notes

1. https://frontera.net/news/asia/emerging-markets-investment-in-south-korea-a-market-with-characteristics-similar-to-developed-markets/
2. www.wsj.com/articles/south-korea-wants-to-graduate-from-emerging-markets-11645786835
3. www.asiafundmanagers.com/us/south-korea-from-emerging-market-to-industrialized-country/

References

Acikdilli, G., Mintu-Wimsatt, A., Kara, A. and Spillan, J.E. (2022), "Export market orientation, marketing capabilities and export performance of SMEs in an emerging market: a resource-based approach", *Journal of Marketing Theory and Practice*, Vol. 30 No. 4, pp. 526-541.

Aitken, B. and Harrison, A. (1999), "Do domestic firms benefit from foreign direct investment? Evidence from Venezuela", *American Economic Review*, Vol. 89 No. 3, pp. 605-618.

Almeida, P. (1996), "Knowledge sourcing by foreign multinationals: patent citation analysis in the US semiconductor industry", *Strategic Management Journal*, Vol. 17 No. S2, pp. 155-165.

Ambos, T.C., Ambos, B. and Schlegelmilch, B.B. (2006), "Learning from foreign subsidiaries: an empirical investigation of headquarters' benefits from reverse knowledge transfers", *International Business Review*, Vol. 15 No. 3, pp. 294-312.

Amin, A. and Cohendet, P. (2005), "Geographies of knowledge formation in firms", *Industry and Innovation*, Vol. 12 No. 4, pp. 465-486.

Andersson, M. and Lööf, H. (2009), "Learning-by-exporting revisited: the role of intensity and persistence", *The Scandinavian Journal of Economics*, Vol. 111 No. 4, pp. 893-916.

Argote, L., Ingram, P., Levine, J.M. and Moreland, R.L. (2000), "Knowledge transfer in organizations: learning from the experience of others", *Organizational Behavior and Human Decision Processes*, Vol. 82 No. 1, pp. 1-8.

Arora, A. and Gambardella, A. (2010), "Ideas for rent: an overview of markets for technology", *Industrial and Corporate Change*, Vol. 19 No. 3, pp. 775-803.

Bertschek, I. (1995), "Product and process innovation as a response to increasing imports and foreign direct investment", *The Journal of Industrial Economics*, Vol. 43 No. 4, pp. 341-357.

Birkinshaw, J. (2001), "Why is knowledge management so difficult?", *Business Strategy Review*, Vol. 12 No. 1, pp. 11-18.

Blind, K. and Jungmittag, A. (2004), "Foreign direct investment, imports and innovations in the service industry", *Review of Industrial Organization*, Vol. 25 No. 2, pp. 205-227.

Blomström, M. and Kokko, A. (1998), "Multinational corporations and spillovers", *Journal of Economic Surveys*, Vol. 12 No. 3, pp. 247-277.

Boehe, D.M. and Jiménez, A. (2016), "How does the geographic export diversification–performance relationship vary at different levels of export intensity?", *International Business Review*, Vol. 25 No. 6, pp. 1262-1272.

Brambilla, I., Hale, G. and Long, C. (2009), "Foreign direct investment and the incentives to innovate and imitate", *The Scandinavian Journal of Economics*, Vol. 111 No. 4, pp. 835-861.

Branstetter, L. (2006), "Is foreign direct investment a channel of knowledge spillovers? Evidence from Japan's FDI in the United States", *Journal of International Economics*, Vol. 68 No. 2, pp. 325-344.

Branstetter, L.G. (2001), "'Are knowledge spillovers international or intranational in scope?', 'Microeconometric evidence from the US and Japan'", *Journal of International Economics*, Vol. 53 No. 1, pp. 53-79.

Buckley, P.J., Munjal, S. and Requejo, I. (2022), "How does offshore outsourcing of knowledge-intensive activities affect the exports and financial performance of emerging market firms?", *Journal of International Business Studies*, Vol. 53 No. 9, pp. 1971-1996.

Cantwell, J. (1989), *Technological Innovation and Multinational Corporations*, Basil Blackwell, Oxford.

Cantwell, J.A. and Andersen, H.B. (1996), "A statistical analysis of corporate technological leadership historically", *Economics of Innovation and New Technology*, Vol. 4 No. 3, pp. 211-234.

Cantwell, J. and Fai, F. (1999), "Firms as the source of innovation and growth: the evolution of technological competence", *Journal of Evolutionary Economics*, Vol. 9 No. 3, pp. 331-366.

Cantwell, J. and Janne, O. (1999), "Technological globalisation and innovative centres: the role of corporate technology leadership and locational hierarchy", *Research Policy*, Vol. 28 No. 2-3, pp. 119-144.

Cantwell, J. and Kosmopoulou, E. (2002), "What determines the internationalisation of corporate technology? ", in Havila, V., Forsgren, M. and Håkanson, H. (Eds), *Critical Perspectives on Internationalisation*, Pergamon, Oxford, pp. 305-334.

Cantwell, J.A. and Mudambi, R. (2011), "Physical attraction and the geography of knowledge sourcing in multinational enterprises", *Global Strategy Journal*, Vol. 1 Nos 3/4, pp. 206-232.

Cantwell, J. and Piscitello, L. (2015), "New competence creation in multinational company subunits: the role of international knowledge", *The World Economy*, Vol. 38 No. 2, pp. 231-254.

Cantwell, J. and Santangelo, G.D. (1999), "The frontier of international technology networks: sourcing abroad the most highly tacit capabilities", *Information Economics and Policy*, Vol. 11 No. 1, pp. 101-123.

Cantwell, J. and Zaman, S. (2018), "Connecting local and global technological knowledge sourcing", *Competitiveness Review: An International Business Journal*, Vol. 28 No. 3, pp. 277-294.

Cassiman, B. and Veugelers, R. (2002), "R&D cooperation and spillovers: some empirical evidence from Belgium", *American Economic Review*, Vol. 92 No. 4, pp. 1169-1184.

Cassiman, B. and Golovko, E. (2011), "Innovation and internationalization through exports", *Journal of International Business Studies*, Vol. 42 No. 1, pp. 56-75.

Cassiman, B., Golovko, E. and Martínez-Ros, E. (2010), "Innovation, exports and productivity", *International Journal of Industrial Organization*, Vol. 28 No. 4, pp. 372-376.

Castellani, D. and Zanfei, A. (2007), "Internationalisation, innovation and productivity: how do firms differ in Italy?", *The World Economy*, Vol. 30 No. 1, pp. 156-176.

Chen, T. and Tang, D. (1987), "Comparing technical efficiency between import-substitution-oriented and export-oriented foreign firms in a developing economy", *Journal of Development Economics*, Vol. 26 No. 2, pp. 277-289.

Chesbrough, H.W. (2003), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business Press.

Cho, S. and Cantwell, J. (2024), "Knowledge sourcing and national technological development: the weak internationalization of R&D in South Korea", *Journal of Business Research*, Vol. 170, p. 114345.

Choi, G. and Cho, S. (2022), "Effect of market versus nonmarket environmental policy stringency on knowledge sourcing behavior for green technology: evidence from OECD countries", *Review of International Business and Strategy*, Vol. 32 No. 1, pp. 72-93.

Cho, S. and Kim, H. (2017), "Intellectual property rights protection and technological innovation", *Multinational Business Review*, Vol. 25 No. 4, pp. 350-368.

Cho, H.D. and Lee, J.K. (2003), "The developmental path of networking capability of catch-up players in Korea's semiconductor industry", *R&D Management*, Vol. 33 No. 4, pp. 411-423.

Chung, W. and Yeaple, S. (2008), "International knowledge sourcing: evidence from US firms expanding abroad", *Strategic Management Journal*, Vol. 29 No. 11, pp. 1207-1224.

Conner, K.R. and Prahalad, C.K. (1996), "A resource-based theory of the firm: knowledge versus opportunism", *Organization Science*, Vol. 7 No. 5, pp. 477-501.

Damijan, J.P. and Knell, M. (2005), "How important is trade and foreign ownership in closing the technology gap? Evidence from Estonia and Slovenia", *Review of World Economics*, Vol. 141 No. 2, pp. 271-295.

Damijan, J.P., Kostevc, Č. and Polanec, S. (2010), "From innovation to exporting or vice versa?", *The World Economy*, Vol. 33 No. 3, pp. 374-398.

Dunning, J.H. (1994), "Multinational enterprises and the globalization of innovatory capacity", *Research Policy*, Vol. 23 No. 1, pp. 67-88.

Eisenhardt, K.M., Santos, F.M., Pettigrew, I.A., Thomas, H. and Whittington, R. (2000), "Knowledge based view", *Handbook of Strategy and Management*, Sage Publications, London.

Elia, S., Munjal, S. and Scalera, V.G. (2020), "Sourcing technological knowledge through foreign inward licensing to boost the performance of Indian firms: the contingent effects of internal R&D and business group affiliation", *Management International Review*, Vol. 60 No. 5, pp. 695-721.

Ferreras-Méndez, J.L., Fernández-Mesa, A. and Alegre, J. (2019), "Export performance in SMEs: the importance of external knowledge search strategies and absorptive capacity", *Management International Review*, Vol. 59 No. 3, pp. 413-437.

Freixanet, J. and Federo, R. (2023), "Learning by exporting: a system-based review and research agenda", *International Journal of Management Reviews*, Vol. 25 No. 4.

Frost, T.S. (2001), "The geographic sources of foreign subsidiaries' innovations", *Strategic Management Journal*, Vol. 22 No. 2, pp. 101-123.

Grant, R.M. (1996), "Toward a knowledge-based theory of the firm", *Strategic Management Journal*, Vol. 17 No. S2, pp. 109-122.

Greenaway, D. and Kneller, R. (2007), "Firm heterogeneity, exporting and foreign direct investment", *The Economic Journal*, Vol. 117 No. 517.

Griliches, Z. and Hjorth-Andersen, C. (1992), "The search for R&D spillovers; comment", *The Scandinavian Journal of Economics*, Vol. 94, pp. S29-S50.

Grossman, G. and Helpman, E. (1991), "Trade, knowledge spillovers, and growth", *European Economic Review*, Vol. 35 Nos 2/3, pp. 517-526.

Hannigan, T.J., Lee, A. and Mudambi, R. (2013), "The pitfalls of an inward oriented economy: lessons from the evolution of Brazil and the Republic of Korea", *Transnational Corporations*, Vol. 22 No. 2, pp. 1-24.

Hu, A.G. and Jaffe, A.B. (2003), "Patent citations and international knowledge flow: the cases of Korea and Taiwan", *International Journal of Industrial Organization*, Vol. 21 No. 6, pp. 849-880.

Hwang, H.R. and Choung, J.Y. (2014), "The co-evolution of technology and institutions in the catch-up process: the case of the semiconductor industry in Korea and Taiwan", *The Journal of Development Studies*, Vol. 50 No. 9, pp. 1240-1260.

Hymer, S.H. (1976), *The International Operations of National Firms: A Study of Direct Foreign Investment*, Vol. 14, MIT press, Cambridge, MA, pp. 139-155.

Iansiti, M. and Clark, K.B. (1994), "Integration and dynamic capability: evidence from product development in automobiles and mainframe computers", *Industrial and Corporate Change*, Vol. 3 No. 3, pp. 557-605.

Jaffe, A., Trajtenberg, M. and Henderson, R. (1993), "Geographic localization of knowledge spillovers as evidenced by patent citations", *The Quarterly Journal of Economics*, Vol. 108 No. 3, pp. 577-598.

Jung, M. and Lee, K. (2010), "Sectoral systems of innovation and productivity catch-up: determinants of the productivity gap between Korean and Japanese firms", *Industrial and Corporate Change*, Vol. 19 No. 4, pp. 1037-1069.

Kano, L., Tsang, E.W. and Yeung, H.W.C. (2020), "Global value chains: a review of the multi-disciplinary literature", *Journal of International Business Studies*, Vol. 51 No. 4, pp. 577-622.

Kim, D.H. (1998), "The link between individual and organizational learning in the strategic management of intellectual capital", *The Strategic Management of Intellectual Capital*, Oxford University Press, pp. 41-62.

Kim, H. and Cho, S. (2021), "Foreign affiliates' knowledge sourcing from parent firms", *Canadian Journal of Administrative Sciences/Revue Canadienne Des Sciences de L'Administration*, Vol. 38 No. 1, pp. 80-91.

Kuemmerle, W. (1999), "Foreign direct investment in industrial research in the pharmaceutical and electronics industries—results from a survey of multinational firms", *Research Policy*, Vol. 28 Nos 2/3, pp. 179-193.

Lane, P.J. and Lubatkin, M. (1998), "Relative absorptive capacity and interorganizational learning", *Strategic Management Journal*, Vol. 19 No. 5, pp. 461-477.

Laursen, K. and Salter, A. (2006), "Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms", *Strategic Management Journal*, Vol. 27 No. 2, pp. 131-150.

Lee, K. and Lim, C. (2001), "Technological regimes, catching-up and leapfrogging: findings from the Korean industries", *Research Policy*, Vol. 30 No. 3, pp. 459-483.

Leiponen, A. and Helfat, C.E. (2010), "Innovation objectives, knowledge sources, and the benefits of breadth", *Strategic Management Journal*, Vol. 31 No. 2, pp. 224-236.

Leone, M.I. and Reichstein, T. (2012), "Licensing-in fosters rapid invention! the effect of the grant-back clause and technological unfamiliarity", *Strategic Management Journal*, Vol. 33 No. 8, pp. 965-985.

Liang, F.H. (2017), "Does foreign direct investment improve the productivity of domestic firms? Technology spillovers, industry linkages, and firm capabilities", *Research Policy*, Vol. 46 No. 1, pp. 138-159.

Liu, T. and Li, X. (2022), "How do MNCs conduct local technological innovation in a host country? An examination from subsidiaries' perspective", *Journal of International Management*, Vol. 28 No. 3, p. 100951.

Liu, X. and Wang, C. (2003), "Does foreign direct investment facilitate technological progress? Evidence from Chinese industries", *Research Policy*, Vol. 32 No. 6, pp. 945-953.

Majocchi, A., Bacchiocchi, E. and Mayrhofer, U. (2005), "Firm size, business experience and export intensity in SMEs: a longitudinal approach to complex relationships", *International Business Review*, Vol. 14 No. 6, pp. 719-738.

Maurseth, P.B. and Verspagen, B. (2002), "Knowledge spillovers in Europe: a patent citations analysis", *The Scandinavian Journal of Economics*, Vol. 104 No. 4, pp. 531-546.

Meyer, K.E. and Sinani, E. (2009), "When and where does foreign direct investment generate positive spillovers? A meta-analysis", *Journal of International Business Studies*, Vol. 40 No. 7, pp. 1075-1094.

Miao, Y., Song, J., Lee, K. and Jin, C. (2018), "Technological catch-up by east Asian firms: trends, issues, and future research agenda", *Asia Pacific Journal of Management*, Vol. 35 No. 3, pp. 639-669.

Mu, J., Peng, G. and Love, E. (2008), "Interfirm networks, social capital, and knowledge flow", *Journal of Knowledge Management*, Vol. 12 No. 4, pp. 86-100.

Niosi, J. (1999), "The internationalization of industrial R&D: from technology transfer to the learning organization", *Research Policy*, Vol. 28 Nos 2/3, pp. 1-7. 117.

Oliva, F.L., Couto, M.H.G., Santos, R.F. and Bresciani, S. (2019), "The integration between knowledge management and dynamic capabilities in agile organizations", *Management Decision*, Vol. 57 No. 8, pp. 1960-1979.

Ozawa, T. (2009), *The Rise of Asia: The 'Flying-Geese' Theory of Tandem Growth and Regional Agglomeration*, Elgar, Cheltenham, Paperback, p. 2011.

Papa, A., Dezi, L., Gregori, G.L., Mueller, J. and Miglietta, N. (2018), "Improving innovation performance through knowledge acquisition: the moderating role of employee retention and human resource management practices", *Journal of Knowledge Management*, Vol. 24 No. 3, pp. 589-605.

Powell, W.W. (1998), "Learning from collaboration: knowledge and networks in the biotechnology and pharmaceutical industries", *California Management Review*, Vol. 40 No. 3, pp. 228-240.

Qiu, R. and Cantwell, J. (2017), "The international geography of general purpose technologies (GPTs) and internationalization of corporate innovations", *Industry and Innovation*, Vol. 25 No. 1, pp. 1-24.

Salomon, R.M. (2006), "Spillovers to foreign market participants: assessing the impact of export strategies on innovative productivity", *Strategic Organization*, Vol. 4 No. 2, pp. 135-164.

Salomon, R.M. and Shaver, J.M. (2005), "Learning by exporting: new insights from examining firm innovation", *Journal of Economics and Management Strategy*, Vol. 14 No. 2, pp. 431-460.

Santoro, G., Bertoldi, B., Giachino, C. and Candelo, E. (2020), "Exploring the relationship between entrepreneurial resilience and success: the moderating role of stakeholders' engagement", *Journal of Business Research*, Vol. 119, pp. 142-150.

Scott-Kennel, J. and Saittakari, I. (2020), "Sourcing or sharing in MNE networks? National headquarters and foreign subsidiaries as knowledge conduits in SMOPECs", *International Business Review*, Vol. 29 No. 1, p. 101622.

Şeker, M. (2012), "Importing, exporting, and innovation in developing countries", *Review of International Economics*, Vol. 20 No. 2, pp. 299-314.

Sinani, E. and Meyer, K.E. (2004), "Spillovers of technology transfer from FDI: the case of Estonia", *Journal of Comparative Economics*, Vol. 32 No. 3, pp. 445-466.

Singh, J. (2005), "Collaborative networks as determinants of knowledge diffusion patterns", *Management Science*, Vol. 51 No. 5, pp. 756-770.

Smith, S.W. (2014), "Follow me to the innovation frontier? Leaders, laggards, and the differential effects of imports and exports on technological innovation", *Journal of International Business Studies*, Vol. 45 No. 3, pp. 248-274.

Song, J., Asakawa, K. and Chu, Y. (2011), "What determines knowledge sourcing from host locations of overseas R&D operations?: a study of global R&D activities of Japanese multinationals", *Research Policy*, Vol. 40 No. 3, pp. 380-390.

Wagner, J. (2007), "Exports and productivity: a survey of the evidence from firm-level data", *The World Economy*, Vol. 30 No. 1, pp. 60-82.

Wang, K. and Tao, W. (2019), "Exploring the complementarity between product exports and foreign technology imports for innovation in emerging economic firms", *European Journal of Marketing*, Vol. 53 No. 2, pp. 224-256.

Wang, J.H. and Tsai, C.J. (2010), "National model of technological catching up and innovation: comparing patents of Taiwan and South Korea", *Journal of Development Studies*, Vol. 46 No. 8, pp. 1404-1423.

Wu, J., Zahoor, N., Khan, Z. and Meyer, M. (2023), "The effects of inward FDI communities on the research and development intensity of emerging market locally domiciled firms: Partial foreign ownership as a contingency", *Journal of Business Research*, Vol. 156, p. 113487.

Xu, B. (2000), "Multinational enterprises, technology diffusion, and host country productivity growth", *Journal of Development Economics*, Vol. 62 No. 2, pp. 477-493.

Further reading

Hausman, J., Hall, B. and Griliches, Z. (1984), "Econometric models for count data with an application to the patents-R&D relationship", *Econometrica*, Vol. 52 No. 4, pp. 909-938.

Kogut, B. and Chang, S.J. (1991), "Technological capabilities and Japanese foreign direct investment in the United States", *The Review of Economics and Statistics*, Vol. 73 No. 3, pp. 401-413.

Qiu, R. and Cantwell, J. (2018), "The international geography of general purpose technologies (GPTs) and internationalisation of corporate technological innovation", *Industry and Innovation*, Vol. 25 No. 1, pp. 1-24.

Appendix 1

Tech. field	US patent class	Tech. field	US patent class
1	127, 131, 426	29	48, 91, 92, 110, 122, 126, 137, 165, 184, 185, 188, 192, 237, 239, 251, 303, 415–418, 431, 432
2	201, 203	30	235, 400
3	423	31	60
4	71	32	376, 976
5	23, 51, 55, 62, 134. 156, 204, 210, 260, 427, 432, 518	33	178, 179, 329, 332, 367, 370, 375, 379, 455
6	430	34	340, 341, 382
7	106, 252, 512	35	342, 343
8	422	36	84, 181, 358, 381
9	260. 520–528	37	313–315, 362
10	8	38	174, 200, 307, 308, 323, 328, 330, 331, 333–339, 361, 363, 372, 439, 505
11	260, 530, 534, 536, 540, 544, 546, 548, 549, 552, 556, 560, 562, 564, 568, 570, 930	39	62, 136, 204, 219, 236, 290, 310, 318, 320, 322, 361, 373, 388, 392, 429, 437
12	424, 435, 436, 514, 800, 935	40	307, 357
13	29, 75, 148, 164, 228, 419, 420	41	235, 360, 364, 365, 369, 71, 377, 902
14	3, 4, 7, 10, 16, 24, 27, 30, 49, 63, 70, 108, 109, 124, 132, 135, 138, 150, 160, 182, 90, 206, 211, 215, 220, 232, 248, 256, 267, 272, 279, 285, 292, 312, 383, 403, 411, 464, 623	42	123
15	99, 127, 131	43	180, 296
16	34, 51, 55, 68, 118, 134, 156, 159, 196, 202, 209, 210, 261, 366, 422, 494, 502, 503	44	244
17	59, 72, 76, 81, 82, 83,163, 164, 173, 225, 228, 234, 266, 269, 308, 384, 407–409, 413, 474	45	114, 440, 441
18	53, 162, 229, 493	46	104, 105, 213, 238, 246
19	65, 241, 249	47	191, 280, 293, 295, 298, 301, 305
20	186, 187, 193, 198, 212, 224, 226, 242, 254, 258, 271, 294, 402, 406, 410, 414, 901	48	2, 36, 245, 289, 450
21	56, 11, 130, 172, 278, 460	49	152, 264
22	37, 171, 404	50	52, 65, 125, 215, 241,428, 501
23	166, 175, 299	51	44, 208, 585
24	445	52	354, 355
25	12, 19, 26, 28, 38, 57, 66, 69, 87, 112, 139, 223	53	33, 73, 74, 128, 177, 187, 235, 250, 324, 346, 350–353, 356, 368, 374, 378, 433, 475, 600,604, 606
26	101, 199, 270, 276, 281–283, 412, 462	54	5, 217, 297
27	142, 144, 145	55	149
28	15, 30, 79, 98, 100, 116,133, 140, 141, 147,157, 169, 194, 221, 222, 227, 254, 277, 291, 300, 401, 425, 453	56	6, 14, 17, 40, 42, 43, 47, 54, 86, 89, 102, 114, 119, 168, 231, 244, 273, 380, 404, 405, 434, 446, 449, 452

Table A1. Technological fields: correspondence with US patent classes

Source: Cantwell and Piscitello (2015)

Appendix 2

DV: International knowledge sourcing	Model 1	2	3	4
Industry dummy	Included	Included	Included	Included
Korean knowledge stock	−0.054 (0.001)***	−0.054 (0.000)***	−0.054 (0.001)***	−0.054 (0.001)***
Knowledge stock of foreign-owned firms in South Korea	0.239 (0.011)***	0.242 (0.011)***	0.248 (0.011)***	0.247 (0.010)***
Export-intensity		0.011 (0.001)***		0.007 (0.001)***
Inward FDI			0.088 (0.004) ***	0.060 (0.005)***
Chi^2	5,575.37***	6,015.17***	5,999.03***	6,168.85***
Pseudo R^2	0.0870	0.0883	0.0882	0.0888
Observations	390,126	390,126	390,126	390,126

Notes: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$
Source: Table by authors

Table A2. Robustness checks using subperiod analysis for international knowledge sourcing

Appendix 3

DV: International knowledge sourcing	Model 1	2	3
Industry dummy	Included	Included	Included
Export-intensity	0.011 (0.002)***		0.004 (0.002)*
Inward FDI		0.216 (0.020)***	0.202 (0.022) ***
Chi^2	30.35***	118.08***	121.15
Pseudo R^2	0.0613	0.0652	0.0653
Observations	55,822	55,822	55,822

Notes: *$p < 0.10$; **< 0.05; ***$p < 0.01$
Source: Table by authors

Table A3. Robustness checks using subperiod analysis for intra versus interindustry knowledge sourcing

Appendix 4

Table A4. Robustness checks by controlling firm effect in an industry for international knowledge sourcing

DV: International knowledge sourcing	Model 1	2	3	4
Industry dummy	Included	Included	Included	Included
Firm dummy	Included	Included	Included	Included
Korean knowledge stock	−0.054 (0.001)***	−0.054 (0.001)***	−0.053 (0.001)***	−0.053 (0.001)***
Knowledge stock of foreign-owned firms in South Korea	0.260 (0.010)***	0.266 (0.010)***	0.273 (0.010)***	0.273 (0.010)***
Export-intensity		0.010 (0.000)***		0.007 (0.001)***
Inward FDI			0.090 (0.004)***	0.064 (0.005)***
Chi^2	6,719.19***	7,203.10***	7,234.63***	7,410.68***
Pseudo R^2	0.8171	0.0884	0.0884	0.0889
Observations	472,303	472,303	472,303	472,303

Notes: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$
Source: Table by author

Appendix 5

Table A5. Robustness checks by controlling firm effect in an industry for intra versus interindustry knowledge sourcing

DV: International knowledge sourcing	Model 1	2	3
Industry dummy	Included	Included	Included
Firm dummy	Included	Included	Included
Export-intensity	0.017 (0.002)***		0.010 (0.002)***
Inward FDI		0.206 (0.019)***	0.166 (0.020)***
Chi^2	103.87***	144.21***	174.34***
Pseudo R^2	0.0639	0.0655	0.0666
Observations	66,065	66,065	66,065

Notes: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$
Source: Table by authors

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