3 Business sector research and development and innovation in Korea

This chapter reviews the business sector's research and development (R&D) and innovation performance in Korea, drawing on extensive qualitative and quantitative analysis, including a benchmarking of the country's technology specialisation in digital and green technologies. It highlights the challenges posed by the polarisation of business innovation performance across different sectors and between larger and smaller firms. Finally, it discusses the recent policy reforms taken to address these imbalances as well as the need for adjusting the policy mix for business innovation to ensure Korea's business sector can seize the opportunities of the digital and green transitions.

Korea has built a very innovative and dynamic business sector, which has been the engine of economic growth and prosperity. However, the success of the Korean business sector has been overshadowed by acute discrepancies across firms and industries: 1) an innovation divide between large firms and small and medium-sized enterprises (SMEs); 2) the productivity gap between information and communication technology (ICT) and non-ICT industry; and 3) a disparity in innovation investments between manufacturing and services.

The chapter begins with a general diagnosis of business sector R&D and innovation in Korea that is followed by a series of policy recommendations.

First, the exceptionally high concentration in R&D spending on the few largest companies in Korea sheds light on the growing discrepancy between large companies and SMEs. A significant gap in R&D investment has resulted in an innovation divide between larger and smaller firms and a decline in the ability of SMEs to absorb new technologies and further their digitalisation. The strong commitment and support for SMEs by the government is encouraging, and there is evidence of a maturing start-up ecosystem, especially around Seoul. The government should sustain its support for SMEs and start-ups with more streamlined and impact-oriented programmes. In particular, the government could strengthen support for the global connectivity of SMEs and start-ups to help scale up and reach new markets.

Second, the ICT industry in Korea has achieved remarkable growth and is now a global leader. However, there is also a widening discrepancy between ICT and non-ICT industry in various aspects ranging from R&D investment to productivity. In fact, the productivity of the non-ICT manufacturing industry is only half that of the ICT manufacturing sector. The government has long strived to support the diversification of its industrial landscape and reduce its reliance on the ICT industry. In this regard, the emergence of the biotech industry is impressive. The share of Korean biotechnology patents has increased significantly, and so has the number of biotech start-ups. The growth of the biotech industry is especially noteworthy in that the public R&D investment paved the way for its successful take-off. The government should continue to foster new and emerging technology-based firms and industries by promoting collaborative R&D and innovation activity across different firms and with academia.

Finally, the large discrepancy in productivity and investment between the manufacturing and the service industry persists despite active government support. Meanwhile, knowledge-based services, notably the software industry, offer the potential for higher value-added and balanced growth in the Korean economy. The government should enhance the role of services by developing a dedicated innovation strategy and addressing remaining regulatory barriers. In particular, the government should support the expansion of “servicification”, which represents the phenomenon whereby services are increasingly embedded in manufacturing products.

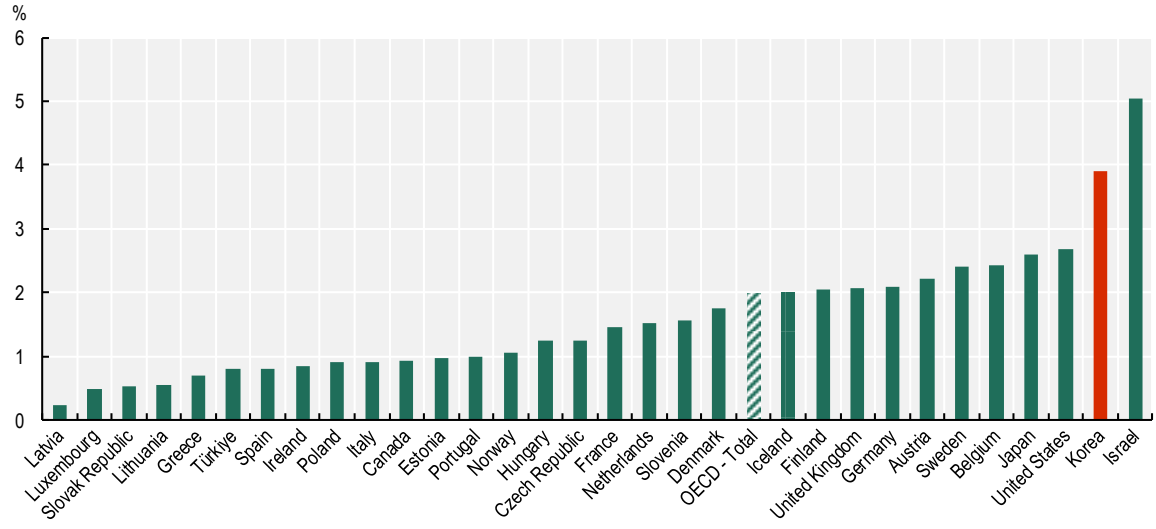
3.1. A general assessment of business innovation in Korea

This section describes Korean business research and development (R&D) and innovation performance and overall strengths based on different indicators. It highlights some of the critical imbalances in business sector innovation performance, notably the dominance of large manufacturing-based R&D, that prevent Korea from harnessing its full productivity potential through innovation in services and by smaller firms. Recognising the positive contributions of recent policies to address the imbalances in business innovation performance, the section advocates for well-designed policy support for *emerging technologies* to help Korea’s business sector seize the opportunities from the digital and green transitions, not only in manufacturing but also in services.

3.1.1. Korean business R&D has grown rapidly and leads globally

Business sector R&D in Korea more than doubled from KRW 32.8 trillion (Korean won) in 2010 to KRW 68.8 trillion in 2019 (OECD, 2021[1]). Moreover, business enterprise expenditures on R&D (BERD) amounted to 3.9% of gross domestic product (GDP) in Korea in 2021, which is more than double the OECD average and the second-highest business R&D intensity among all OECD countries, behind Israel (Figure 3.1) (OECD, 2023[2]). In terms of business R&D expenditure, 60 of the global top 2 500 firms are Korean, including Samsung Electronics and other chaebols. In 2020, Korea hosted the highest number of R&D players after the United States (779 firms), the People's Republic of China (hereafter "China") (597), Japan (293), Germany (124), the United Kingdom (105), Chinese Taipei (86) and France (66) (European Commission, 2022[3]).

Figure 3.1. Business enterprise expenditures on R&D as a percentage of GDP, OECD countries, 2021

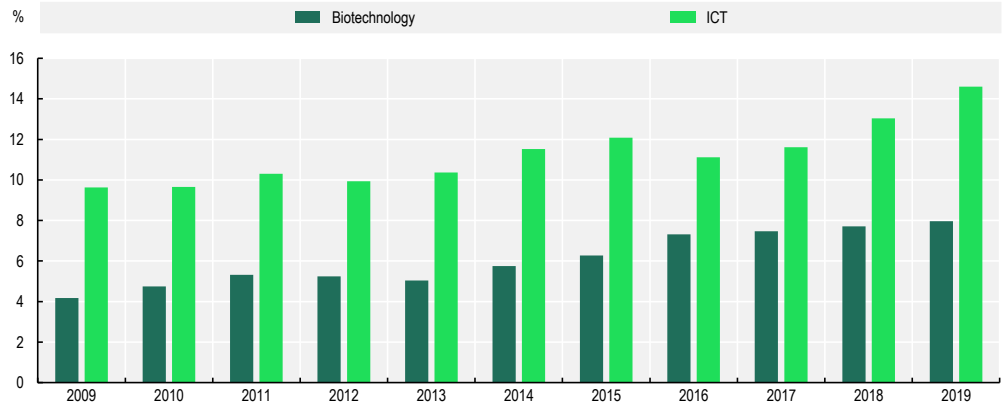


Source: OECD (2023[4]), "Main Science and Technology Indicators", *OECD Science, Technology and R&D Statistics* (database), https://doi.org/10.1787/data-00182-en (accessed on 8 June 2023).

Outcomes of R&D activities can be measured through intellectual property (IP) production and, in particular, patents, which are mainly applied for by the business sector. The number of Korean patents filed under the PCT (Patent Cooperation Treaty) increased from 8 731 (5.6% of the world total) in 2009 to 17 333 (6.8% of the world total) in 2018 (OECD, 2023[2]). Moreover, Korea's patent performance has improved not only in absolute but also in relative terms. The country's patent share within the OECD has increased in high-tech industries, such as ICT and biotechnology (Figure 3.2). As of 2017, Korea had the second-highest number of ICT patent filings among all OECD countries, behind Japan, and the third-highest number of biotechnology patent filings, behind the United States and Japan. Korea's patent filings per unit of GDP have been higher than in the United States and Japan in both high-tech sectors (Hemmert, 2020[4]).

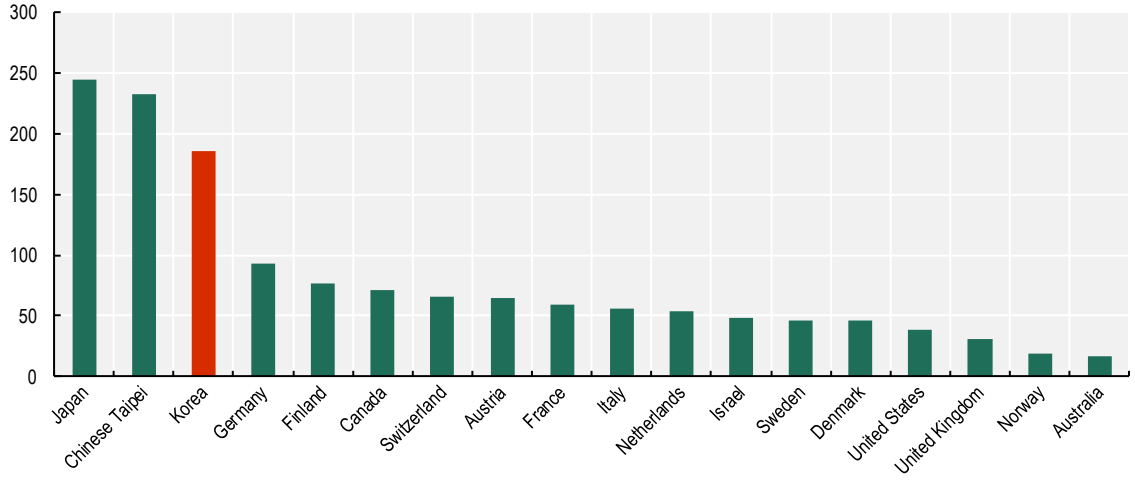
Individual Korean companies have also increased their IP positions in impressive ways. As of 2020, Samsung Electronics and LG Corporation have ranked second and third in the number of US utility patents among all companies worldwide (Harrity, 2021[5]). Moreover, strong R&D investment combined with high patent filing has advanced Korea over other economies in terms of patenting performance to R&D expenditure. Korea has placed third after Japan and Chinese Taipei (Figure 3.3).

Figure 3.2. Korea's share in OECD ICT and biotech PCT patents, 2009-19



Note: Patent data are based on the inventor's residence and priority year.
Source: Authors' calculations based on OECD STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, accessed on 9 June 2023).

Figure 3.3. Number of IP5 patents family per USD Billion of GERD, selection of economies, 2019



Note: Patent data are based on the inventor's residence and priority year. IP5 patent families refer to patents filed in at least two IP offices among five major patent offices in China, Europe, Japan, Korea and the United States.
Source: Authors' calculations based on OECD, *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats (accessed on 9 June 2023) and (OECD, 2023[2]), "Main Science and Technology Indicators", *OECD Science, Technology and R&D Statistics (database)*, https://doi.org/10.1787/data-00182-en (accessed on 8 June 2023).

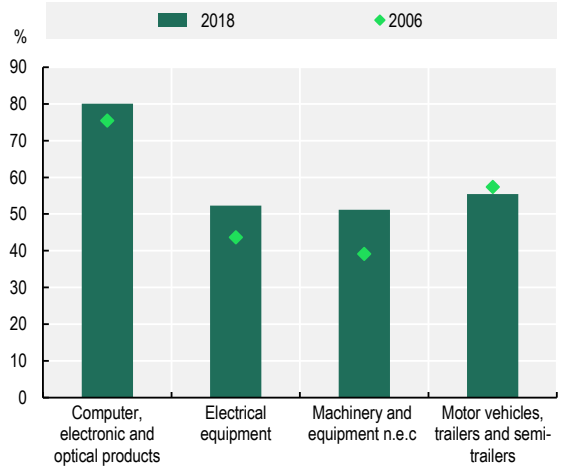
3.1.2. Korea is advancing toward knowledge-intensive industry with increased global market share in high-tech products

Innovation performance can be associated with the ratio of domestic value added to gross exports in high-tech industries. When Korea industrialised, companies in knowledge-intensive industries initially focused on downstream activities, such as the final assembly of electronic products and automobiles. As a result, the value added within Korea represented a relatively low share of industry output and exports. However, this ratio has significantly increased across major knowledge-intensive industries (Figure 3.4). As a result of the technological upgrading of Korean firms and foreign suppliers' direct investment in Korea, value

chains in knowledge-intensive manufacturing industries, which play a leading role in Korean exports, appear to have been localised to a high degree.

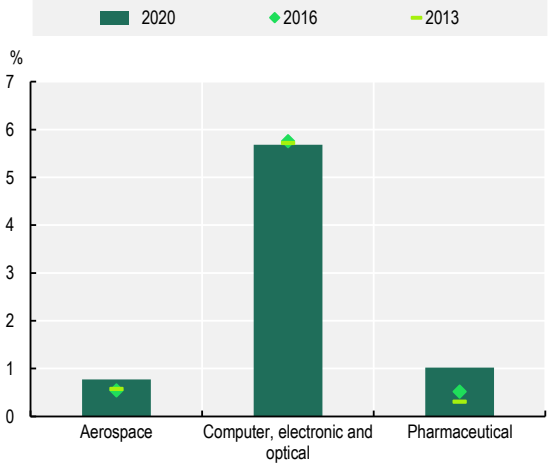
Business innovation performance can also be observed later in the innovation process through companies' competitive performance, which can strongly reflect their innovation performance in high-tech industries (Figure 3.5). The world export market share of Korean companies in the computer, electronic and optical industry is above 5% and third-highest among all countries, behind China and the United States. Korean companies still have a small but growing share of the global export market in the pharmaceutical and aerospace industries.

Figure 3.4. Korea's share of domestic value added embodied in foreign final demand, 2006 and 2018 for a selection of industrial sectors



Note: Computer, electronics and optical products correspond to Isic D26, Electrical equipment D27, Machinery and equipment n.e.c D28 and Motor vehicles, trailers and semi-trailers D29
Source: OECD (2023[6]), "Trade in value added", *OECD Statistics on Trade in Value Added* (database), https://doi.org/10.1787/data-00648-en, (accessed on 9 June 2023).

Figure 3.5. World export market share of Korean firms in high-tech industries



Source: OECD (2023[7]), "Main Science and Technology Indicators", *OECD Science, Technology and R&D Statistics* (database), https://doi.org/10.1787/data-00182-en, August 2022.

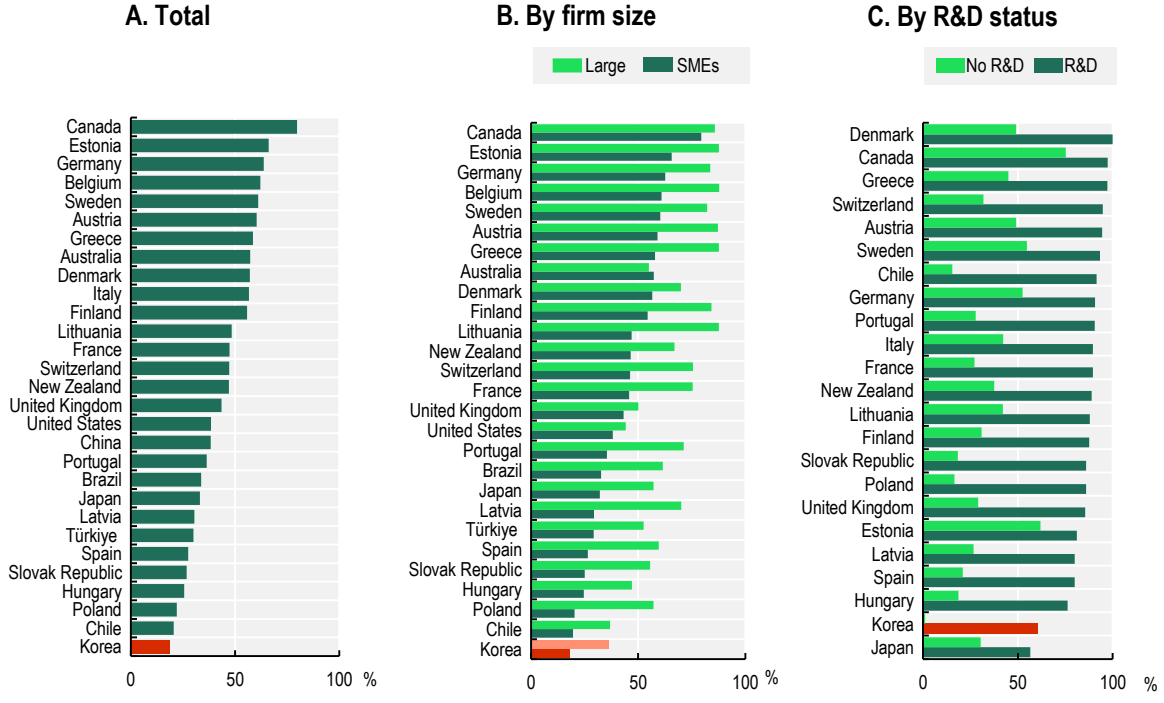
3.1.3. Despite outstanding progress in business innovation, Korean firms' innovation performance still has room for improvement

Overall, the Korean business sector's innovation performance is strong and improving with impressive scale and speed when measured by IP production, export competitiveness in high-tech industries and domestic value added in knowledge-intensive industries. In particular, Korean firms' performance is strong in the ICT sector in many measures. However, somewhat different pictures emerge when assessing the innovation performance activities of Korean firms from different angles.

First, Korea's total ratio of innovating firms is the lowest among all OECD countries, and the low ratio of innovating firms consistently holds across firm size and R&D status (Figure 3.6). Furthermore, it is second-lowest in product innovation and the lowest in business process innovation (OECD, 2020[8]). Meanwhile, the most recent Korean Innovation Survey (KIS) on innovation activities by Korean manufacturing firms from 2017 to 2019 reveals several features of firm innovation activities in a more detailed manner. Overall, 14.2% of Korean manufacturing firms introduced a new product or service (product innovation); 17.8% innovated in processes, organisationally, or in marketing (business process innovation); and 20.6% innovated in at least one of the two categories (Figure 3.7). Adjusted values for Korea calculated for direct comparison with Community Innovation Survey (CIS) data are 23.8% for product innovation and 28.3% for business process innovation – thereby closer to, but still below, the EU average (STEPI, 2021[9]). Caution should be used when translating the results of the innovation surveys, however, due to cultural differences and different industrial landscapes across countries.

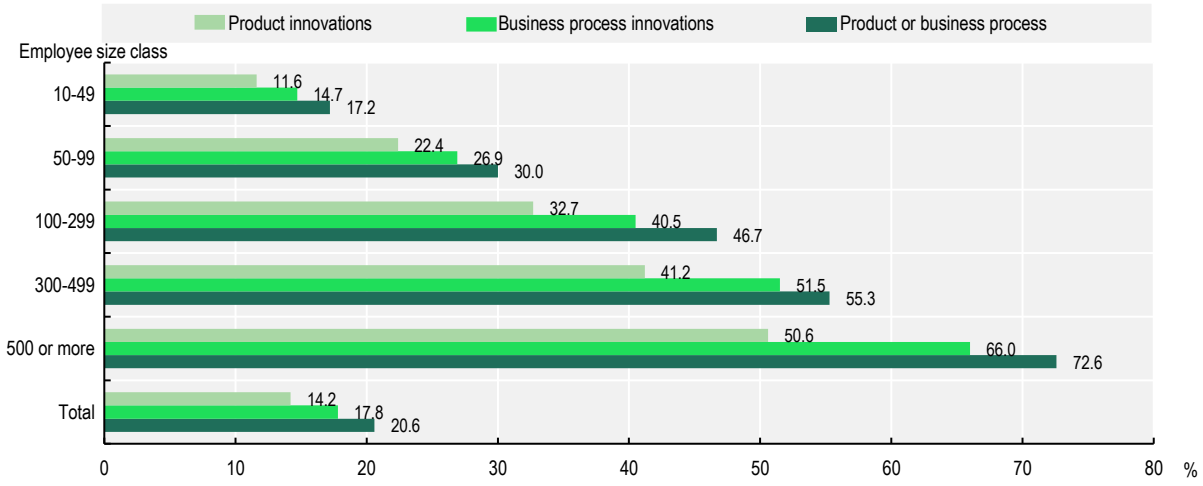
Figure 3.6. Innovative firms in Korea and selected countries, 2016-18

As a percentage of total firms (within the scope of national innovation surveys) within each group



Note: Innovative firms are those reporting at least one product or business process innovation in the reference period (2016 18).
Source: OECD calculations, based on the 2021 OECD Survey of Business Innovation Statistics and the Eurostat's Community Innovation Survey (CIS-2018), https://www.oecd.org/sti/inno-stats.htm, April 2022.

Figure 3.7. Share of innovating Korean manufacturing firms, 2017-19



Source: STEPI (2021[10]), *Report on the Korean Innovation Survey 2020: Manufacturing Sector 2019*, https://www.stepi.re.kr/kis/service/sub03_report.do.

Second, most Korean firms significantly rely on in-house R&D when innovating. Some 39.4% of Korean manufacturing firms conduct in-house R&D. In comparison, 5.6% engage in collaborative R&D, and 1.6% rely on out-contracted R&D. Among large firms with 500 or more employees, 94.3% conduct in-house R&D. In comparison, only 32.9% and 11.8% rely on collaborative and out-contracted R&D, respectively (STEPI, 2021[10]). The high ratio of in-house R&D in the Korean manufacturing industry is associated with a high level of vertical integration. In comparison, 12.2% of all manufacturing firms in the EU27 have contracted out R&D. Among medium-sized and large companies, the propensity to out-contract R&D exceeds 30% in many EU countries (Eurostat, 2021[11]). On top of R&D activities, Korean firms rely to a great extent on internal information sources when innovating. Among the surveyed manufacturing firms, 83.0% use company-internal sources of innovation. The second and third most frequent information sources are external private firms and universities and higher education institutions, which have been used by 27.7% and 19.7% of the firms, respectively. The statistics above imply that Korean business still has room for improvement regarding promoting open innovation, which espouses sourcing ideas from external and internal sources.

Third, most innovation activities by Korean firms are focused on R&D. Some 80.8% of their innovation expenses fall to in-house R&D, followed by 13.2% for in-house non-R&D expenses, 4.2% for collaborative R&D expenses and 1.3% for out-contracted R&D expenses. In contrast, the innovation expenses of innovating firms in most of Europe are less concentrated on R&D expenses in general and in-house R&D expenses in particular (Eurostat, 2021[11]).

Finally, Korean manufacturing firms mostly focus on incremental innovation. While 85.9% of the firms surveyed in the KIS 2020 worked on improving existing goods or services, only 39.8% targeted introducing new goods or services. This incremental innovation focus can be broadly observed across different enterprise size classes and industries (STEPI, 2021[10]). Meanwhile, it is worth noting that the Korean government is encouraging disruptive innovation and more innovative R&D across industry, as illustrated by the recently launched Alchemist Project that aims to develop technologies to transform industry.

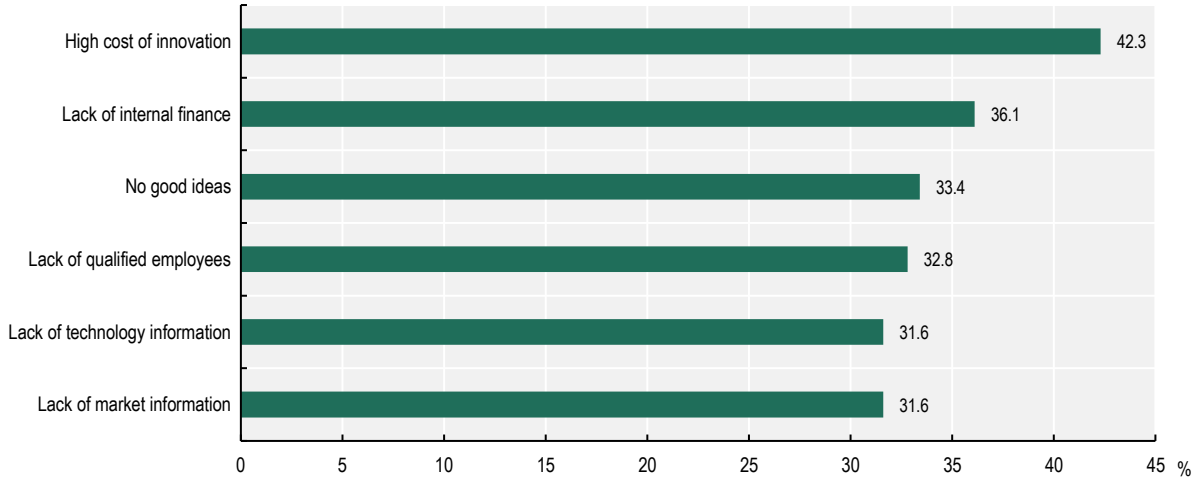
3.1.4. Financial difficulties and a lack of qualified labour hinder Korean firms' innovation

According to KIS 2020, the innovation barriers most frequently recognised as significant by Korean firms have been the high cost of innovation (42.3%), followed by a lack of internal finance (36.1%) and no good

ideas (33.4%) (Figure 3.8). A lack of qualified employees and technology and market information also constitute important innovation barriers for Korean manufacturing firms. Overall, barriers related to financial difficulties and companies' capabilities are most frequent. In contrast, market-related barriers (e.g. uncertainty about market demand) and necessity-related barriers (e.g. no need for additional innovation) are regarded not as hindering as financial difficulties and firms' capabilities (STEPI, 2021[10]). Similar observations have been made for service firms, which play a lesser role in business innovation in Korea than manufacturing firms. The innovation barriers reported most frequently as significant by Korean service companies in the years 2015-17 have been a lack of internal finance, difficulties with obtaining financial support from the government and the high cost of innovation (STEPI, 2019[12]). Service companies appear to rely to a relatively high degree on government support for innovation, as they have identified difficulties with obtaining such support as one of the most frequently significant innovation barriers.

Figure 3.8. Innovation barriers for Korean manufacturing firms, 2017-19

Percentage of firms that perceived barriers as high



Source: (STEPI, 2021[10]), *Report on the Korean Innovation Survey 2020: Manufacturing Sector 2019*, https://www.stepi.re.kr/kis/service/sub03_report.do.

The finance- and capability-related innovation barriers in Korea are more important for smaller than for larger firms. However, they are highly relevant even for many large firms. While 46.0% of small firms with 10-49 employees perceive the high cost of innovation as an important innovation barrier, the proportion of large firms with 500 or more employees that share this perception is 40.3%. The size-related difference is greater regarding the lack of internal finance, which is perceived by 38.9% of small firms and 15.8% of all large firms as a significant innovation barrier (STEPI, 2021[10]). In other words, while small Korean manufacturing firms often do not innovate due to high cost or lack of finance, large firms may have more internal financial resources but also do not innovate due to high cost. Overall, while most Korean firms feel a need to innovate, they are frequently hindered from doing so due to a lack of resources and capabilities, including finance, qualified staff, ideas and technology- and market-related information.

3.1.5. Internationalisation of business R&D and innovation is still relatively low

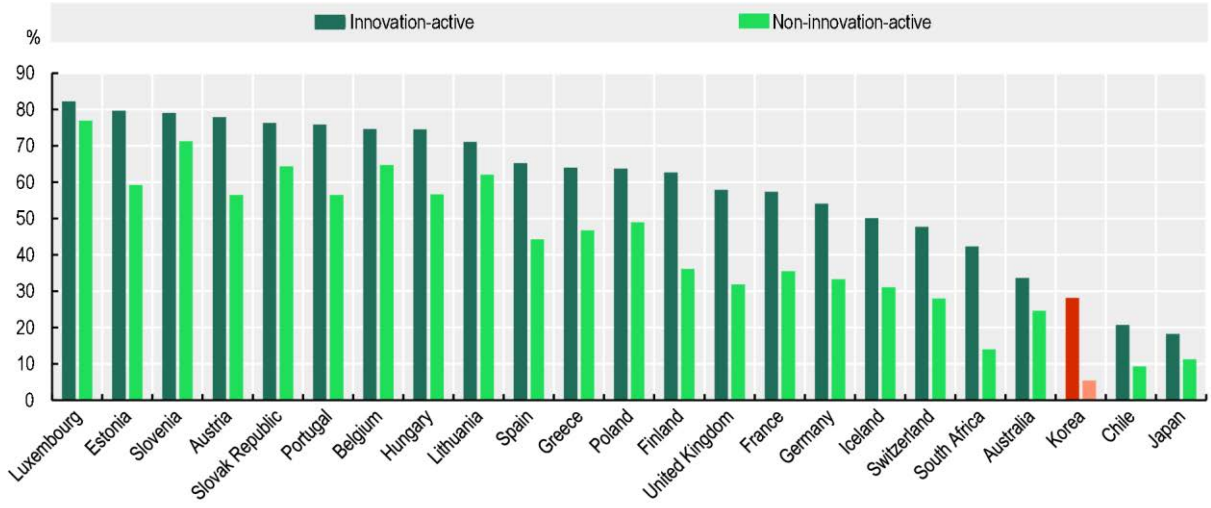
Business R&D in Korea is dominated largely by domestic companies. The R&D expenditures by foreign-owned companies in the manufacturing sector amounted to only 3.9% of all manufacturing sector R&D in 2018 (KISTEP, 2019[13]). In the meantime, the number of non-Korean companies with R&D activities in

Korea increased from 60 in 1999 to 375 in 2014 (Hemmert, 2018[14]), indicating an increasing interest by foreign multinationals to conduct R&D in Korea.

The degree of global integration of Korean business innovation is also relatively low among developed countries, yet increasing, partly due to the expansion of Korean conglomerates and policy initiatives such as the "Buy R&D" fund (KRW 100 billion), which supports technology adoption, the promotion of global mergers and acquisitions (M&As) and international joint R&D projects. Regarding inward global integration, R&D spending by foreign multinationals in Korea has rapidly increased from a very low base (Figure 3.9). Many foreign multinationals are active in upstream manufacturing industries, such as chemicals, high-tech materials and automotive parts and components (Hemmert, 2020[4]). Meanwhile, in terms of outward global R&D integration, some Korean conglomerates have established overseas R&D labs to support the customisation of their products or to acquire new technologies that are leveraged in their global new product development (Hemmert, 2018[14]). Recent OECD business innovation indicators also confirm the relatively weak global market integration of Korean businesses (OECD, 2020[8]). For example, Korean business shows low shares of firms operating in global markets regardless of whether they are innovative.

Figure 3.9. Firms operating in foreign markets in Korea and selected countries, by innovation-active status, 2016-18

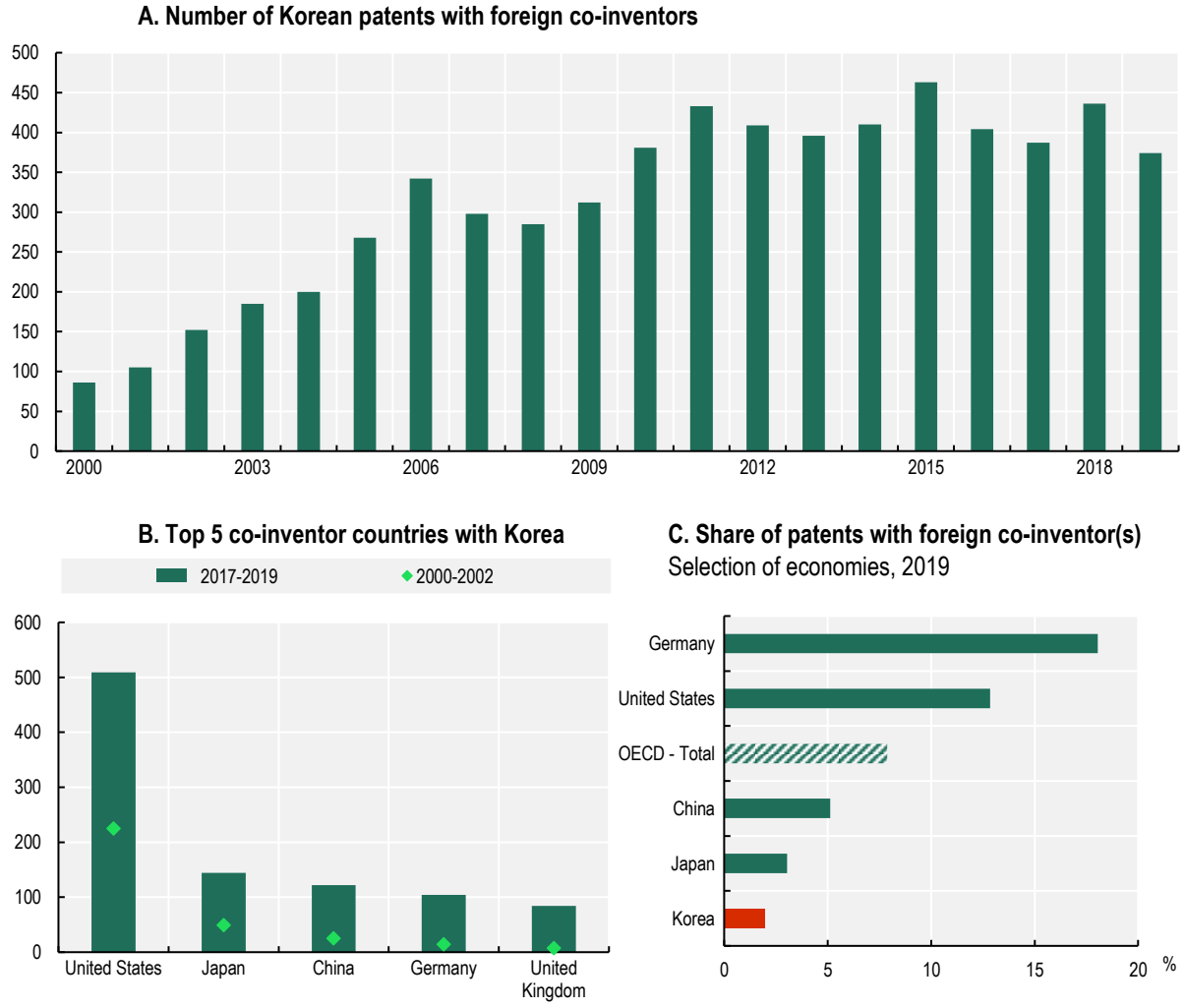
As a percentage of innovation-active firms and non-innovation-active firms, respectively



Note: Innovative firms are those reporting at least one product or business process innovation in the reference period (2016 18).
Source: OECD based on the 2021 OECD Survey of Business Innovation Statistics and Eurostat (Eurostat, 2021[11]), *Community Innovation Survey (CIS 2018)*, https://www.oecd.org/sti/inno-stats.htm, April 2022.

The degree of R&D globalisation can also be observed through co-patenting activities. The number of patents jointly published by Korean and foreign applicants greatly increased in the late 2000s and early 2010s (Figure 3.10 Panel A). Most Korean co-patenting has occurred with partners in the United States, followed by Japan, China, Germany, India and the Russian Federation (hereafter, "Russia") (Figure 3.10, Panel B). Overall, while international co-patenting by Korean firms has increased since the turn of the millennium, the recent decrease suggests that the scale of the firms' global R&D activities may have levelled off. Moreover, Figure 3.10 (Panel C) reveals that Korean international co-operation in patenting with countries abroad is much behind the OECD average.

Figure 3.10. Korean co-patenting, 2000-17



Note: In the last few years, data may be partly due to time lags between the application and publication dates (generally taking one and a half years). Counting patents with multiple inventors/applicants: the indicators presented here are based on simple counts.
Source: OECD (2022[15]), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, May 2022.

3.1.6. Korean technology is highly specialised in ICTs but less so in other emerging technologies

This section provides a snapshot of technology specialisation in the Korean business sector, emphasising selected technology fields instrumental to the digital and green transitions. Table 3.1 shows Korea's revealed technology advantage (RTA[1]), measured as an index greater than 1, against the world average across the World Intellectual Property Organization classification of 35 technologies.[2] Korea's specialisation in ICT or semiconductors remains robust, while it has reinforced its specialisation in certain domains such as biotechnology. Although Korea's technology specialisation remains concentrated in a few selected technology domains, its RTA has become more diversified as its economy has advanced, adding more complexity to its industrial landscape. Table 3.2 illustrates the RTA distribution of 35 technology domains across selected economies. In domains where Korea has high indices, including semiconductors and nanotechnology, Chinese Taipei and China demonstrate similar propensity. On the contrary, Germany and Japan appear to have greater RTA in mechanical areas, whereas Korea shows

relatively low indices. While Korea has increased its specialisation in chemical, biotechnology and pharmaceutical technologies (Panel B), it is still below that of the United States and Germany.

Table 3.1. Technology specialisation (RTA), IP5 patent families in Korea, 2004-18

Field of technology	2004-08	2009-13	2014-18
Electrical machinery, apparatus, energy	1.2	1.2	1.2
Audio-visual technology	1.8	1.7	1.7
Telecommunications	2.1	1.6	1.2
Digital communication	1.6	1.5	1.2
Basic communication processes	1.5	1.2	1.2
Computer technology	1.3	1.5	1.4
IT methods for management	0.9	1.1	0.9
Semiconductors	2.3	2.1	2.1
Optics	1.5	1.2	1.2
Measurement	0.5	0.7	0.7
Analysis of biological materials	0.5	0.7	0.7
Control	0.6	0.7	0.6
Medical technology	0.3	0.5	0.6
Organic fine chemistry	0.4	0.6	1.1
Biotechnology	0.5	0.7	0.7
Pharmaceuticals	0.3	0.5	0.6
Macromolecular chemistry, polymers	0.6	0.8	1.1
Food chemistry	0.4	0.5	0.8
Basic materials chemistry	0.5	0.6	0.8
Materials, metallurgy	0.6	0.8	0.9
Surface technology, coating	0.7	1.0	0.9
Micro-structural and nano-technology	1.9	1.7	0.8
Chemical engineering	0.6	0.7	0.7
Environmental technology	0.5	0.6	0.8
Handling	0.4	0.4	0.4
Machine tools	0.3	0.4	0.4
Engines, pumps, turbines	0.4	0.4	0.6
Textile and paper machines	0.6	0.4	0.3
Other special machines	0.4	0.5	0.5
Thermal processes and apparatus	1.3	0.9	1.0
Mechanical elements	0.3	0.5	0.6
Transport	0.4	0.7	0.8
Furniture, games	0.8	0.7	0.8
Other consumer goods	1.5	1.2	1.3
Civil engineering	0.4	0.4	0.4

Note: IP5 patent families refer to patents filed in at least two IP offices among five major patent offices of China, Europe, Japan, Korea and the United States. These tables show red gradients as RTAs increase above 1.0 (RTA>1.0) and blue gradients as RTAs decrease below 1.0 (RTA<1.0)

Source: Authors' calculations based on OECD (2022[15]), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, May 2022.

Table 3.2. Technology specialisation (RTA), IP5 patent families in Korea and selected economies

Field of technology	Korea	Germany	Japan	United States	China	Chinese Taipei
Electrical machinery, apparatus, energy	1.2	1.1	1.3	0.7	1.0	1.2
Audio-visual technology	1.7	0.4	1.2	0.6	1.7	1.9
Telecommunications	1.2	0.5	1.1	0.9	1.4	1.3
Digital communication	1.2	0.4	0.5	1.2	2.4	0.8
Basic communication processes	1.2	0.6	1.0	1.0	0.9	1.9
Computer technology	1.4	0.4	0.8	1.1	1.6	1.5

Field of technology	Korea	Germany	Japan	United States	China	Chinese Taipei
IT methods for management	0.9	0.4	0.8	1.4	1.3	0.7
Semiconductors	2.1	0.4	1.2	0.6	1.2	3.0
Optics	1.2	0.4	1.7	0.5	1.5	1.7
Measurement	0.7	1.4	1.0	1.0	0.8	0.8
Analysis of biological materials	0.7	0.9	0.6	1.5	0.5	0.6
Control	0.6	1.1	1.1	1.1	0.9	0.8
Medical technology	0.6	0.9	0.7	1.6	0.5	0.6
Organic fine chemistry	1.1	1.2	0.6	1.2	1.0	0.4
Biotechnology	0.7	0.7	0.5	1.9	0.8	0.5
Pharmaceuticals	0.6	0.5	0.4	2.0	0.8	0.6
Macromolecular chemistry, polymers	1.1	0.9	1.5	0.8	0.6	0.5
Food chemistry	0.8	0.6	0.7	1.2	0.6	0.4
Basic materials chemistry	0.8	1.0	1.1	1.1	0.6	0.4
Materials, metallurgy	0.9	1.1	1.4	0.8	0.8	0.4
Surface technology, coating	0.9	1.0	1.4	0.9	0.7	0.8
Micro-structural and nano-technology	0.8	1.4	0.6	1.0	1.1	2.1
Chemical engineering	0.7	1.4	0.7	1.1	0.8	0.5
Environmental technology	0.8	1.5	0.9	1.0	0.7	0.4
Handling	0.4	1.5	1.1	0.8	0.6	0.5
Machine tools	0.4	2.0	1.1	0.8	0.6	1.0
Engines, pumps, turbines	0.6	1.6	1.0	1.3	0.3	0.3
Textile and paper machines	0.3	1.0	2.0	0.6	0.4	0.4
Other special machines	0.5	1.6	0.9	1.0	0.5	0.6
Thermal processes and apparatus	1.0	1.2	1.1	0.7	0.8	0.6
Mechanical elements	0.6	2.1	1.0	0.9	0.5	0.5
Transport	0.8	1.8	1.1	1.0	0.4	0.3
Furniture, games	0.8	1.2	0.7	0.9	1.0	1.2
Other consumer goods	1.3	1.2	0.7	0.8	1.0	0.7
Civil engineering	0.4	1.6	0.4	1.3	0.6	0.5

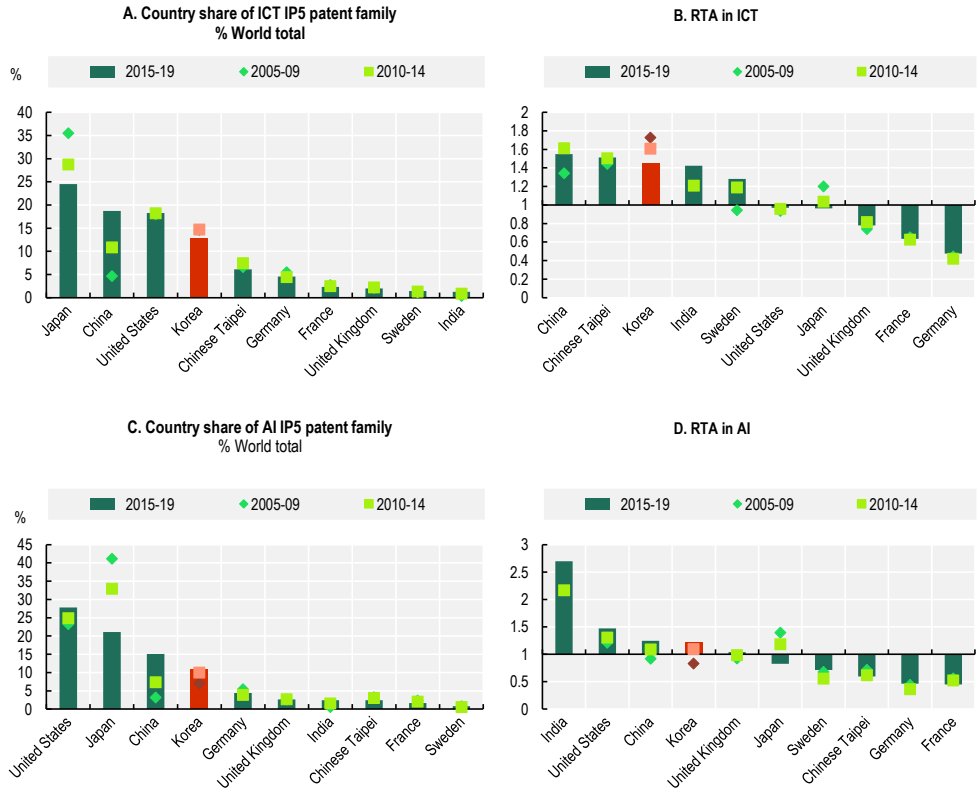
Note: IP5 patent families refer to patents filed in at least two IP offices among five major patent offices of China, Europe, Japan, Korea and the United States. These tables show red gradients as RTAs increase above 1.0 (RTA>1.0) and blue gradients as RTAs decrease below 1.0 (RTA<1.0)

Source: Authors' calculations based on OECD (2022[15]), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, May 2022.

While Korea has accumulated patents in the fields of ICT and artificial intelligence (AI) and holds high shares compared to the world total (13.8% in ICT and 9.8% in AI) (Figure 3.11, Panel A), its specialisation differs in each field. For ICT, it shows greater value of RTA indices exceeding 1 after China and Chinese Taipei, whereas, for AI, Korea's RTA is slightly above 1, indicating a little positive specialisation (Figure 3.11, Panel B). Thus, despite Korea's relative strength in ICT in general, the country may do well to devote considerable efforts to specialise in AI, an emerging and enabling technology for Korea's digital transformation. In AI, India, Israel, the United States and China have a higher RTA.

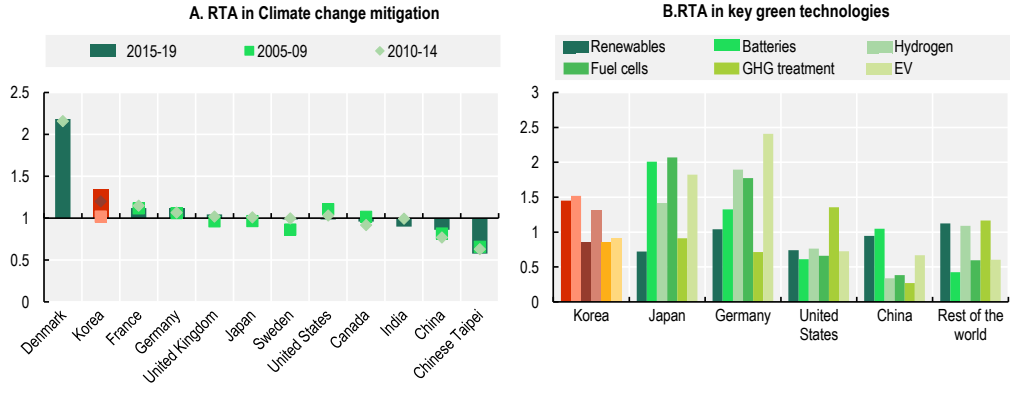
In contrast to its performance in ICTs, Korea's specialisation in environmental technologies is below the world average, with an RTA below 1. However, in terms of climate change mitigation/adaptation technology, in particular among environmental technologies, Korea ranks second after Denmark (Figure 3.12, Panel A). Among the sub-categories in climate change mitigation or adaptation technologies, Korea has the highest RTA in renewables (Figure 3.12, Panel B) among comparable advanced economies. Korea's RTA in batteries and fuel cells also exceeds 1, while hydrogen, treatment of greenhouse gas (GHG) and electric vehicles are below 1. Based on company-level data, Korean firms such as LG Chem and LG Electronics have emerged as global leaders in patenting and trademarks on climate change mitigation/adaptation technologies (Figure 3.13).

Figure 3.11. Country patent share and relative specialisation in ICT and AI patent families, for a selection of economies



Note: IP5 patent families refer to patents filed in at least two IP offices among five major patent offices of China, Europe, Japan, Korea and the United States.
Source: OECD, *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, June 2023

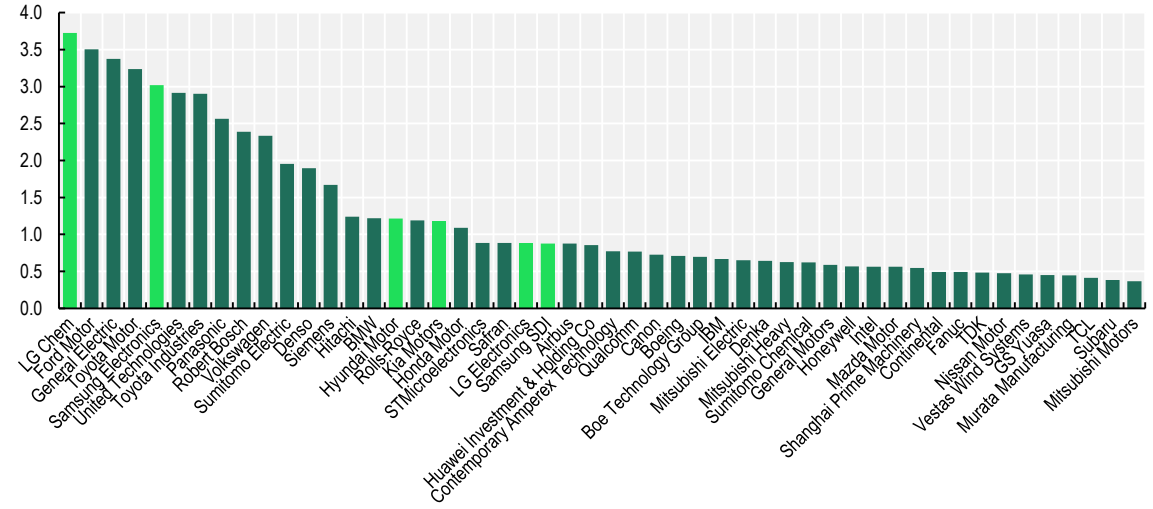
Figure 3.12. Technology specialisation (RTA) in climate change mitigation for a selection of economies



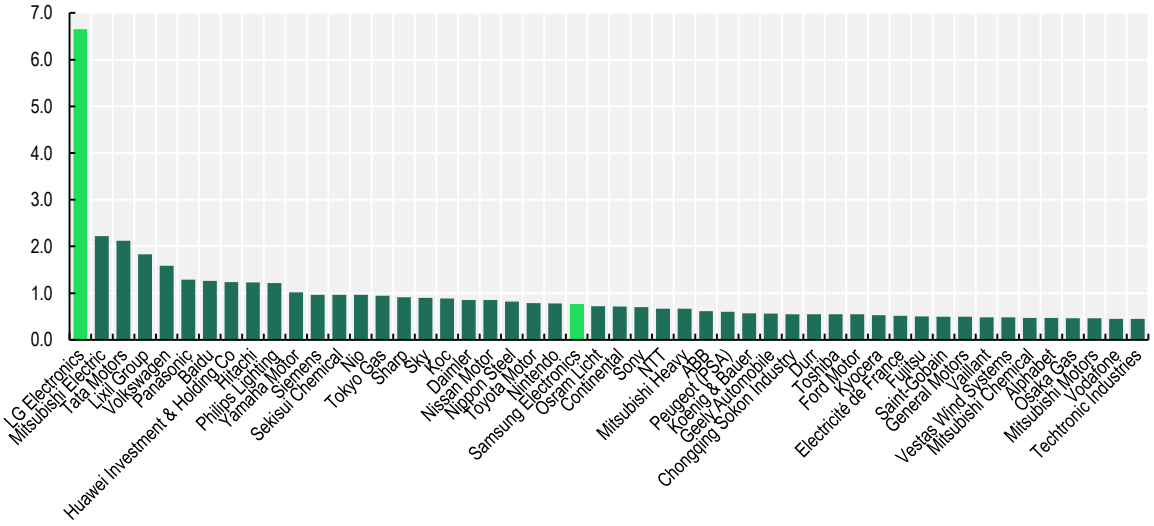
Note For Panel A: IP5 patent families refer to patents filed in at least two IP offices among five major patent offices of China, Europe, Japan, Korea and the United States.
Source: Authors' calculations based on *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, June 2023 and on OECD (2023), "Patents in environment-related technologies: Technology development by inventor country", *OECD Environment Statistics* (database), https://stats.oecd.org/Index.aspx?DataSetCode=PAT_DEV (accessed on 20 June 2023).

Figure 3.13. Top 50 patenting or trademarking companies in climate change mitigation and adaptation, 2016-18

A. Top 50 patenting companies



B. Top 50 trademarking companies



Note: Bars in red are Korean firms. IP5 patent families and trademarks at the EUIPO, JPO and USPTO. Data relate to the share of the patents (respectively trademarks) related to climate change mitigation and adaptation owned by companies in total patents (respectively trademarks) in that domain owned by the top 2 000 corporate R&D sample in 2016-18.

Source: European Commission et al., (2021[16]), *World Corporate Top R&D Investors*: *Paving the Way for Climate Neutrality,* https://data.europa.eu/doi/10.2760/49552.

3.2. Public support for business R&D and innovation in Korea

The aforementioned developments and the strong rise of Korean business innovation in selected fields could not be possible without dedicated government support. This section shows that the Korean government's efforts have significantly driven the rise of Korean business innovation while acknowledging a significant focus on supporting small and medium-sized enterprises (SMEs). Finally, this section

describes how recent initiatives aim to alleviate some of the concerns about the partial fragmentation of government support.

3.2.1. Government support to business R&D is among the highest in OECD countries, with a heavy focus on SMEs

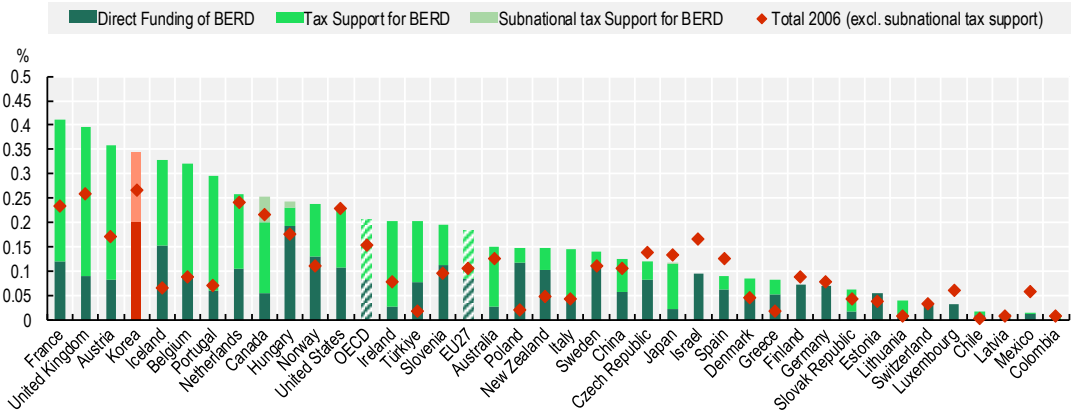
In 2020, Korea placed among the OECD countries that provide the largest level of total government support to business R&D as a percentage of GDP, at a rate of 0.29% of GDP (Figure 3.14) (OECD, 2022[17]). Most public support for business R&D is directed at SMEs. In 2019, the government financed 13.2% of all R&D conducted by SMEs. In contrast, the government financed only 1.8% of the R&D expenditures of large firms (MSIT and KISTEP, 2021[18]). Heavy focus on SMEs in public support for business R&D applies not only to direct funding but also to tax support. In line with the government's direct financing of business R&D, R&D tax breaks for SMEs are much more generous than for large firms. Specifically, tax credits for large firms are capped at 2% of R&D spending, while there is no ceiling for the R&D tax credits for SMEs. As a result, the implied tax subsidy rate for profit-making SMEs was 26% in 2020, in contrast to 2% for large firms (Box 3.1. R&D tax incentives in Korea). Nonetheless, due to the dominant role of large firms in R&D spending in Korea, the share of the total amount of R&D tax credits given to SMEs among all R&D tax credits was only 40% in 2018 (OECD, 2023[2]).

Korea is an outlier among major OECD countries in its strong focus on SMEs in R&D tax credits. With the exception of the United Kingdom, other large, developed countries provide more or less the same R&D tax incentives to large and small firms. Meanwhile, between 2007 and 2019, the importance of tax incentives increased in Korea in absolute terms, whereas the relative magnitude of tax compared to direct support remained fairly stable. As a result, R&D-related taxable income deductions for business firms amounted to KRW 2.81 trillion in 2018 (MOTOE and KIAT, 2020[19]).

Government support for SMEs in Korea encompasses a wide range of policy tools, including financing subsidies, notably business R&D; favourable access to public procurement; regulations differentiated by company size; and whole market segments reserved for SMEs. Although many of these policies may have some justification when seen in isolation, they add up to a system that supports the survival of low-productivity firms against a backdrop of regulatory complexity.

Figure 3.14. Direct government funding of business R&D and tax incentives for R&D in Korea and selected economies, 2020 (nearest year)

As a percentage of GDP



Note: Data on subnational tax support are only available for a group of economies.
Source: OECD (2022[17]), *R&D Tax Incentives (database)*, http://oe.cd/rdtax, April 2022.

Box 3.1. R&D tax incentives in Korea

Design of R&D tax relief provisions

Korea provides R&D tax relief through a hybrid R&D credit and a volume-based investment credit for machinery, equipment, and buildings (see Table 3.3).

Key features include the following:

- Under the hybrid R&D tax credit, R&D tax relief generally equals the larger of the volume-based or incremental tax off-set.
- In case of insufficient tax liability, unused credits can be carried forward for ten years (previously five years) under the hybrid R&D tax credit and for five years under the R&D investment credit.

Table 3.3. Main design features of R&D tax incentives in Korea, 2021

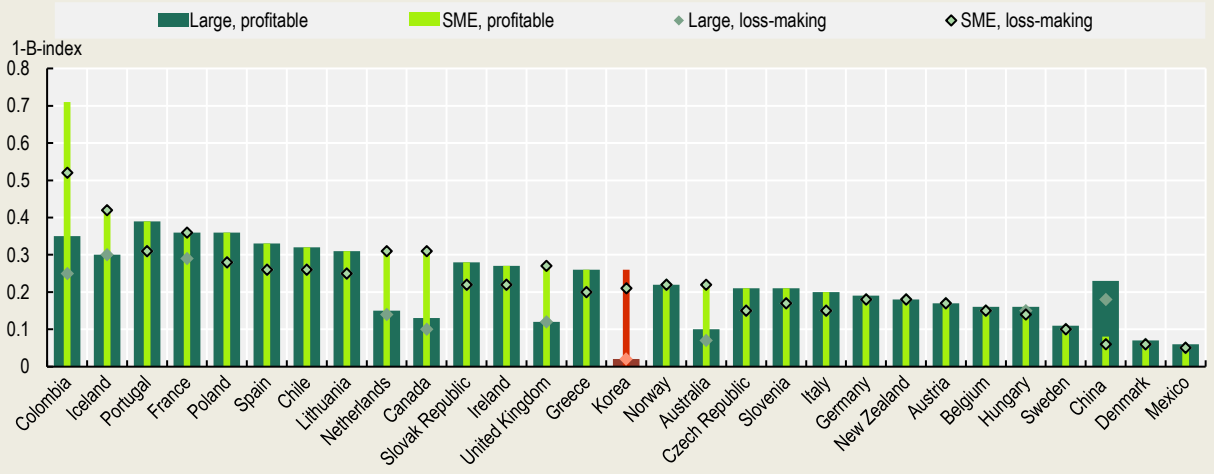
		R&D tax credit		R&D investment credit
Type of instrument		Hybrid (volume or increment)*		Volume-based
Eligible expenditures		Current		Machinery and equipment, buildings
Headline rates (%)		Volume: 0-2 (Large firm) [0.5 R&D expense-sales ratio], 8-15 (HPE), 25 (SME) GIBT**: 20-30 (Large firm, HPE), 30-40 (SME)	Increment: 25 (Large firm), 40 (HPE), 50 (SME)***	1 (Large firm), 3 (HPE), 7 (SME)
Refund		No		
Carry-over (years)		10 (carry forward)		5 (carry forward)
Thresholds and ceilings	Base amount	R&D spending in the previous year		n.a.
	Ceiling	Tax credit capped at 2% of R&D spending (Large firms)		No

Note: R&D expense ratio=R&D/revenue; HPE: High Potential Enterprise (do not qualify as SME, respect rules about being part of a group and have sales below KRW 500 billion); *The R&D tax credit equals the greater of either: 1) the volume-based tax off-set, or the 2) incremental tax off-set; **Under the Growth Industry and Basic Technology scheme available to firms with R&D aimed at New Growth and Basic technologies (235 technologies in 12 areas, including future cars, next-generation electronic information devices, energy and environment), enhanced volume-based tax credit rates apply to SMEs (30~40; 15/10 for firms losing SME status, see compendium) and to large firms and HPEs (20~30); *** 40 for firms losing the SME status. Korea also offers an income-based tax incentive for outcomes of R&D activities. This incentive is beyond the scope of this chapter. For more details, see the *OECD R&D Tax Incentive Compendium* at https://www.oecd.org/sti/rd-tax-stats-compendium.pdf and "Eligibility of current and capital expenditure for R&D tax relief" at https://www.oecd.org/sti/rd-tax-stats-expenditure.pdf.
Source: OECD (2022[17]), *R&D Tax Incentives* (database), http://oe.cd/rdtax, December 2021.

The generosity of R&D tax support in 2021

Differences in the design of R&D tax incentives drive significant variation in the expected generosity of tax relief per additional unit of R&D investment. For example, in 2022, the marginal tax subsidy rate for profit-making (loss-making) SMEs in Korea was estimated at 0.26 (0.21), above the OECD median of 0.20 (0.18) (Figure 3.15). On the other hand, the implied R&D tax subsidy rate for large firms equals 0.02 (0.02) in the profit (loss) case, well below the OECD median of 0.17 (0.15). These estimates focus on the hybrid R&D tax credit (not accounting for the enhanced tax credit rates applicable to a subset of firms under the Growth Industry and Basic Technology scheme) and the R&D investment credit.

Figure 3.15. Implied tax subsidy rates on R&D expenditures in Korea and selected economies, 2022



Note: Implied marginal tax subsidy rates, presented for different firm size and profitability scenarios, are calculated based on headline tax credit/allowance rates (see the methodology and country-specific notes), providing an upper bound value of the generosity of R&D tax support, not reflecting the effect of thresholds and ceilings that may limit the amount of qualifying R&D expenditure or value of tax relief.
Source: OECD (2022[17]), *R&D Tax Incentives* (database), http://oe.cd/rdtax (accessed on 12 June 2023).

3.2.2. Support for business R&D is in part fragmented, although recent policy initiatives are encouraging

Despite considerable and generous government support for business R&D in Korea, government support has long been under pressure to be more efficient and have more impact, as some problems, including fragmentation, have been identified. Institutionally, the three main actors of the R&D support policy for SMEs are the Ministry of Trade, Industry and Energy, the Ministry of SMEs and Start-ups, and the Ministry of Science and ICT. In 2019, these ministries administered 42.3%, 29.3% and 8.6% of the overall government budget for R&D support directed at SMEs, respectively (Ahn, Lee and Lee, 2021[20]). The ministries conduct a wide range of R&D support programmes that mostly focus on providing direct R&D subsidies or loans for SMEs (KISTEP, 2019[21]). Despite various R&D support portfolios from different ministries, R&D support policies in Korea have been assessed as highly fragmented. The government's online portal for SME support policies lists over 400 separate programmes related to technology support (Ministry of SMEs and Start-ups, 2021[22]).

On top of fragmented support programmes, the following problems have also long been identified in terms of the R&D support programmes for SMEs in Korea: 1) subsidising R&D of SMEs that lack the research capabilities to use the funds effectively; 2) widespread multiple disbursements of R&D subsidies to the same firms; and 3) support of firms that lack managerial proficiency (Ahn, Lee and Lee, 2021[20]).

Meanwhile, recent policy initiatives which envision long-term support throughout technology development and commercialisation, link government support to private investment, emphasise collaborative R&D activities and reduce the administrative burden for participating firms (Ministry of SMEs and Start-ups, 2019[23]) are still in the early phase, to be monitored and assessed.

A different and new type of government support policy relates to public procurement to enhance innovation, which has been promoted in Korea through an amendment in the Public Procurement Law in 2020.

Monitored by the Ministry of Economy and Finance, a target has been set that every public agency should spend at least 1% of its total procurement on innovative products (Lee, 2021[24]). Such products are certified by the Central Procurement Agency based on their technological excellence in order to enhance the quality of procured products and to support SMEs and venture firms. Suppliers of selected products also receive support for R&D related to developing these products (MOTIE, 2021[25]).

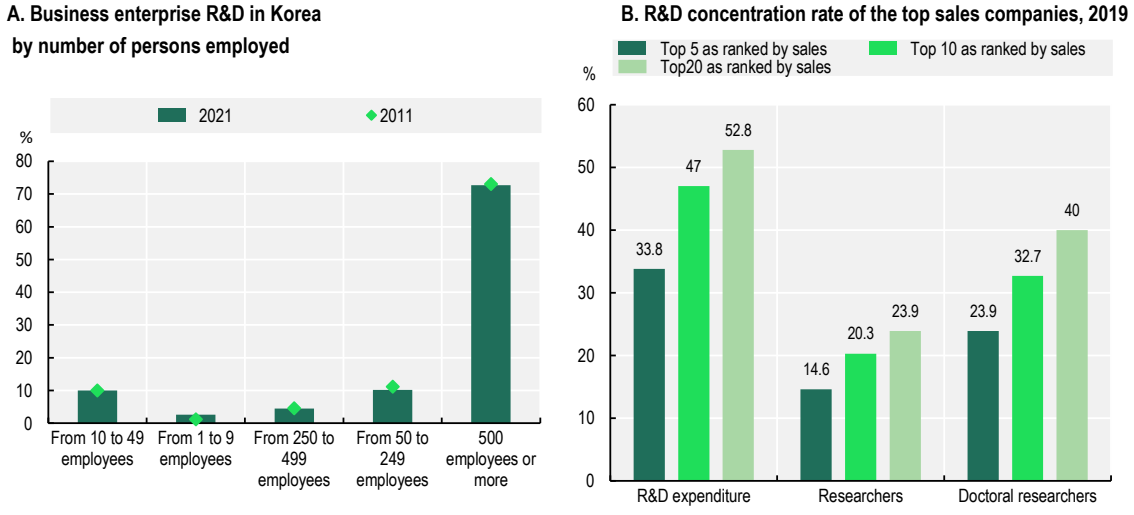
3.3. Imbalances in Korean business innovation

This section draws a more differentiated overview of Korean business innovation by showing that despite the strengths of the Korean business innovation system, several imbalances and concentration risks also exist. These imbalances persist with regard to firm size and type of industry, i.e. manufacturing and services, as well as ICT and non-ICT industries.

3.3.1. Strong concentration of R&D in large firms warrants cautious assessment of business innovation in Korea

In Korea, more than 70% of total R&D spending falls to large companies with 500 or more employees, compared with less than 14% spent by small enterprises with fewer than 50 employees (Figure 3.16, Panel A). This high concentration of business R&D spending on large firms is typical among developed countries. For example, the proportion of all business R&D expenditures falling to firms with 500 or more employees was 90.4% in Japan in 2019, 87.5% in Germany in 2017, 69.2% in the United Kingdom in 2018 and 64.8% in France in 2017 (OECD, 2021[26]). However, the exceptionally high concentration in business sector R&D spending on the largest companies is unusual among major industrialised countries like Korea. Some 33.8% of all business R&D spending fell to the five largest companies in 2019, up from 33.5% in 2014, and 47.0% to the ten largest companies, up from 44.1% in 2014 (Table 3.4) (MSIT and KISTEP, 2021[18]). Understandably, these companies also account for a large share of researchers in the business sector, such as 14.6% of the total researchers and 23.9% of doctoral researchers (Figure 3.16, Panel B).

Figure 3.16. Business R&D spending by firm size and top companies in Korea, 2019



Source: OECD (2023), "Research and Development Statistics: Business enterprise R-D expenditure by size class and by source of funds - ISIC Rev 4", *OECD Science, Technology and R&D Statistics* (database), https://doi.org/10.1787/7ce7448d-en (accessed on 11 June 2023).

Table 3.4. R&D concentration rate of top sales companies in Korea

In percentage

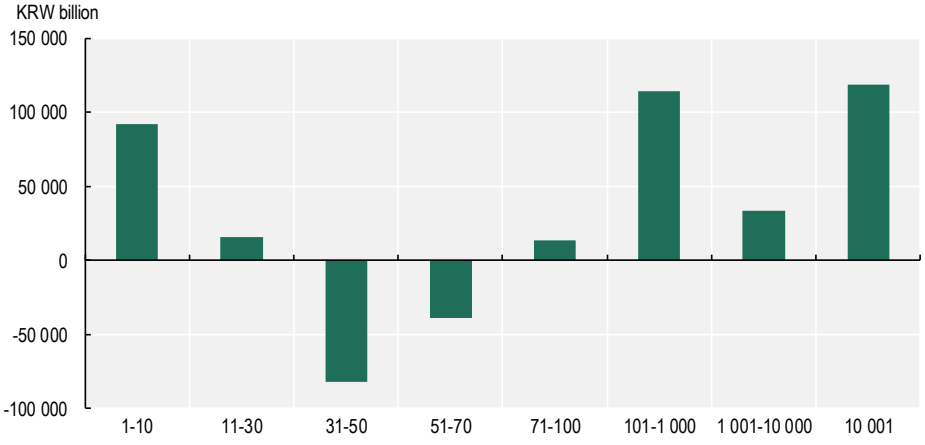
		2014	2015	2016	2017	2018	2019
R&D expenditure	Top 5	33.5	37.2	37.7	40.4	36.8	33.8
	Top 10	44.1	41.7	44.3	50.2	47.4	47.0
	Top 20	51.6	49.3	51.6	54.0	53.7	52.8
	Top 30	53.9	51.5	53.4	55.5	54.5	54.0
	Top 50	58.9	57.3	56.3	58.0	58.4	56.6
	Top 100	63.4	61.9	62.3	63.7	63.1	60.7

Source: MSIT and (KISTEP, 2019[13]), Survey of Research and Development in Korea, 2019, https://www.kistep.re.kr/reportDownload.es?rpt_no=RES0220210050&seq=res_0026P@5

This significant concentration in business R&D necessitates caution, however, when examining the overall picture of Korean business innovation. Looking at the overall trend in business innovation could risk missing the actual underlying status of business innovation in Korea. For example, the expenditure of the top 30 sales companies has risen recently, whereas the R&D expenditure of companies ranking 31st through 70th in sales has decreased year on year (Figure 3.17). Furthermore, the dominance of the global information technology (IT) giant Samsung Electronics (Box 3.2), in terms of R&D spending, is so significant, accounting for around 20% of total business R&D in the country, that it inevitably could mislead the translation of aggregated statistics in business innovation.

Figure 3.17. Fluctuations of R&D expenditure among top Korean sales companies, 2019

R&D expenditure change of top companies ranked by sales (year on year)

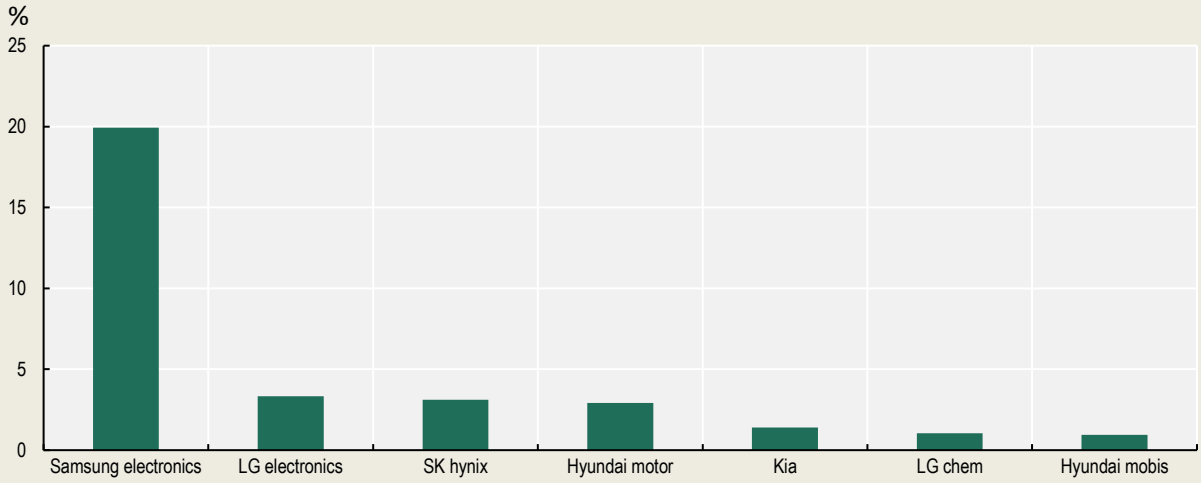


Source: MSIT and (KISTEP, 2019[13]), *Survey of Research and Development in Korea, 2019*, https://www.kistep.re.kr/reportDownload.es?rpt_no=RES0220210050&seq=res_0026P@5.

Box 3.2. The dominance of Samsung Electronics in Korean business innovation

In the Korean business R&D landscape, Samsung Electronics, a world ICT giant, is prominently leading in input (R&D expenditure), output, and commercialisation (patents and trademarks). It accounts for 2.3% of global R&D expenditures (after Alphabet), 3.6% in world IP5 family patenting (ranks top) and 1.2% in trademarking (seventh in the world) (European Commission et al., 2021[16]). From a domestic perspective, Samsung Electronics alone invested 19.9% of Korean business R&D expenditure in 2020 (Figure 3.18). As evidenced by Samsung's intensive R&D investment, the electronic and electrical equipment sector is overwhelming others in Korea, which accounts for 19.1% of all domestic business R&D expenditure.

Figure 3.18. Firm shares in Business R&D expenditure in Korea, 2020



Source: European Commission (2022[3]), *The 2021 EU Industrial R&D Investment Scoreboard*, https://iri.jrc.ec.europa.eu/scoreboard/2021-eu-industrial-rd-investment-scoreboard; (OECD, 2022[27]), *Research and Development Statistics* (database), https://oe.cd/rds.

3.3.2. The innovation divide between larger and smaller firms is more acute in Korea than in other countries

Like R&D investment, there is also a large disparity in the ratio of innovating firms across enterprise size classes in Korea. Both for product innovations and business process innovations, the proportion of innovating firms with 500 or more employees is approximately five times that of innovating firms with 10-49 employees (OECD, 2020[8]). These differences across enterprise class sizes are much more acute than in other developed countries. For example, in Germany, 23.4% of manufacturing firms with 10-49 employees, 32.7% of firms with 50-249 employees and 49.4% of firms with 250 or more employees have innovated ((Eurostat, 2021[11])).

Despite the Korean government's efforts to foster SMEs' innovative capacity – notably by increasing government R&D investment in SMEs – the role of SMEs in Korea's business innovation is relatively minor. This is partly due to large conglomerates conducting most of their R&D activities and innovation in-house. For example, expenditures for external R&D, including expenditures paid to member firms of the same conglomerate, amounted to only 6% of all R&D expenditures of Korean firms in 2019 (MSIT and KISTEP,

2021[18]). This relative amount of external R&D expenditures in Korea is much lower than in other major industrialised countries. For example, in the manufacturing sector, it was 23.7% in Germany in 2017, 17.2% in Japan in 2020, and 14.3% in the United States in 2018. However, it should be noted that there are some promising developments in the role of SMEs in Korea. In particular, manufacturing SMEs that have successfully innovated have often occupied market niches for technology-intensive products that have not received the attention of large conglomerates and have relied largely on global customers. As a result, some have established themselves as "hidden champions" (Box 3.3).

Box 3.3. Korea's hidden champions

While innovation in the Korean manufacturing sector has been dominated by large conglomerates (chaebols), the innovation activities of a different type of companies have gained importance. These companies are much smaller and focus on a much narrower range of products than large conglomerates. Still, they hold a high or dominant global market share in their products. However, public awareness of these companies tends to be low. They may, therefore, be classified as "hidden champions", as defined by Simon (2009[28]), who referred to them as companies that: 1) have high global market shares; 2) are not large; and 3) are not well-known to the general public.

Humax specialises in digital set-top boxes that connect TVs with external signals. It was founded by engineering graduates from Seoul National University and has focused on enhancing its technological capabilities and selling its products under its own brand based on in-house R&D (Kim, Sengupta and Kim, 2009[29]). The company has a strong global business presence and sells its products in almost all parts of the world (Humax, 2021[30]).

IDIS was founded by former students from the computer science department of the Korea Advanced Institute of Science & Technology (KAIST), a leading technical university, in a bid to create a global technology company. Based on its internally developed core technology, it has become a global pioneer and major competitor in digital camera surveillance systems (Lee, 2010, pp. 287-293[31]).

Suprema, founded by an engineering PhD from Seoul National University, has developed fingerprint recognition devices for security applications. It has focused on global markets from the outset, as the domestic demand for the company's products has been initially small. The company has created technologically leading algorithms that can be applied to various types of product solutions (Cho, 2012[32]). It has regularly won international product competitions and has become a global market leader in access control biometric readers (Suprema, n.d.[33]).

Commonalities of these and other Korean hidden champions include an innovation focus based on in-house R&D, driven by their founders' deep technological expertise and a strong global business orientation. As a result, such firms are becoming more numerous.

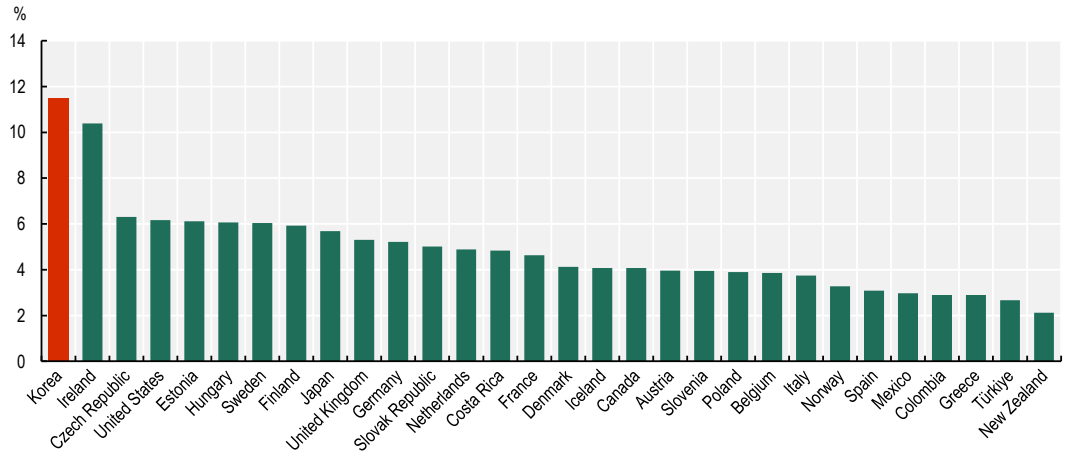
Meanwhile, the Korean government has promoted the growth of SMEs into "hidden champions". The Korean government's most notable policy initiatives include implementing the World Class 300 Project, which aimed to promote 300 world-class enterprises by stimulating SMEs' motivation and potential for growth with various support programmes, including financing, R&D and marketing, required to expand their global markets.

Source: Cho (2012[32]), *The Growth Process and Key Success Factors of Technology-Intensive Ventures: The Case of Suprema Co.*, Humax (2021[30]), *Humax Global Network*, https://dearhumax.com/en/bbs/page.php?hid=Humaxintroduce3; Kim, Sengupta and Kim (2009[29]), "How Can Non-Chaebol Companies Thrive in the Chaebol Economy?", https://doi.org/10.1080/12297119.2009.9707296; Lee (2010[31]), *Small Giants: Korea's Strong SMEs*; Simon (2009[28]), *Hidden Champions of the 21st Century: Success Strategies of Unknown World Market Leaders*, https://doi.org/10.1007/978-0-387-98147-5; Suprema (n.d.[33]), *Suprema, Who We Are, Proven Leader in Access Control, Time & Attendance and Biometric Solutions*, https://www.supremainc.com/en/about/suprema.asp.

3.3.3. Korea's ICT industry has achieved remarkable growth and leads globally

Korea's ICT industry is outstanding in the Korean industrial landscape and against comparable advanced economies on the global stage. Korea ranked the highest in ICT value added (11.46%; see Figure 3.19) and third in the share of patents in ICT(18%; see Figure 3.20) among OECD countries (OECD, 2017[34]). Korea also ranked fourth in the utilisation of industrial robots (Figure 3.21). According to the Bank of Korea (2017), the real GDP of the Korean ICT industry accounted for 10.9% of whole GDP (Table 3.5). The real GDP growth rate of the ICT industry was 7.1% in 2017 compared to 2.6% for the non-ICT industry, and the contribution rate of the ICT industry to GDP growth amounted to 18.5% in 2017. For the previous five years (2012-17), the real GDP growth rate of the ICT industry was 5.5% per year, exceeding the overall industrial growth rate of 3.0%. As such, the ICT industry continues to play a leading role in Korea's economic growth.

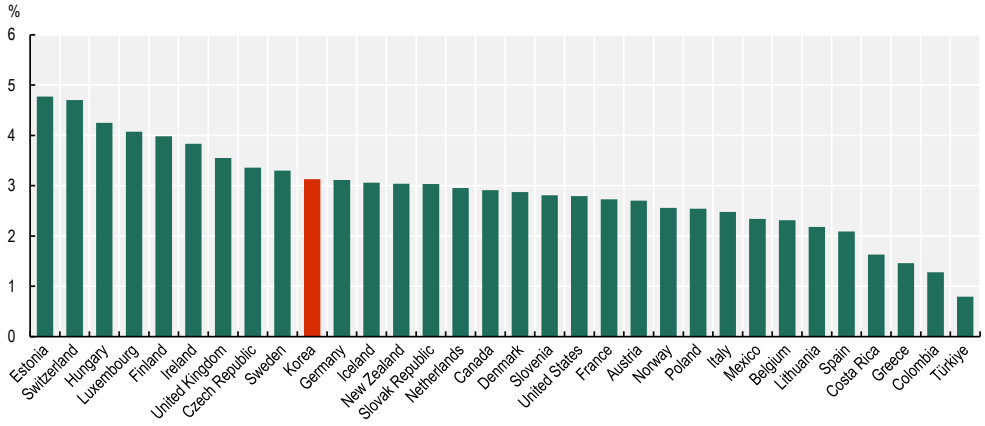
Figure 3.19. Value added of the ICT sector in Korea and OECD countries, 2018



Source: OECD (2023), "STAN Industry ISIC Rev. 4", *STAN: OECD Structural Analysis Statistics* (database), https://doi.org/10.1787/data-00649-en (accessed on 10 June 2023).

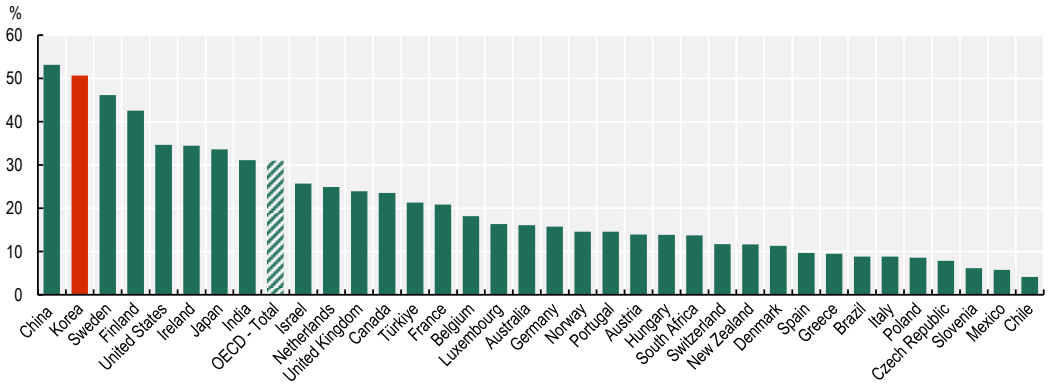
Figure 3.20. Specialisation in ICT-related patents in Korea and selected economies, 2016-19

Patents in ICT as a percentage of total IP5 patent families



Source: OECD (2023), "STAN Industry ISIC Rev. 4", *STAN: OECD Structural Analysis Statistics* (database), https://doi.org/10.1787/data-00649-en (accessed on 10 June 2023).

Figure 3.21. Top-ten countries with the highest number of operational industrial robots, 2016-19



Source: OECD Going Digital Toolkit, based on the OECD STI Micro-data Lab, http://oe.cd/ipstats (accessed on 11 June 2023).

Table 3.5. Korea's GDP growth rate and contribution of the ICT industry, 2011-17

In percentage

Type	2011	2012	2013	2014	2015	2016	2017
ICT industry GDP growth rate (real)	14.8	3.1	6.6	5.1	3.1	5.7	7.1
Non-ICT industry GDP growth rate (real)	2.3	2.3	2.7	3.0	2.6	2.4	2.6
ICT industry as a percentage of GDP (real)	9.6	9.7	10.0	10.2	10.2	10.5	10.9
ICT industry's contribution to GDP	34.2	11.8	20.3	13.3	9.2	15.8	18.5

Source: Bank of Korea (2017).

Table 3.6. Korea's top-ten manufacture exports, 2019-20

In USD million

	2019		2020	
1	Semiconductors	93 930	Semiconductors	99 177
2	Automobiles	43 036	Automobiles	37 399
3	Petroleum products	40 691	Petroleum products	24 168
4	Automobile parts	22 535	Marine offshore structures and parts	19 749
5	Flat panel displays and sensors	20 657	Synthetic resin	19 202
6	Synthetic resin	20 251	Automobile parts	18 640
7	Marine offshore structures and parts	20 159	Flat panel displays and sensors	18 151
8	Steel plates	18 606	Steel plates	15 997
9	Wireless communication devices	14 082	Computers	13 426
10	Plastic products	10 292	Wireless communication devices	13 184

Source: Korean export customs data, https://www.index.go.kr/unity/potal/main/EachDtlPageDetail.do?idx_cd=2455.

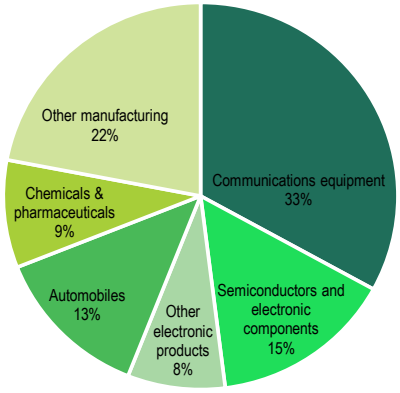
The ICT industry has led to the trade surplus of Korean industry. In 2017, ICT exports amounted to USD 197.6 billion (US dollars), accounting for 34.4% of total exports (USD 573.7 billion). As a result, the trade surplus of the ICT industry was USD 95.5 billion, leading to the country's overall trade surplus (USD 95.22 billion; non-ICT industries suffered a USD 290 million deficit). The top-ten export items of all industries in 2020 (Table 3.6) included semiconductors, flat panel displays, computers and wireless

communication devices. In particular, semiconductors ranked first, with USD 99.2 billion; computers ranked ninth, with USD 13.4 billion; and wireless telecom equipment ranked tenth, with USD 13.2 billion.

3.3.4. The widening discrepancy in R&D and productivity between Korea's ICT and non-ICT industries is of concern

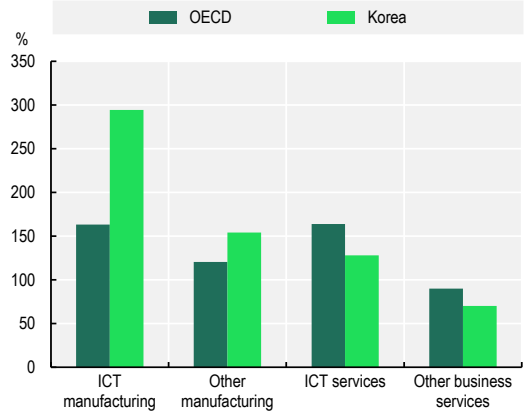
The remarkable growth and strength of Korea's ICT industry reveal a widening discrepancy between ICT and non-ICT industries in various aspects. Business R&D concentration in Korea is outstanding not only across different firm sizes but across industries. In particular, business R&D concentration in the ICT industry is as conspicuous as the extent of business R&D concentration in large firms. In the manufacturing sector, no less than 56% of all R&D spending in 2019 fell to electronic components, computer, visual, sounding and communication equipment (broadly covering the IT and electronics industries), with 33% being spent by the communications equipment (mobile phone) industry alone (Figure 3.22). Other major R&D spenders are the semiconductor and electronic component industry (15%) and the automobile industry (13%). In contrast, the combined proportion of the chemical and pharmaceutical industries (9%) is modest, considering their generally high R&D intensity.

Figure 3.22. Manufacturing sector R&D in Korea by industry, 2019



Source: MSIT and KISTEP (2021[18]), *Survey of Research and Development in Korea, 2019*, https://www.kistep.re.kr/reportDownload.es?rpt_no=RES0220210050&seq=res_0026P@5.

Figure 3.23. Sector productivity relative to total productivity in Korea and OECD, 2015



Note: "ICT manufacturing" includes the manufacture of computer, electronic and optical products. "ICT services" include publishing, telecommunication and IT services. "Other business services" excludes the housing sector.
Source: OECD (2020[35]), *OECD Economic Survey: Korea 2020*, https://doi.org/10.1787/2dde9480-en.

The disparity in innovation activity, including R&D investment across varying industries, could lead to increased disparity in productivity. In effect, the significant concentration on business R&D in the ICT industry mirrors the productivity gap between ICT and other industries. While the productivity of Korean ICT manufacturing business to total productivity (294%) is much higher than the OECD average (163%), the productivity of others remains at half of ICT manufacturing (154%) (Figure 3.23) (OECD, 2020[35]).

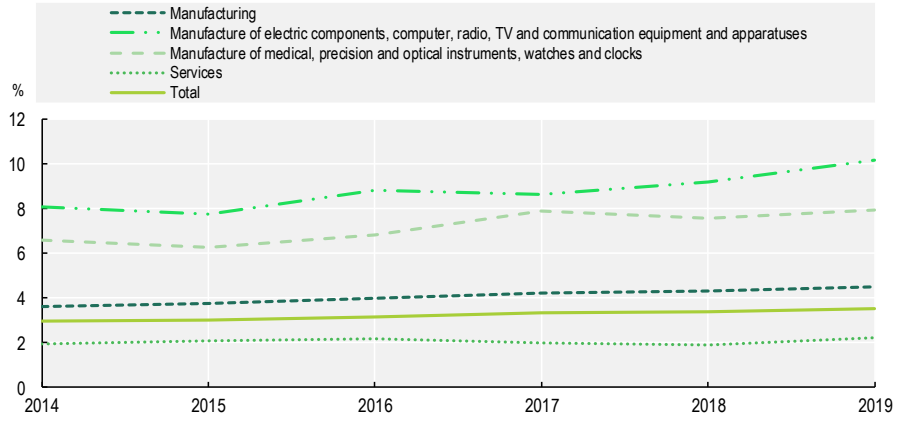
3.3.5. Stark discrepancies in R&D and productivity between manufacturing and services industries also exist

In Korea, almost 90% of all business R&D in Korea is spent on the manufacturing sector. The share of non-manufacturing R&D decreased from 12.5% in 2011 to 10.4% in 2015 before recovering to 12.5% again in 2019 (Figure 3.24). While the manufacturing sector generally plays an important role in business R&D across industrialised countries, the strong concentration of R&D on manufacturing firms in Korea stands

out in international comparison. The average proportion of business R&D falling to manufacturing in the five largest developed economies (United States, Japan, Germany, United Kingdom and France) was 70.8% in 2016 (calculated from (OECD, 2023[2])).

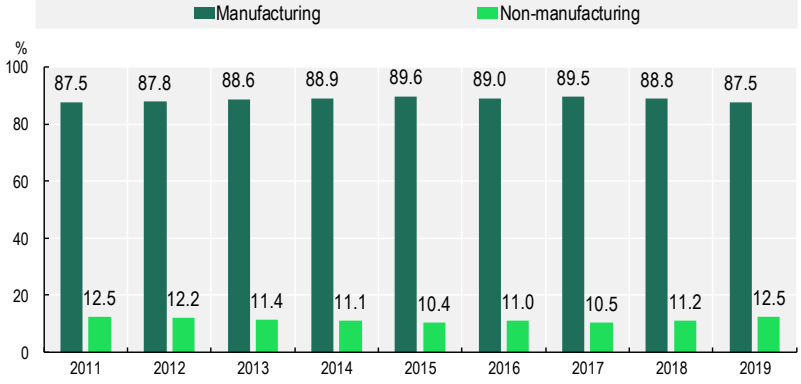
Furthermore, Korean manufacturing firms spend much more on R&D in relation to their revenue size than their counterparts in the service sector. In 2019, R&D intensity (the ratio between R&D expenditures and sales) was 4.49% in the manufacturing sector and 2.21% in the service sector (Figure 3.25) (MSIT and KISTEP, 2021[18]). Moreover, R&D intensity in manufacturing has risen over the last five years, from 3.63% to 4.49%, while the service sector has stagnated. In the service sector, the largest R&D spender is the "information service publishing" industry, which mainly consists of software companies (Figure 3.26). Most of the remaining R&D spending in services falls to other ICT services, including broadcasting, advertisement, R&D services, engineering and technical services. These service industries are thought to rely to a great extent on manufacturing business customers. In other words, substantial parts of service R&D appear to be linked to innovation in the manufacturing sector. The dominance of the manufacturing sector in business R&D in Korea thus may be even stronger than the overall sectoral composition of R&D spending suggests.

Figure 3.24. R&D expenditure rate to sales by major industries, Korea, 2014-19



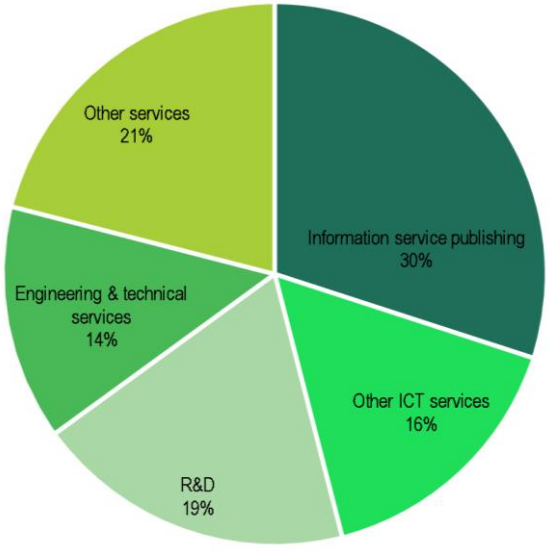
Source: MSIT and KISTEP (2021[18]), *Survey of Research and Development in Korea, 2019*, https://www.kistep.re.kr/reportDownload.es?rpt_no=RES0220210050&seq=res_0026P@5.

Figure 3.25. Business enterprise R&D in Korea by sector, 2011-19



Source: MSIT and KISTEP (2019[13]), *Survey of Research and Development in Korea, 2019*, https://www.kistep.re.kr/reportDownload.es?rpt_no=RES0220210050&seq=res_0026P@5.

Figure 3.26. Service sector R&D in Korea by industry, 2019



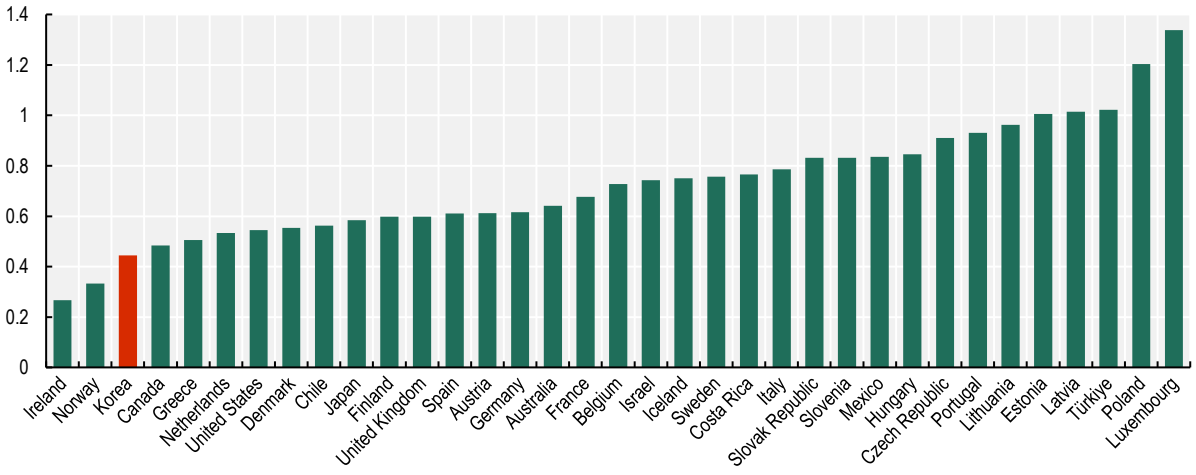
Source: MSIT and KISTEP (2021[18]), *Survey of Research and Development in Korea, 2019*, https://www.kistep.re.kr/reportDownload.es?rpt_no=RES0220210050&seq=res_0026P@5.

The gap between Korea's manufacturing and service industries does not stop at R&D investment and spans various aspects of innovation. First, a wide productivity gap exists between Korea's manufacturing and service industries (Figure 3.27). The sector productivity gap in Korea is among the highest in the OECD (OECD, 2023[6]). Meanwhile, a robust productivity-wage premium exists in OECD countries (Berlingieri, Calligaris and Criscuolo, 2018[36]). Higher wages are paid by more productive firms; thus, a close link can be observed between productivity and wages. Therefore, the productivity gap identified between Korea's manufacturing and service sectors matches equally pervasive wage gaps. Adding the additional layer of imbalance between large and small firms on top of the sectoral productivity gap opposes large manufacturing firms to SMEs in the service sector. Combining the size and sectoral dimensions from the within-industry analysis and linking them to wages, it appears that productivity gains overwhelmingly accrue to large manufacturing firms. Productivity in small manufacturing and service firms of all sizes is low compared to large manufacturing firms, and the gap is larger in Korea than in other OECD countries on average (Figure 3.28, Panel A). Wage gaps largely reflect the productivity gaps (Figure 3.28, Panel B) (OECD, 2023[6]). Meanwhile, lack of productivity can also influence competitiveness and the Korean service industry's advantage in terms of global integration. Korea ranked 7th among manufacturing hubs in global value chains and only 21st among services (OECD, 2021[37]).

3.3.6. The servicification of manufacturing can offer great potential but remains largely untapped

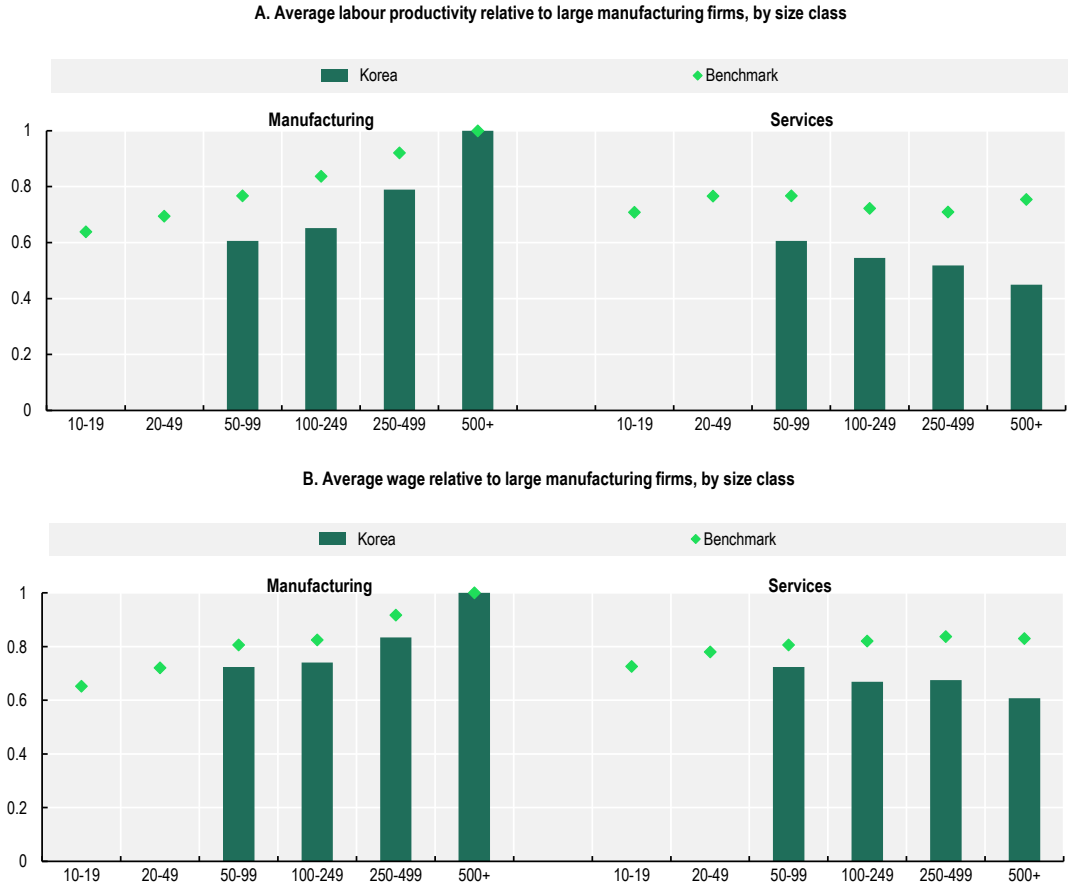
With the development of ICT technologies, services are increasingly embedded in manufacturing products as manufacturing firms increasingly rely on services, either as inputs, as production activities within a firm, or as outputs sold bundled with goods (Miroudot and Cadestin, 2017[38]). This phenomenon is known as "servicification" of the manufacturing industry. Korea has great potential for this servicification (OECD, 2020[35]). For instance, cell phone manufacturers can bundle their products with telecommunication services to allow users to install apps, generating additional service transactions. In this regard, Korea can benefit from the manufacturing sector itself to develop some value-added services. However, data show that Korea has not fully tapped into the potential of servicification. In effect, the contribution of domestic services to manufacturing exports is one of the lowest among OECD countries at 15%, while the OECD average is 28% (OECD, 2021[39]).

Figure 3.27. Labour productivity in services relative to manufacturing in Korea and OECD countries, 2015



Source: OECD (2021[37]), *Inclusive Growth Review of Korea: Creating Opportunities for All*, https://doi.org/10.1787/4f713390-en.

Figure 3.28. Average labour productivity and wages relative to large manufacturing firms in Korea, 2015



Source: OECD (2021[37]), *Inclusive Growth Review of Korea: Creating Opportunities for All*, https://doi.org/10.1787/4f713390-en.

3.4. Ongoing developments, achievements, and a way forward

This section discusses developments relevant to the Korean business innovation system and industry structure more generally, which is highly concentrated in the ICT and manufacturing industries. The section focuses on the emergence of biotechnology, which holds vast potential for Korea and constitutes a significant shift to emerging non-ICT technologies. In addition, it alludes to the importance of not neglecting high-value-added and knowledge-intensive services to counter the prevalent imbalance.

3.4.1. Korea relies the most highly on ICT industries among OECD countries, but new technology-based industries, such as biotechnology, are emerging

Korea has strived to diversify its industry landscape from ICT-centred manufacturing to knowledge- and high-tech-based industries with more diversity. Despite continued reliance on the ICT industry, the growing presence of the biotech industry in Korea provides a potential pathway for advancing toward a more diversified and knowledge-based economy. Korea envisioned promoting the biotech industry decades ago; its move started in the early 1980s with the Biotechnology Support Act (see Box 3.4), which provided the legal framework for governing support policies in the field of biotechnology.

Box 3.4. Korea's Biotechnology Support Act

The purpose of Korea's Biotechnology Support Act is to develop and support biotechnology more efficiently by laying the foundation for biotechnology research and to contribute to the sound progress of the national economy by facilitating the industrialisation of the technology.

The Minister of Science and ICT shall formulate the basic plan for biotechnology support (hereafter, the "basic plan"). The basic plan includes the following:

- comprehensive plans and guidelines on fundamental studies of biotechnology and the promotion of studies for industrial application thereof
- guidelines related to a comprehensive development plan and efficient utilisation of human resources necessary for research in biotechnology
- plans and guidelines related to research in biotechnology and the international exchange of talents and technology.

The Council for Comprehensive Biotechnology Policy shall be formed under the authority of the Minister of Science and ICT for the management of affairs relating to the establishment of the basic plan and its execution and co-ordination.

The Government of Korea shall promote co-operative activities among academia, research institutes and industry for efficient research and technological development in biotechnology. The Government of Korea may take policy steps to provide assistance in matters falling under each of the following subparagraphs in order to vitalise the R&D of biotechnology and to facilitate the industrial application of the results thereof:

- matters concerning assistance in the production of goods using new technology
- matters concerning R&D aimed at facilitating the industrial application of the results of biotechnology research and the building of regional R&D bases
- matters concerning assistance in start-ups and SMEs involved in biotechnology.

The Government of Korea shall endeavour to promote R&D by gathering information for biotechnological research and distributing it to related organisations.

The Government of Korea shall establish a system regarding safety and clinical tests for biotech products.

Source: Korea Legislation Research Institute and Korea Law Translation Center (2021[40]), *Biotechnology Support Act*, https://elaw.klri.re.kr/eng_service/lawView.do?hseq=60046&lang=ENG.

The growth of the Korean biotech industry has been impressive, with many Korean biotechnology firms now taking leading positions around the globe. Overall, the biotech industry has become one of Korea's major industries. According to the latest data from the Ministry of Trade, Industry and Energy, Korean biotech industry production increased to KRW 1 749.23 billion in 2020, a significant jump, equivalent to 38.2% over the previous year, the greatest increase since the statistics were collected and announced (see Table 3.7, section A). Moreover, biotech industry exports rose 53.1% in 2020 (see Table 3.7, section B). This remarkable increase has been accompanied by a rapid increase in employment in the industry; in 2020, employment in biotech rose by 10% (Ministry of Trade, Energy and Industry, 2021[41]).

Table 3.7. Progress in Korea's biotechnology industry, 2016-20

Biotech industry production and domestic demand, 2016-20, in KRW 100 million

	A. Biotech industry production and domestic demand, 2016-20, in KRW 100million						
		2016	2017	2018	2019	2020	Average annual rate of change
Production (Domestic sales + exports)	Amount	92 611	101 457	106 767	126 586	174 923	
	Rate of change	8.9%	9.6%	4.5%	19.3%	38.2%	17.2%
Domestic demand (Domestic sales + imports)	Amount	60 898	65 466	70 966	81 836	98 189	
	Rate of change	8.2%	7.5%	8.4%	15.3%	20.0%	12.8%
B. Biotech industry exports, 2016-20, in KRW 100 million							
		2016	2017	2018	2019	2020	Average annual rate of change
Export	Amount	46 310	51 684	52 382	65 414	100 158	
	Rate of change	8.0%	11.6%	1.4%	24.9%	53.1%	21.3%

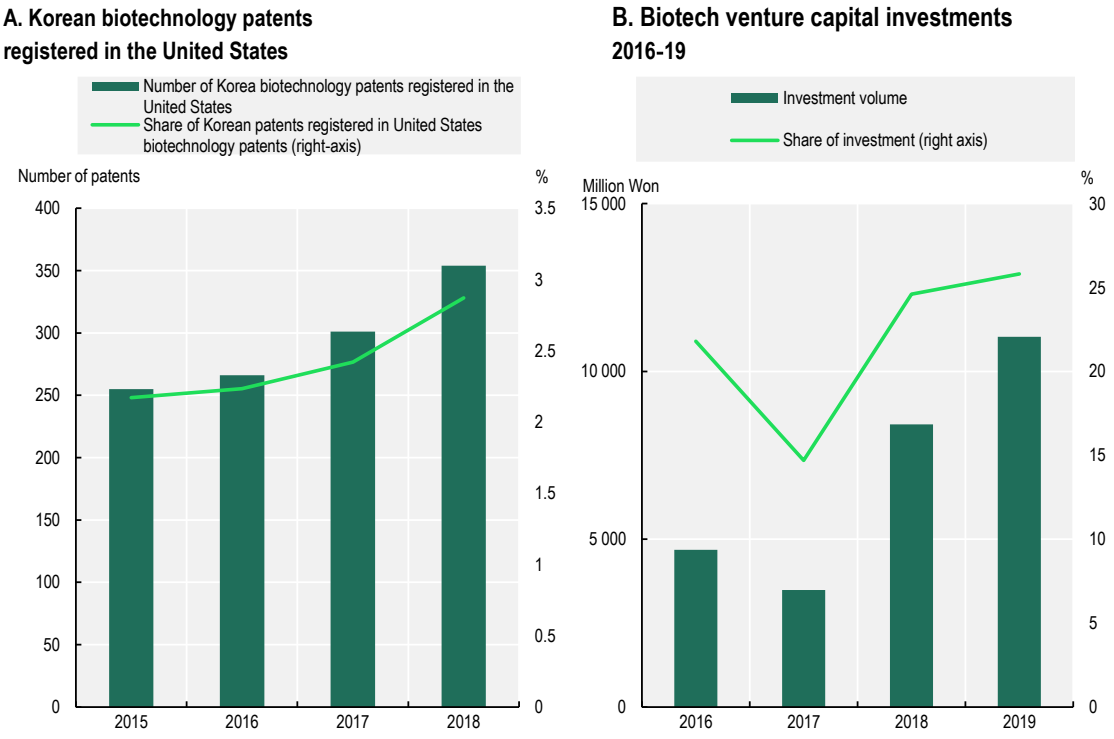
Source: Ministry of Trade, Energy and Industry (2021[41]), *Ministry of Trade, Energy and Industry Announcement of 2020 Bioindustry Survey Results*, http://www.motie.go.kr/common/download.do?fid=bbs&bbs_cd_n=81&bbs_seq_n=165037&file_seq_n=1.

3.4.2. Public R&D investment in biotechnology has led to the rapid increase of Korean firms' biotech patents and the creation of start-ups

Public R&D investment in biotechnology has played a critical role in creating Korea's robust bio-industry ecosystem. Government R&D investment in biotechnology increased markedly from USD 1.2 billion in 2007 to USD 3.4 billion in 2016. Biotechnology investment in government R&D accounted for 15.7% of whole government R&D spending in 2016, rising to 19.2% in 2020. Moreover, the Korean government has chosen the biotech industry as one of three innovative growth engines ("Big 3"), along with system semiconductors and future vehicles. The government has prioritised its policy measures, including R&D, tax, and regulation reform, to drive the growth of the Big 3 industry. The government planned to invest USD 5.2 billion in 2022, a 42.7% increase from 2021. Government support for the biotech industry stretches the whole innovation cycle, from technology development, authorisation and production to market entrance. Sustaining the government's strong support for R&D has yielded active patent applications and high-impact research performance (Figure 3.29). On top of academic and technological development, strong and continuing government investment has played a role in supporting entrepreneurs in creating and expanding biotechnology-related businesses, resulting in the rise of biotech venture capital

investments as well (Figure 3.29). The number of biotech start-ups created in Korea was 140 in 2010, increasing to 440 in 2016. As a result, the Korean biotech industry has become competitive around the globe; Korea ranked second in terms of the production capacity of biomedicine in 2020 (Ministry of Trade, Energy and Industry, 2021[41]).

Figure 3.29. Development of Korea's biotechnology industry



Source: Ministry of Science and ICT (2021[42]), *Biotechnology 2020 in Korea*, https://www.khidi.or.kr/board/view?pageNum=1&rowCnt=3&no1=&linkId=48855931&menuId=MENU02296.

Table 3.8. The number of SCI paper publications in Korea, 2013-17

	2013	2014	2015	2016	2017
Number of publications	52 827	55 791	58 832	60 471	61 163
Total number of publications worldwide	1 572 889	1 622 978	1 670 162	1 733 431	1 790 016
Percentage of global publications	3.36%	3.44%	3.52%	3.49%	3.42%
World ranking	12	12	12	12	12

Source: Ministry of Science and ICT (2021[42]), *Biotechnology 2020 in Korea*, https://www.khidi.or.kr/board/view?pageNum=1&rowCnt=3&no1=&linkId=48855931&menuId=MENU02296.

Meanwhile, the competitiveness of Korea's biotech industry was particularly evident during Korea's response to COVID-19. Korea was one of the first countries to succeed in developing and exporting COVID-19 diagnostic test kits shortly after the outbreak. The accumulated experience in developing diagnostic test kits and the prompt response by the government contributed to establishing a system for an early diagnosis of COVID-19. Korean SMEs specialised in diagnosis and emergency screening had developed the capacity to develop diagnostic test kits for the swine flu and Middle East Respiratory Syndrome outbreaks in past decades. In the meantime, the Ministry of Food and Drug Safety approved

the COVID-19 diagnostic test kits by emergency use authorisation, which shortened the duration of the authorisation process by approximately 150 days. As a result, Korean biotech SMEs supplied 190 million COVID-19 diagnostic test kits to 150 countries between April and August 2020. In addition, the Ministry of Food and Drug Safety approved 166 diagnostic reagent products, while the United States approved 16 products in the same period.

3.4.3. Korea's biotech industry has huge potential, notably from the perspective of information technology-biotechnology convergence

The biotech industry in Korea has huge potential to grow into a top-notch industry in the world with a clear edge over competitors. The world's number one ICT technology can provide enormous opportunities for the future growth of the biotech industry in Korea, given that biotechnology (BT) and IT are converged in technological development and the application of technology, notably in cases such as mobile medical devices. On top of its competitive ICT technology, Korea is ranked as number one in the electronic medical records penetration rate, which could be the foundation for data-driven medical service and research, resulting from one of the most efficient and strongest universal health insurance systems. Even though the Korean biotech industry has grown remarkably, it faces some challenges (see Box 3.5). In order to become a real powerhouse in the biotech industry on the global stage, Korea's biotech business should make strong efforts to overcome these challenges.

Box 3.5. Challenges of the Korean biotech industry

Despite the outstanding growth of Korea's biotech industry, many biotech firms have pointed out major challenges and hurdles they need to overcome to advance to become a global leader in the field. Several policy initiatives have been developed by the Korean government, including the Innovative Strategy on the Bio-health Industry (2019), which presents a strengths, weaknesses, opportunities and threats (SWOT) analysis. Across different aspects that comprise the competitiveness of the biotech industry, some challenges include:

- Even leading Korean biotech firms suffer from a lack of financial resources compared to top global pharmaceutical companies. Because of this, many big Korean biotech firms have decided to export intermediary technology rather than focus on novel drug development. In fact, one of the world's number one pharmaceutical companies, Lauche, is investing KRW 13 trillion, while domestic top-ten companies in Korea are investing KRW 1 trillion combined.
- Health practitioners in hospitals aim to collaborate with academia on research, while stakeholders in academia appear to have a strong interest in using clinical infrastructure in hospitals. However, the biotech industry in Korea has not yet fully matured in terms of industry-academia and hospital collaboration, which could be critical in technology transfer and commercialisation. Some institutional hurdles still hinder close collaboration. For example, while doctors in private hospitals in the United States can create businesses, it is forbidden by law in Korea.
- Traditionally, the biotech industry in Korea has been strictly regulated to protect customers' lives and health. As a result, Korean pharmaceutical companies have to go through a longer and more time-consuming process to obtain a licence for novel health and bioproducts.

Source: Government of Korea (2019[43]), *Innovative Strategy on the Bio-health Industry*, http://www.mohw.go.kr/eng/nw/nw0101vw.jsp?PAR_MENU_ID=1007&MENU_ID=100701&page=1&CONT_SEQ=349515.

3.4.4. Although Korea has not achieved notable success, it has promoted its service industries with various policy measures

The Korean government has introduced numerous measures since the 2000s to enhance the competitiveness of the service industry. It is important to highlight some of these measures to understand the ongoing developments and identify what needs to be done going forward. This section will highlight some of the major policy measures, along with some encouraging developments in knowledge-based service industries and the creative industry[3].

First, the Korean government has worked to level the playing field between its manufacturing and service industries, given the imbalance that resulted from the government's previous prioritisation of the manufacturing industry. In July 2019, the Ministry of Economy and Finance announced a plan to provide the service sector with the same level of fiscal and financial support as the manufacturing sector in order to promote service R&D, service standardisation and service-manufacturing convergence (MOEF, 2019[44]). The plan aimed to provide the same level of support, operate under the same tax rules and address the regulatory barriers faced by service industries to allow young firms and start-ups to emerge.

For example, the support policies announced for strategic industries selected by the government – such as future cars, bio-health, smart industry industrial complex, fin-tech, new energy industry, smart cities, smart farms and drones – should balance support for both manufacturing and services. Furthermore, the support should align with broader inclusiveness objectives for society, such as labour market and skill policies. Government support policies could ensure that innovation and activity in emerging sectors are not discouraged or displaced.

In 2019, Korea also introduced a regulatory sandbox, notably including ICT-industry convergence and financial innovation (OECD, 2023[6]).[4] The introduction of the regulatory sandbox is particularly significant for the service industry, as the legacy regulations that could favour incumbents over new innovators have often been cited as a hindrance to the industry's lagging competitiveness. The regulatory sandbox can be a strategic approach for new innovations to enter the service industry by providing new opportunities for innovative business models and firms.

It is worth elaborating on the entire process of the regulatory sandbox to highlight its significance in the Korean context, where relatively heavy regulatory state rules exist for the service industry. Under the sandbox programme, companies that want to introduce a new business model can submit proposals and receive a response in no later than 30 days if the proposal is subject to regulation. If there is a regulation that conflicts with the proposal, the applicant may be able to obtain temporary permission or a regulatory exception for demonstrations or a declining answer if, for example, there are issues relating to safety that cannot be resolved. The temporary permissions are for two years and can be renewed for another two years. If regulatory improvements are initiated, they can obtain additional extensions until the relevant regulation is revised.

By December 2022, 860 cases had been approved. Of these, 96 were given temporary permissions, 717 exemptions for demonstrations, and 47 cases were resolved by government officers proactively engaging with policy recommendations (for example, changing internal guidelines before presenting the issue before a deliberative committee to make the decision or give advice).

Building upon the successful implementation of the regulatory sandbox would pave the way for broader and general regulatory reform, mainly for the service industry and industry in general. The OECD's 2018 Product Market Regulation Index indicates that Korea's regulations are the sixth-most stringent among OECD countries. Moreover, regulations weigh more heavily on services, with adverse impacts on SMEs, given their concentration in the sector. Further tailoring regulations to company size would help reduce the burden on SMEs, which tend to have less capacity to conform to regulatory standards. In addition, regulatory reform should include a comprehensive negative-list system and expanded use of regulatory

sandboxes, which facilitate the creation of firms using new technologies and producing new goods and services (OECD, 2022[45]).

3.4.5. The emergence and growth of several knowledge-based service industries are encouraging

The Korean government has prioritised its policy to promote the service industry, focusing on a few high-value-added service industries, such as healthcare, education, culture and software (SW). This section takes a deeper approach to analysing the SW and culture industries.

The estimated domestic production of software in 2020 (Table 3.9) amounted to KRW 66.4 trillion, representing a 7.1% increase from the previous year. From 2016 to 2020, the industry demonstrated annual growth of 7.7%, with package SW showing the highest growth and IT services showing the least growth (Ministry of Science and ICT, 2021[46]; Software Policy Research Institute, 2021[47]) (Table 3.9, Section A). IT services accounted for the highest proportion of total production, with 59.0%. Regarding SW exports, from 2016 to 2020, Korean SW industry exports grew by an annual rate of 9.6%. In particular, the game SW sector showed a very strong growth rate of 18.2% during the same period (Ministry of Science and ICT, 2021[48]; Software Policy Research Institute, 2021[47]) (Table 3.9, Section B). Some recent developments aimed at building better framework conditions for promoting the software industry, ranging from nurturing talents to streamlining the regulations on data use, are encouraging.

Table 3.9. Progress in Korea's software industry, 2016-20

A. Domestic software industry production, 2016-20, in KRW trillion						
	2016	2017	2018	2019	2020	Compound annual growth rate (2016-20)
Package software	7.6	8.9	10.3	12.2	13.1	14.8%
IT services	31.8	33.7	34.9	37.7	39.2	5.4%
Game software	10	11.4	11.9	12	14.1	8.9%
Total	49.3	54	57.1	62	66.4	7.7%
B. Domestic software industry exports, 2016-20, in KRW trillion						
	2016	2017	2018	2019	2020	Compound annual growth rate (2016-20)
Package software	9.4	10.3	10.4	12.4	9.5	0.3%
IT services	61.1	61.5	63.2	72.3	75.1	5.3%
Game software	32.8	52	62.4	63.4	64	18.2%
Total	103.2	123.8	136	148.1	148.6	9.6%

Note: A. Software production statistics are the sum of software item sales and differ from the company's total sales. 2020 figures are tentative values based on the ICT Major Item Trend Survey (monthly). B. The provisional value for 2020 is based on the Software Export Statistics Survey (monthly)

Source: A. Ministry of Science and ICT (2021[46]), *ICT Status Survey (2021.5), ICT Major Item Trend Survey (2021.5)*; Software Policy Research Institute (2021[47]), *Software Industry Annual Report 2020*, https://spri.kr/posts/view/23366?code=annual_reports&s_year=&data_page=1.
B. Ministry of Science and ICT (2021[48]), *Software Export Statistics Survey (Annual) (2021.5), Software Export Statistics Survey (Monthly) (2021.5);* Software Policy Research Institute (2021[47]), *Software Industry Annual Report 2020*, https://spri.kr/posts/view/23366?code=annual_reports&s_year=&data_page=1.

In addition to the SW industry, the cultural industry has been growing in Korea. The contribution of cultural industries to GDP and employment in 2012 was only 2.4% and 2.6%, respectively, which is far lower than in most other OECD countries (OECD, 2014[49]). However, since the turn of the millennium, some creative industries in Korea have grown significantly. Following the initial success of Korean films and TV dramas

in China and Japan, Korean music entertainment has become highly popular, particularly in East Asia and Southeast Asia. International interest in Korean cultural content has become frequently referred to by the term “Hallyu” (Box 3.6).

Box 3.6. The Hallyu phenomenon

Hallyu, which literally means “Korean wave”, was first used by the Ministry of Culture and Tourism in 1999 as a Chinese title for a music CD containing Korean content. It subsequently became an established term for Korean cultural products and content in China and Japan around the turn of the millennium and later in other countries as well. Hallyu has become a widely encompassing umbrella concept for global interest in Korean creative industries, covering broadcast programmes, film, music, performing arts, computer games, comics and webtoons, literature, fashion, food, tourism and beauty (KOFICE, 2020[50]).

Hallyu can initially be traced to the success of Korean movies and TV dramas in China in the late 1990s and in Japan in the early 2000s. These triggered a more general interest in Korean cultural content in neighbouring East Asian countries, where knowledge of Korea had been limited. In particular, Korean pop music entertainment (K-pop) became highly popular from the 2000s, particularly in China, Japan and Southeast Asia. In addition, some Korean online drama series have also become globally popular.

Hallyu has helped grow global interest in Korean culture at large, resulting in increased exports of Korean food and beauty products and an increase in foreign tourists visiting Korea. Hallyu has arguably also contributed to a more modern and positive image of Korea in other countries where negative associations related to the country’s 20th-century history, including poverty, war, dictatorship and political conflict, had previously been widespread.

Source: KOFICE (2020[50]), *2019 Hallyu White Paper*, https://kofice.or.kr/b20industry/b20_industry_00_view.asp?seq=1130.

K-pop has emerged as a major contributor to the global success of Korean cultural products and content. Additionally, the online game industry is another area where Korea has achieved notable success. Since around 2000, several newly established companies have published highly successful multiplayer online games, taking advantage of the rapid proliferation of broadband Internet in Korea. Some of these games have attracted and retained large player communities, leading to the growth of these companies. In fact, in 2019, 5 out of the 13 Korean “venture companies” with annual revenues of more than KRW 1 trillion were online game companies (Ministry of SMEs and Start-ups, 2021[22]). In the 2010s, games accounted for more than half of all exports of cultural products from Korea (Jin, 2016[51]). The broadcasting and film industries have also become major exporters, and similarly to music and online games, their largest markets are in East Asia and Southeast Asia (KOFICE, 2020[50]).

Governmental policies have supported creative industries mainly in two ways. First, following the enactment of the Basic Law for Promoting Cultural Industries in 1999, the government promoted the development and internationalisation of cultural industries through various specific support measures for the production and global distribution of cultural content (Jin, 2016[51]). Second, most companies that are active in creative industries qualify as venture companies, making them eligible for support measures available to such companies. In 2019, the Korean government identified cultural industries as a new major economic growth engine and formulated innovation strategies for these industries (Briefing, 2019[52]). As a result, specific programmes have been initiated to support different aspects of the creative industry business, including ideation, production, marketing and export (Lee, 2020[53]).

3.5. Korea's start-up system

In recent years, start-up activity in Korea has thrived, thanks in part to targeted and proactive government support. This section provides an overview of the Korean start-up ecosystem and its support system, followed by ongoing challenges that persist despite its strong growth. These challenges include issues related to internationalisation and diversity, as well as the need for comprehensive government support throughout all stages of business development.

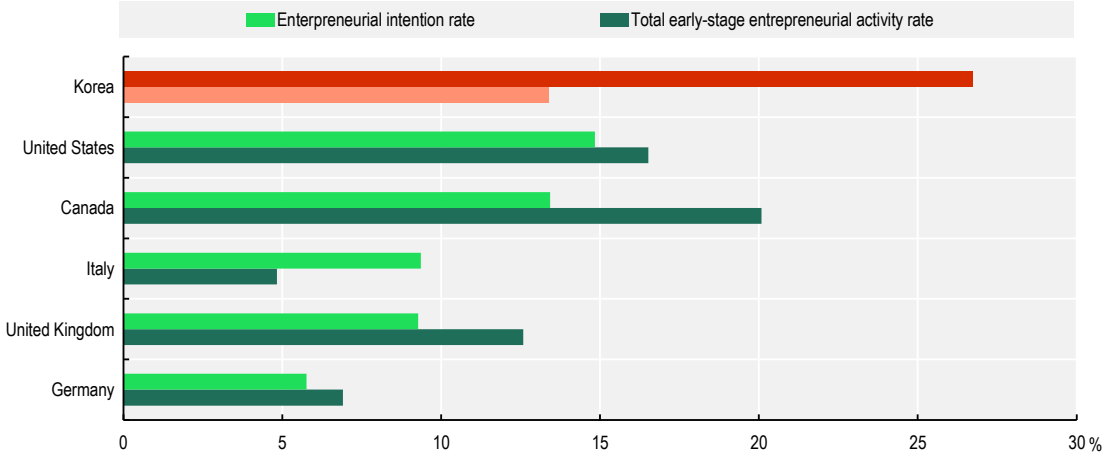
3.5.1. Korea is building a vibrant start-up ecosystem with a high level of entrepreneurial activity

Generally speaking, Korea has a high level of entrepreneurial activity compared with other developed countries. Large-scale surveys conducted by the Korea Institute of Startup and Entrepreneurship Development among adults aged 18-64 indicate that the intention to start a new business within the next three years is higher in Korea than in major Western countries, with 26.7% of respondents expressing such intentions in 2021. The proportion of nascent entrepreneurs in the process of setting up a new business is 13.4% in Korea, which is higher than in European countries and somewhat lower than in the United States and Canada (Figure 3.30). Additionally, the enterprise birth rate (calculated as the ratio of new enterprises founded in the last year to all existing enterprises) was 15.1% in 2017 for enterprises with employees, which is higher than in the United Kingdom (13.9%), France (11.4%), Italy (9.3%) and Germany (6.9%) (OECD, 2021[54]). In 2018 and 2019, 102 400 and 109 500 new companies were registered in Korea, respectively (STEPI, 2021[9]).

In Korea, the number of newly registered venture companies is a useful indicator for assessing and monitoring the development of start-up entrepreneurship. Under the Special Law to Promote Venture Capital Companies enacted in 1997, SMEs that receive significant investment by venture capital companies, are R&D intensive, or are primarily engaged in high-tech industries, can seek registration as venture companies and become eligible for privileges such as tax cuts. The total number of venture companies increased from 2 042 in 1998 to 36 503 in 2019 (Korea Venture Business Association, 2020[55]). Among all venture companies in 2019, 19.4% were engaged in the machinery, automotive and metal industries; 12.5% in the SW and IT service industries; 10.3% in the computer, semiconductor and electronic component industries; and 8.7% in the energy, chemical and precision industries.

Figure 3.30. Entrepreneurial activity in Korea and selected countries, 2021

Entrepreneurs as a percentage of adults aged 18-64



Source: Global Entrepreneurship Monitor (2022[59]), *GEM 2021/2022 Global Report: Opportunity Amid Disruption*, https://gemconsortium.org/report/gem-20212022-global-report-opportunity-amid-disruption.

3.5.2. Active government support has played an important role in creating a vibrant start-up ecosystem in Korea

In recent years, the promotion of entrepreneurship has become a top priority in Korea and has played a significant role in the growth of start-up entrepreneurship since the 2010s. The Ministry of SMEs and Start-ups co-ordinates national-level start-up support policies, with various other national government ministries also offering programmes. At the subnational level, the Seoul Municipal Government and provincial governments have their own start-up support policies. Governmental support policies for start-ups include direct investment, matching investment, R&D support and various indirect support programmes, such as entrepreneurship education, workspace provision, mentoring and consulting, and the organisation of networking events. In 2022 alone, the Korean government budgeted almost KRW 3.7 trillion (including loans) for start-up support programmes.

Many policy measures focus on providing financial support for start-ups, particularly for the commercialisation of technologies. This policy focus contrasts with the more indirect policy measures emphasised by other OECD countries where start-up ecosystems emerged earlier than in Korea, including Denmark, Germany, Israel, the Netherlands, Sweden, the United Kingdom and the United States. In these countries, policy focuses more on enhancing the general business environment for entrepreneurial activity and inter-regional and global connectivity, relying to a great extent on private actors (Brown and Mawson, 2019[56]).

3.5.3. Despite strong growth, start-up financing remains insufficient to support all stages of start-up development

In recent years, the conditions for financing and scaling up start-ups in Korea have greatly improved, although they differ significantly across different stages of start-up development. In the initiation stage, governmental seed finance support (mostly via small, non-repayable grants) is widely available. However, only around one-quarter of start-up entrepreneurs have been found to use these funding support programmes. Around half use personal funds, including funding from family and friends and loans from financial institutions to start their businesses (Hemmert and Kim, 2021[57]). In the scale-up stage, financing by angel investors (including angel investor associations) and venture capital firms has steeply increased. In 2019, KRW 4.28 trillion of venture capital was invested in Korea, up from KRW 2.08 trillion in 2015. Angel investment increased from KRW 96 billion in 2014 to KRW 554 billion in 2018 (STEPI, 2021[9]). However, the COVID-19 pandemic has significantly impacted financial support for start-ups. As new start-up activities contracted due to the COVID-19 outbreak, the growth rate of venture and growth capital was greatly reduced. While in 2018, venture and growth capital registered a growth rate of about 44%, in 2019, the growth rate was approximately 25%. In 2020, the growth in venture and growth capital registered a steep decline, with only 0.6% year-over-year growth (OECD, 2022[58]).

The increase in venture capital investment has been primarily driven by a government-financed fund-of-funds, the Korea Fund of Funds, operated by the Korea Venture Investment Corporation, with an accumulated capital of KRW 4.52 trillion by 2019. The Korea Fund of Funds enables the government to provide various financial support to start-ups, including the Tech Incubator Program for Startups (TIPS) (Box 3.7), recognised as one of the most successful government support programmes for start-ups. The critical factor contributing to its success is inviting private investors to select a technology entrepreneurship team and provide mentoring with the investment. The government provides R&D funding with matching investment, commercialisation and marketing support to ensure that technology start-ups survive “Death Valley”. Subsequent investments from domestic and foreign investors are actively made.

In addition to government-financed financial support for start-ups, the increase in angel investment has been enhanced by income-level tax exemptions introduced in 2018. The exemptions amount to 100% of

investors' annual income up to KRW 30 million and 70% for income between KRW 30 million and KRW 50 million.

Box 3.7. Korea's TIPS program

The Tech Incubator Program for Startups (TIPS) was initiated in 2013 to expand funding opportunities for scaling start-ups in Korea. The programme was specifically designed to combine private and governmental funding. Promising start-ups are selected by accelerators, which invest KRW 100 million of venture or angel capital into them. This private equity investment is matched by up to KRW 1 200 million in government funding for R&D and other business expenses. Selected start-ups are also offered professional support by the accelerators that have invested in them. Successful start-ups are required to pay back 10% of the government grant as a royalty later (Korea Business Angels Association, 2021[59]). The government effectively outsources the selection of start-ups eligible for TIPS grants to accelerators, which need to be certified by the government to participate in the programme.

Many Korean start-ups have avoided government funding programmes due to the high perceived paperwork burden, including application and reporting requirements. The TIPS program reduces the administrative burden as accelerators help the start-ups they have selected navigate the administrative processes related to acquiring and operating government grants (Kyungjae, 2019[60]). Overall, the TIPS program is credited with substantially increasing funding opportunities for start-ups in Korea.

Source: Kyungjae, (2019[60]), "The reason why start-ups call TIPS 'Korea's mistake'"; Korea Business Angels Association (2021[59]), *Tech Incubator Program for Startups, About TIPS,* http://www.jointips.or.kr/global/.

In 2021, significant deregulation was introduced regarding private-led financial support for start-ups. Previously, Korean conglomerates were prohibited from investing in start-ups by establishing corporate venture capital (CVC) funds in order to protect investors and consumers by separating industrial and financial capital. However, the Korean government lifted this regulation in 2021, paving the way for the establishment of major venture capital funds by Korean conglomerates, with the aim of promoting collaboration between large companies and start-ups and increasing potential financial resources for start-ups. Despite this, some critics argue that the latest policy shift in CVCs is insufficient to tap into the full potential of CVCs by large companies, as some detailed restrictions are still in place. For instance, the ratio of funding by third-party investors (other than the companies setting up the CVCs) is limited to 40%.

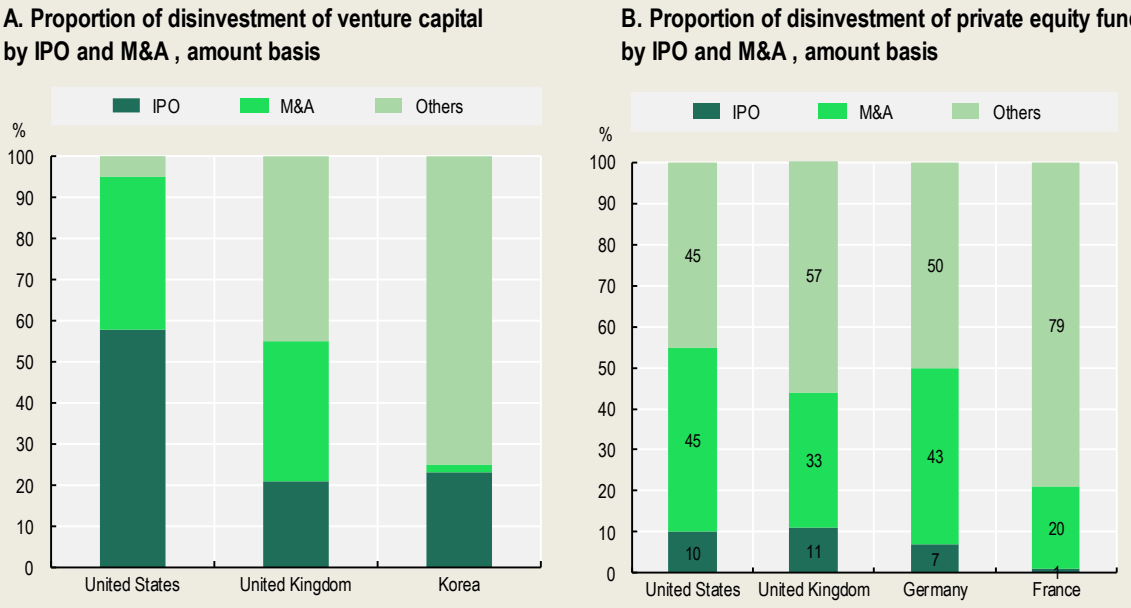
Exit models for start-ups in Korea have been relatively weak with respect to both initial public offerings (IPOs) and M&As. There were only 17 IPOs on KOSDAQ (Korea's main stock exchange) in 2019, down from 49 in 2015. The number of IPOs on KONEX (a separate stock exchange for SMEs) also decreased from 109 in 2015 to 97 in 2019. In addition, only 43 start-up M&As were recorded in 2019, a slight increase from 40 M&As in 2015 (STEPI, 2021[9]). It is estimated that recently, only approximately 30% of scaled-up Korean start-ups are achieving an exit via IPOs and 10% through M&As. An international comparison reveals weak exit models for start-ups in Korea (Box 3.8).

There have been some positive developments in this area, however. First, regulatory requirements for IPOs have been eased in recent years. Second, major domestic and foreign technology companies have shown increasing interest in strengthening their technological competencies by acquiring Korean start-ups. Nonetheless, some start-ups still face challenging exit conditions.

Box 3.8. International comparative study on the start-up ecosystem in Korea and selected countries

The Asan Nanum Foundation in Korea, a non-profit organisation established to promote entrepreneurship and strengthen the Korean start-up ecosystem, conducted an interesting study. Its report extensively analyses various indicators to assess the current status of the Korean start-up ecosystem in comparison with selected countries, including France, Germany, the United Kingdom and the United States. The indicators range from the creation of businesses to culture and perception, internationalisation and finance accessibility. The report specifically examines the financial accessibility in the exit phase for start-ups; some of the indicators used for this comparison are illustrated in Figure 3.31.

Figure 3.31. Comparison of IPOs and M&As in start-ups' exit phase (venture capital and private equity) in Korea and selected countries, 2021



Note: IPO: Initial public offering; M&A: Merger and acquisition.
Source: Asan Nanum Foundation (2021[61]), *International Comparative Study on Start-up Ecosystem (한국의 창업생태계 경쟁력 제고를 위한 국제 비교 연구)*.

3.5.4. Insufficient diversity and weak global connectedness could hinder Korea's start-up ecosystem from developing further

Despite the encouraging developments of the start-up ecosystem in Korea, there are also areas for improvement. This section highlights some of these areas, particularly from the perspective of diversity

and global connectedness, which evidence from OECD countries has demonstrated to be essential for improving sustainable innovation for start-ups.

First, the diversity of founders and management teams in Korean start-ups is low in terms of the majors they have studied, their gender and their nationality (Born2Global Centre, 2021[62]; Hemmert and Kim, 2021[57]). Most start-up founders have an engineering background, while relatively few have studied other disciplines, such as economics, business, humanities and science. The observed ratio of female technology start-up founders across surveys ranges from 5% to 20%, with a large majority being male. Non-Korean founders are also very few, with one large-scale survey finding their ratio as low as 0.3% (Hemmert and Kim, 2021[57]). The low diversity of start-up founders and management teams is problematic, as diversity tends to enhance creativity and innovation (Østergaard, 2011[63]; Bouncken, Brem and Kraus, 2016[64]). This low proportion of foreign start-up founders is in stark contrast to leading Western start-up ecosystems, where approximately half of all start-up founders are immigrants (Migrants, 2020[65]). Although the Korean government started issuing visas for foreigners intending to establish technology start-ups from 2013, the number of visas issued in related categories has been low, and the impact of new measures remains to be seen ((STEPI, 2021[9])). In 2021, only 98 technology start-up visas (D-8-4) were granted to foreigners looking to start a business in Korea.

Second, relatively few Korean start-ups expand internationally, and even fewer succeed in doing so. In 2019, the ratio of newly founded firms in Korea that had expanded internationally stood at only 2.2% (STEPI, 2021[9]). This low internationalisation rate is in stark contrast to Europe, where around 20% of all recently founded firms have been classified as “born globals”, meaning they internationalise from the outset or soon after their establishment (Knight and Liesch, 2016[66]). Korean technology start-ups internationalise more frequently than newly founded firms in general, with an observed international expansion ratio of 26%. However, approximately half of these internationalised firms have an international sales ratio that does not exceed 10% (Hemmert and Kim, 2021[57]). While many Korean start-ups are interested in expanding their business to foreign countries, a perceived lack of knowledge or resources often prevents them from doing so. Others retreat from international markets after having entered them, as they find the hurdles to developing internationally profitable business models too high. Many start-ups lack international market knowledge because they do not have any non-Korean members in their management teams. Since their initial business models tend to be developed with a view to the Korean market, they often struggle to adapt later to foreign customer preferences or regulations.

3.6. Concluding remarks

Korea needs to address a number of imbalances in business R&D and innovation performance and respond to a number of challenges if it wishes to improve productivity performance and seize the opportunities from the digital and green transitions. Despite efforts to promote innovation more broadly in the economy, there remains ample room to further improve innovation in SMEs and high-value-added service sectors. In addition, further investment in emerging and converging technologies that will be the new drivers of productivity and growth will be necessary. In this context, connecting the Korean business innovation system to global innovation networks in terms of R&D and talent will be important. Finally, public policies to support business innovation should continue to be assessed for impact and improved without creating excessive policy uncertainty, which limits business uptake and efficient use of public support instruments. Table 3.10 summarises the main achievements and challenges facing business innovation in Korea going forward and is the basis for the recommendations contained in the overall assessment and recommendations (OAR) chapter.

Table 3.10. Korea's main achievements and challenges related to its business innovation

Achievements	Challenges
• Korea has seen rapid growth in its business sector R&D and shows top-notch business R&D spending among OECD countries.	• Korea's total ratio of innovating firms is the lowest among OECD countries.
• Korea has the world's second-highest number of ICT patent filings and the third-highest biotechnology patent filings.	• Korea relies significantly on R&D (vsthan non R&D) and in-house R&D rather (than collaboration)
• Korea has seen a significant increase in value-added, localising the value chain of its knowledge-intensive manufacturing industry.	• Many firms in Korea are still focusing on incremental innovation rather than disruptive innovation.
• Korea's global market share in high-tech industries, such as computers and pharmaceuticals, is increasing.	• Korea still lacks internationalisation of business R&D and innovation (e.g. co-patenting).
• Korea provides the largest total government support to business R&D as a percentage of GDP.	• There is fragmented public support for business R&D in Korea, with potential loss of efficiency and effectiveness.
• World-leading multinational firms in Korea have driven a significant increase in R&D expenditure (resulting in high concentration).	• The disparity in innovation between large and small firms is more acute in Korea than in other countries.
• Korea ranks at the top in ICT value-added, share of ICT sector employment and share of patents in ICT.	• The widening discrepancy, such as R&D and productivity between ICT and non-ICT industries, is of concern.
• Korea is building a vibrant start-up ecosystem with a high level of entrepreneurial activity (especially in Seoul).	• Exit models for start-ups have been relatively weak in Korea regarding both IPOs and M&As.
• Korea's government is actively and strongly committed to supporting start-ups (e.g. fund-of-funds, deregulation for CVC).	• There is Insufficient diversity (e.g. gender, nationality) and weak global connectedness in Korea's start-up ecosystem.
• Korea has seen impressive growth in its biotech industry, backed by a rapid increase in biotech patents and start-up creation.	• There is insufficient support for large-scale clinical trials and immature industry-academia-hospitals collaboration in Korea.
• Korea's government strongly supports promoting its service industry, e.g. by levelling its support to the service sector with manufacturing and introducing a regulatory sandbox.	• Service firms are still lagging in R&D investment in Korea, resulting in discrepancies in productivity and wages between the manufacturing and service industries.

References

Ahn, S., K. Lee and S. Lee (2021), "Major Issues and Policy Recommendations for Goverment R&D Subsidies for SMEs", *KISTEP Issue Paper* 2021-04, https://www.kistep.re.kr/board.es?mid=a10306010000&bid=0031&list_no=42025&act=view. [20]

Asan Nanum Foundation (2021), *International Comparative Study on Start-up Eco-system (한국의 창업생태계 경쟁력 제고를 위한 국제 비교 연구)*. [61]

Baruffaldi, S. et al. (2020), "Identifying and measuring developments in artificial intelligence: Making the impossible possible", *OECD Science, Technology and Industry Working Papers*, No. 2020/05, OECD Publishing, Paris, https://doi.org/10.1787/5f65ff7e-en. [73]

Berlingieri, G., S. Calligaris and C. Criscuolo (2018), "The productivity-wage premium: Does size still matter in a service economy?", *OECD Science, Technology and Industry Working Papers*, No. 2018/13, OECD Publishing, Paris, https://doi.org/10.1787/04e36c29-en. [36]

Born2Global Centre (2021), *Korea Startup Index 2020*. [62]

Bouncken, R., A. Brem and S. Kraus (2016), "Multi-Cultural Teams as Sources for Creativity and Innovation: The Role of Cultural Diversity on Team Performance", *International Journal of Innovation Management*, Vol. 20/1. [64]

Briefing, R. (2019), *Three main innovaiotn strategies for content industries*. [71]

Briefing, R. (2019), *Three main innovation strategies for content industries*. [52]

Brown, R. and S. Mawson (2019), "Entrepreneurial ecosystems and public policy in action: A critique of the latest industrial policy blockbuster", *Cambridge Journal of Regions, Economy and Society*, Vol. 12/3, pp. 347-368. [56]

Cho, Y. (2012), *The Growth Process and Key Success Factors of Technology-Intensive Ventures: The Case of Suprema Co*. [32]

European Commission (2022), *The 2021 EU Industrial R&D Investment Scoreboard*, https://iri.jrc.ec.europa.eu/scoreboard/2021-eu-industrial-rd-investment-scoreboard. [3]

European Commission et al. (2021), *World Corporate Top R&D Investors: Paving the Way for Climate Neutrality*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2760/49552. [16]

Eurostat (2021), *Community Innovation Survey 2018 (CIS 2018)*, https://ec.europa.eu/eurostat/web/science-technology-innovation/data/database?node_code=inn. [11]

Global Entrepreneurship Monitor (2022), *GEM 2021/2022 Global Report: Opportunity Amid Disruption*, GEM, London, https://gemconsortium.org/report/gem-20212022-global-report-opportunity-amid-disruption. [68]

Government of Korea (2019), *Innovative Strategy on the Bio-health Industry*, http://www.mohw.go.kr/eng/nw/nw0101vw.jsp?PAR_MENU_ID=1007&MENU_ID=100701&page=1&CONT_SEQ=349515. [43]

Harrity (2021), *2021 Patent 300@ List Based on U.S. Utility Patents Issued in 2020*, https://harrityllp.com/patent300/. [5]

Hemmert, M. (2020), "Learning from Korea", in Frosse, F. (ed.), *Doing Business in Korea*, Routledege, London and New York. [4]

Hemmert, M. (2018), *The Evolution of Tiger Management: Korean Companies in Global Competition*, Routledge. [14]

Hemmert, M. et al. (2019), "The distinctiveness and diversity of entrepreneurial ecosystems in China, Japan and South Korea: An exploratory analysis", *Asian Business & Management*, Vol. 18/3, pp. 211-247. [70]

Hemmert, M. and J. Kim (2021), *Entrepreneurship in Korea: From Chaebols to Startups*, Routledge. [57]

Humax (2021), *Humax Global Network*, https://dearhumax.com/en/bbs/page.php?hid=Humaxintroduce3. [30]

Inaba, T. and M. Squicciarini (2017), "ICT: A new taxonomy based on the international patent classification", *OECD Science, Technology and Industry Working Papers*, No. 2017/1, OECD Publishing, Paris, https://doi.org/10.1787/ab16c396-en. [72]

Jin, D. (2016), *New Korean Wave: Transnational Cultural Power in the Age of Social Media*, University of Illinois Press, Urbana, Chicago and Springfield. [51]

Kim, N., S. Sengupta and D. Kim (2009), "How Can Non-Chaebol Companies Thrive in the Chaebol Economy?", *Journal of Global Academy of Marketing Science*, Vol. 19/3, pp. 28-36, https://doi.org/10.1080/12297119.2009.9707296. [29]

KISTEP (2019), *Study on Direction for Improving Governmental R&D Investment through Company Support*. [21]

KISTEP (2019), *Survey of Research and Development in Korea*, Ministry of Science and ICT. [13]

Knight, G. and P. Liesch (2016), "Internationalization: From incremental to born global", *Journal of World Business*, Vol. 51/1, pp. 93-102. [66]

KOFICE (2020), *2019 Hallyu White Paper*, Korean Foundation for International Cultural Exchange, Seoul, https://kofice.or.kr/b20industry/b20_industry_00_view.asp?seq=1130. [50]

Korea Business Angels Association (2021), *Tech Incubator Program for Startups, About TIPS*, http://www.jointips.or.kr/global/. [59]

Korea Legislation Research Institute and Korea Law Translation Center (2021), *Biotechnology Support Act*, https://elaw.klri.re.kr/eng_service/lawView.do?hseq=60046&lang=ENG. [40]

Korea Venture Business Association (2020), *2020 Survey of Korea Venture Firms*, https://venture.or.kr/#/home/bizNotice/h0203/2/3798/1. [55]

Kyungjae, H. (2019), *The reason why start-ups call TIPS 'Korea's mistake'*. [60]

Lee, H. (2020), "Making creative industries policy in the real world: Differing configurations of the culture-market-state nexus in the UK and South Korea", *International Journal of Cultural Policy*, Vol. 26/4, pp. 544-560, https://doi.org/10.1080/10286632.2019.1577401. [53]

Lee, J. (2021), *Demand-side innovation policy for technology development: The case of Korea*, Taipei Efficiency and Productivity Association 2021 Annual Conference. [24]

Lee, J. (2010), *Small Giants: Korea's Strong SMEs*. [31]

Migrants, S. (2020), *Inclusive Entrepreneurship: The Handbook, How to create succesful founders in your city*, Startup Migrants, Berlin and Oslo. [65]

Ministry of Science and ICT (2021), *Biotechnology 2020 in Korea*, https://www.khidi.or.kr/board/view?pageNum=1&rowCnt=3&no1=&linkId=48855931&menuId=MENU02296. [42]

Ministry of Science and ICT (2021), *ICT Status Survey (2021.5), ICT Major Item Trend Survey (2021.5)*. [46]

Ministry of Science and ICT (2021), *Software Export Statistics Survey (Annual) (2021.5), Software Export Statistics Survey (Monthly) (2021.5)*. [48]

Ministry of SMEs and Start-ups (2021), *Directions for SMEs Success*, https://www.bizinfo.go.kr/see/seea/selectSEEA121View.do?menuId=80001001002. [22]

Ministry of SMEs and Start-ups (2019), *Press release: Presentation of innovation proposal for SMEs support system*, https://www.korea.kr/news/pressReleaseView.do?newsId=156345610. [23]

Ministry of Trade, Energy and Industry (2021), *Ministry of Trade, Energy and Industry Announcement of 2020 Bioindustry Survey Results*, http://www.motie.go.kr/common/download.do?fid=bbs&bbs_cd_n=81&bbs_seq_n=165037&file_seq_n=1. [41]

Miroudot, S. and C. Cadestin (2017), "Services In Global Value Chains: From Inputs to Value-Creating Activities", *OECD Trade Policy Papers*, No. 197, OECD Publishing, Paris, https://doi.org/10.1787/465f0d8b-en. [38]

MOEF (2019), *18th Ministerial Meeting on Boosting the Economy*. [44]

MOTIE (2021), *Press release: Public procurement of innovative technology is not difficult*, https://www.korea.kr/news/pressReleaseView.do?newsId=156448028. [25]

MOTOE and KIAT (2020), *2020 Industry Technology Statistics*, MOTIE. [19]

MSIT and KISTEP (2021), *Survey of Research and Development in Korea, 2019*, https://www.kistep.re.kr/reportDownload.es?rpt_no=RES0220210050&seq=res_0026P@5. [18]

OECD (2023), "Main Science and Technology Indicators", *OECD Science, Technology and R&D Statistics* (database), https://doi.org/10.1787/data-00182-en (accessed on 4 April 2023). [7]

OECD (2023), "Main Science and Technology Indicators", *OECD Stat*, https://doi.org/10.1787/data-00182-en. [2]

OECD (2023), "Trade in value added", *OECD Statistics on Trade in Value Added* (database), https://doi.org/10.1787/data-00648-en (accessed on 4 April 2023). [6]

OECD (2022), "Business enterprise R&D expenditure by industry", *OECD.Stat*, https://stats.oecd.org/Index.aspx?DataSetCode=BERD_INDU. [67]

OECD (2022), *Financing SMEs and Entrepreneurs 2022: An OECD Scoreboard*, OECD Publishing, Paris, https://doi.org/10.1787/e9073a0f-en. [58]

OECD (2022), *OECD Economic Surveys: Korea 2022*, OECD Publishing, Paris, https://doi.org/10.1787/20bf3d6e-en. [45]

OECD (2022), *R&D Tax Incentives (database)*, http://oe.cd/rdtax (accessed on April 2022). [17]

OECD (2022), *Research and Development Statistics (database)*, https://oe.cd/rds. [27]

OECD (2022), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats (accessed on May 2022). [15]

OECD (2021), "Business enterprise R&D expenditure by source of funds and number of persons employed", *OECD.Stat*, http://stats.oecd.org/Index.aspx?DataSetCode=BERD_SOF_SIZE. [1]

OECD (2021), "Business enterprise R&D expenditure by source of funds and number of persons employed (organization size class)", *OECD.Stat*, https://stats.oecd.org/Index.aspx?DataSetCode=BERD_SOF_SIZE. [26]

OECD (2021), *Inclusive Growth Review of Korea: Creating Opportunities for All*, OECD Publishing, Paris, https://doi.org/10.1787/4f713390-en. [37]

OECD (2021), "SDBS Business Demography Indicators (ISIC Rev. 4): Birth rate of enterprises", *OECD Stat*, https://stats.oecd.org/index.aspx?queryid=81074. [54]

OECD (2021), *Trade in Value Added (TiVA) 2021 ed.*, https://stats.oecd.org/Index.aspx?QueryId=110682. [39]

OECD (2020), *Highlights from OECD Innovation Indicators 2019*, https://www.oecd.org/sti/inno/innovation-indicators-2019-highlights.pdf. [8]

OECD (2020), *OECD Economic Surveys: Korea 2020*, OECD Publishing, Paris, https://doi.org/10.1787/2dde9480-en. [35]

OECD (2017), *OECD Digital Economy Outlook 2017*, OECD Publishing, Paris, https://doi.org/10.1787/9789264276284-en. [34]

OECD (2014), *Tourism and the Creative Economy*, OECD Publications, Paris. [49]

Østergaard, C. (2011), "Does a different view create something new? The effect of employee diversity on innovation", *Research Policy*, Vol. 40/3, pp. 500-509. [63]

Simon, H. (2009), *Hidden Champions of the 21st Century: Success Strategies of Unknown World Market Leaders*, Springer, New York, NY, https://doi.org/10.1007/978-0-387-98147-5. [28]

Software Policy Research Institute (2021), *Software Industry Annual Report 2020*, https://spri.kr/posts/view/23366?code=annual_reports&s_year=&data_page=1. [47]

Startup Genome (2022), *The Global Startup Ecosystem Report (RSER) 2022*, https://startupgenome.com/report/gser2022. [69]

STEPI (2021), "Intrenational comparison of the status of business innovation and directions for invigoration, focused on results from KIS 2020 and CIS 2018", *STEPI Insight*, Vol. 278, https://stepi.re.kr/common/report/Download.do?reIdx=285&cateCont=A0501&streFileNm=52d8d7ad-2102-4aa5-bcf5-592fa6ce861f.pdf. [9]

STEPI (2021), *Report on the Korean Innovation Survey 2020: Manufacturing Sector 2019*, STEPI, https://www.stepi.re.kr/kis/service/sub03_report.do. [10]

STEPI (2019), *Report on 2018 Korean Innovation Survey: Service Sector*, STEPI, https://www.stepi.re.kr/kis/service/sub03_report.do. [12]

Suprema (n.d.), *Suprema, Who We Are, Proven Leader in Access Control, Time & Attendance and Biometric Solutions*, https://www.supremainc.com/en/about/suprema.asp (accessed on 8 March 2023). [33]

Notes

1. The RTA is defined as a country's share of patents in a particular technology field divided by the country's share in all patent fields. The index is equal to 0 when the country holds no patents in a given sector; is equal to 1 when the country's share in the sector equals its share in all fields (no specialisation); and above 1 when a positive specialisation is observed.

2. For further information, see https://www.wipo.int/export/sites/www/ipstats/en/docs/wipo_ipc_technology.pdf.

3. While there is no clear-cut definition of creative industries, they are broadly understood as economic activities concerned with the generation or exploitation of cultural or creative content, such as advertising, animation, architecture, design, film production, gaming, gastronomy, music, performing arts, software and interactive games, and television and radio (OECD, 2014).

4. As of the end of 2022, Korea had embraced six different areas for the adoption of the regulatory sandbox. These included: ICT and industrial convergence; financial innovation; regulation-free zone; smart city development; and R&D industrial cluster.