2022 ICT Industry Outlook of Korea

KOREA INFORMATION SOCIETY DEVELOPMENT INSTITUTE

2022 ICT Industry Outlook of Korea

KOREA INFORMATION SOCIETY DEVELOPMENT INSTITUTE

18, Jeongtong-ro, Deoksan-eup, Jincheon-gun, Chungcheongbuk-do, 27872 Rep. of KOREA
Phone : +82-43-531-4383
Fax : +82-43-531-4099

Message from the President

Despite the continued uncertainty from the COVID-19 pandemic, the Korean economy is expected to gain momentum from expanding vaccination coverage and a favorable turn in exports, which will most likely keep the country on a path towards a robust recovery in 2022. However, the global economy is fraught with threats to Korea's economic growth, such as rising uncertainty at home and abroad due to US-China trade disputes and race for leadership in technology as well as the adoption of "My Country First" policies by an increasing number of countries, not to mention intensifying global competition. Against this backdrop, the ICT sector, particularly its semiconductor sub-sector, is becoming more and more important as it has been a key driver behind the growth of the Korean economy over the past years. Furthermore, the full-swing implementation of digital transformation and the changing global supply chain are triggering a paradigm shift in the ICT sector. Given these developments, it is necessary to provide comprehensive data and information on outlooks for the Korean ICT sector, including its current market status, outlooks, competitiveness and growth engines, in order to facilitate the development of ICT policies by the government and private ICT investments for the continuous growth of the ICT sector.

The goals of this study are to assess the achievements of the Korean ICT sector in 2021 and offer forecasts on production, exports and subscriptions for 2022, by ICT industry. This study also aims to analyze the global competitiveness of the Korean ICT sector by comprehensively considering international competitiveness indexes and to examine new growth engines in order to identify policy implications that should be factored into the development of future ICT industry strategies.

This report consists of three parts covering the current state and issues of Korea's ICT sector. For the purpose of this report, we have divided the ICT sector into three sub-sectors – information, communications and broadcasting equipment; information, communications and broadcasting services; and software. Part I presents the trends and outlooks of these sub-sectors, while Part II assesses the Korean ICT sector's competitiveness and finds improvement opportunities based on an international comparison. Part III looks into artificial intelligence (AI) semiconductors that perform learning, inference and other functions required by AI systems. With AI technology being adopted rapidly and widely across all industrial areas, the needs for AI semiconductors have been growing as advanced semiconductors optimized to AI systems.

2022 ICT Industry Outlook of Korea is an annual report published by the Korea Information Society Development Institute (KISDI). The 21st report of its kind released this year represents our efforts to provide richer and better-structured information on the Korean

ICT sector. We hope that this report proves useful in helping our readers to make right decisions in the process of developing government policy or corporate strategy. We also look forward to your honest and candid opinion about how this report can be improved.

Thank you.

Kwon Ho-Yeoul
President
Korea Information Society Development Institute

Contents

List of Tables

List of Figures

List of Figures

Introduction

This report has three parts. Part I classifies Korea's ICT sector into three categories: information, communications and broadcasting equipment; information, communications and broadcasting services; and software to describe the trends and outlook of each subsector. Specifically, for information, communications and broadcasting equipment, it offers production and export projections with focus on key product items in each industry: semiconductor and display panels (electronic components), mobile devices (communications and broadcasting equipment), and computers and peripherals. The information, communications and broadcasting services sub-sector can be divided largely into communications services, broadcasting services, and information services. Under the category of communications services, revenue forecasts are offered for wired and wireless services. For the broadcasting services industry, revenue projections are provided, focusing on terrestrial broadcasting and pay channels. As for information services, we investigate the market situation and come up with market size projections, focusing on information infrastructure services as well as information media and provision services. Lastly, on the front of software, production and export forecasts are available for software packages, games, and ICT services under the category of software.

Part II compares Korea with other OECD countries in terms of ICT competitiveness to assess its international standing in this sector, by measuring Korea's performance in areas considered closely related to ICT competitiveness: export competitiveness, technology development investments and innovation levels, human resource environment, financial and entrepreneurial environment, ICT infrastructure, and industry-friendly policies and laws. We also look for ways of improving Korea's ICT competitiveness based on the strengths and weaknesses that have been commonly pointed out in objective evaluations by various international institutions.

Part III takes a multi-faceted look at the artificial intelligence (AI) semiconductor industry, which has emerged as a key technology for national security amid intensifying global competition in the field of advanced semiconductors and is becoming increasingly more important due to the widespread adoption of AI across the full range of industries. This part aims to find ways for advancing the Korean AI semiconductor industry based on the concept of AI semiconductor and the background of its emergence, and the current state of the domestic market and prospects for AI semiconductors on both the domestic and global stages as well as an analysis of semiconductor policies (including AI semiconductors) at home and abroad.

Part I

Current Status and Outlook for Korea's ICT Sector[1)]

1. ICT Sector in General

In 2022, production in the ICT sector is expected to increase 4.2% year-on-year to KRW 547 trillion. The information, communications and broadcasting equipment market will maintain a stable demand in spite of global supply chain issues, but the growth rates of displays, computers and peripherals, and mobile phones are likely to decline as the COVID-19 pandemic slows down the growing demand for ICT devices. The information, communications and broadcasting services market is forecast to slow down because demand for information services, which has been growing due to increases in contactless services coupled with the stagnation of the communications and broadcasting services market, starts to decrease modestly. Lastly, the software market will face a slowing growth curve as the economic slowdown will reduce new IT investments. The packaged software and IT services markets, however, are predicted to maintain stable growth thanks to continued investments in security, cloud and public sector.

ICT exports are forecast to grow by 7.2% to USD 243.9 billion in 2022 on a year-on-year basis. As for the electronic components market, global demand for semiconductor memory and OLED panels will continue because of global semiconductor supply shortages, but their growth is likely to slow down as result of falling OLED prices and LCD market shares. The communications and broadcasting equipment market will expand, mostly driven by foldable phones where Korean companies have a competitive edge, but its growth rate is projected to be lower due to dwindling global demand for smartphones. Lastly, the computers and peripherals market will see both Korean and foreign IT companies' demand for data centers grow exponentially as they accelerate their drives for digital transformation, which will sustain demand for enterprise SSDs. However, the growth is expected to be slower as the pandemic-caused surge in global demand for computers and peripherals is likely to be followed by a drop across the globe.

1) This part is a summary of a paper published by Hakki Lee, et al. (December 2021).

Table 1-1 Production in the ICT Sector

(In KRW trillions)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Total	479.2	525.0	547.0	9.6%	4.2%
Information, communications and broadcasting equipment	332.1	368.4	383.4	10.9%	4.1%
Electronic components	204.7	230.3	239.4	12.5%	3.9%
Computers and peripherals	15.0	16.7	17.4	11.8%	4.0%
Communications and broadcasting equipment	37.4	38.8	39.9	3.6%	2.9%
Video and audio equipment	8.3	8.8	8.6	5.7%	-1.8%
Information and communications application and infrastructure equipment	66.7	73.8	78.1	10.6%	5.8%
Information, communications and broadcasting services	80.7	85.2	88.3	5.6%	3.6%
Communications services	37.1	37.9	38.7	2.3%	2.0%
Broadcasting services	19.5	20.0	20.4	2.4%	2.0%
Information services	24.1	27.3	29.2	13.2%	7.1%
Software	66.4	71.4	75.3	7.5%	5.4%

Source: Ministry of Science and ICT (MSIT), Korea Association of Information and Telecommunications (KAIT) and Korean Electronics Association (KEA) data (2021 data for terrestrial broadcasting, pay channels and program providers was sourced from the MSIT and the Korea Communications Commission (KCC), while MSIT, KAIT and KEA data was used for program production and other broadcasting services). KISDI forecasts for 2021 and beyond.

Table 1-2 Export and Import Forecasts for ICT Equipment

(In USD 100 millions)

		2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
ICT Total	Exports	1,835	2,274	2,439	23.9%	7.2%
	Imports	1,126	1,346	1,426	19.5%	5.9%
Electronic components	Exports	1,311	1,650	1,781	25.9%	7.9%
	Imports	616	746	788	21.0%	5.6%
Computers and peripherals	Exports	139	174	186	25.0%	7.2%
	Imports	134	167	181	24.7%	8.2%
Communications and broadcasting equipment	Exports	137	166	175	21.3%	5.7%
	Imports	145	160	168	10.4%	4.9%
Video and audio equipment	Exports	26	24	21	-10.0%	-9.7%
	Imports	34	39	42	15.8%	7.7%
Information and communications application and infrastructure equipment	Exports	222	261	275	17.3%	5.5%
	Imports	197	233	247	18.6%	5.7%

Source: MSIT and Institute for Information and Communications Technology Promotion (IITP). KISDI forecasts for 2021 and beyond

2.1. ICT Equipment

2.1.1. Electronic Components

Table 1-3 Electronic Component Production and Exports

(Production in KRW trillions , exports/imports in USD 100 millions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Production	204.7	230.3	239.4	12.5	3.9
Exports	1,311	1,650	1,781	25.9	7.9
Imports	616	746	788	21.0	5.6

Source: MSIT, KAIT and KEA data for production, MSIT and IITP data for exports and imports, and KISDI forecasts for 2021 and beyond

Electronic component production in 2021 is estimated at KRW 230.3 trillion, with a projected growth rate of 12.5% over the previous year. Such a significant growth can be expected thanks to continuous demand for semiconductor memory for data centers, edge computing (IoT), automobiles and 5G smartphones as well as soaring demand for OLED panels for TV and mobile devices.

Electronic component exports in 2021 are expected to post USD 165 billion at a year-on-year growth rate of 25.9%. A high growth rate is projected for 2021 based on rising global demand for semiconductors, backed up by soaring demand for data center capacity increases due to the COVID-19 pandemic as well as the expansion of production in ICT devices, automobiles, and consumer electronics. Another contributing factor is the expansion of production of OLED panels for TV and mobile devices as well as even LCD panels that display manufacturers were planning to discontinue.

Production in 2022 is forecast to climb 3.9% year-on-year to KRW 239.4 trillion. Despite continued demand for semiconductors and expanding demand for OLED panels, it is expected to achieve only a slight growth over the previous year on account of demand adjustment across the global semiconductor market and the reduced production of LCD panels.

Exports in 2022 are predicted to increase 7.9% from the previous year to USD 178.1 billion. Although demand for semiconductors and OLED panels will continue, the year-on-year growth rate is expected to be lower as the market goes through DRAM price adjustments and demand for display panels slows down because of slower demand for ICT devices.

■ Semiconductors

Table 1-4 Semiconductor Production and Exports

(Production in KRW 100 millions, exports/imports in USD millions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Production	1,184,398	1,399,958	1,475,556	18.2	5.4
Exports	100,251	128,702	140,543	28.4	9.2
Imports	50,627	61,717	65,297	21.9	5.8

Source: MSIT, KAIT and KEA data for production, MSIT and IITP data for exports and imports, and KISDI forecasts for 2021 and beyond

Semiconductor production in 2021 is estimated to have jumped 18.2% from a year earlier to KRW 139,995.8 billion. As supply increased to meet rising demand for a wide range of ICT devices including smartphones, servers, automobiles, IoT, tablets and game consoles, both the production and exports of semiconductor memory products are expected to post positive growth rates. As of October 2021, the production of semiconductor memories (share of 68%) is estimated to have risen by 17.2%, while the production of system semiconductors (17%) and that of other products (12%), such as optoelectronics and wafers, are estimated to have grown 23.1% and 12%, respectively.

Semiconductor exports in 2021 are estimated at USD 128.7 billion, with the year-on-year growth rate projected at 28.4%. Diversifying and continuous demand from applications for data centers, edge computing (IoT), automobiles and 5G smartphones has driven growth for semiconductors. Semiconductor exports (cumulative up to November 2021) amount to USD 115.9 billion at a growth rate of 27.7% against the previous year, accounting for 56.4% of total ICT exports. Semiconductor memory exports over the same period are estimated at USD 74 billion, recording a YoY growth rate of 27.8%, while system semiconductor exports are estimated at USD 35.9 billion, a YoY growth rate of 31.5%.

Production in 2022 is forecast to grow 5.4% over the previous year to KRW 147,555.6 billion. With the global semiconductor market poised to go through slight adjustments in 2022, production growth is expected to decline slightly year-on-year due to the base effect of the previous year's high production.

Exports in 2022 are forecast to increase by 9.2% from the previous year to USD 140.5 billion. The semiconductor industry experienced a temporary supply shortage caused by COVID-19, natural disasters and trade disputes, but the shortage is expected to abate over the mid to long term.

■ Display panels

Table 1-5 Display Panel Production and Exports

(Production in KRW 100 millions, exports/imports in USD millions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Production	561,943	576,482	579,229	2.6	0.5
Exports	20,713	24,657	25,254	19.0	2.4
Imports	3,818	3,868	3,864	1.3	-0.1

Source: MSIT, KAIT and KEA data for production, MSIT and IITP data for exports and imports, and KISDI forecasts for 2021 and beyond

Display panel production in 2021 is estimated at KRW 57.6 trillion, with a growth rate of 2.6% from the previous year. With demand for non-face-to-face services spreading across the world due to the COVID-19 pandemic, demand for IT panels surged rapidly. Coupled with this trend, an increase in OLED panel production raises expectations about positive growth in total display panel production, despite reductions in LCD production caused by the ongoing restructuring of the industry.

Display panel exports in 2021 are estimated to have jumped by 19.0% from the year before to USD 24.7 billion. Increasing demand for mobile and ICT devices fueled by rising global demand for contactless services across world boosted demand for panels rapidly. Furthermore, Korean manufacturers maintained their global competitiveness especially for flexible and foldable OLED panels. These factors are considered to have contributed to the achievement of a double-digit growth rate in spite of reduced LCD panel exports.

Production in 2022 is forecast to edge up by 0.5% from a year earlier to KRW 57.9

trillion. The world panel market enjoyed rapid growth thanks to rising demand for contactless activities to cope with the COVID-19 pandemic, but is likely to see revenues decline in 2022 owing to lower demand for set products (compared with the previous year) as well as downward price dynamics, coupled with the base effect from the previous year. With Korean manufacturers leading the production of both OLED panels for TV sets and mobile devices, overall production is expected to rise as the market will see more widespread adoption of OLED for IT products including tablets and laptops. As for LCD panels, however, the gap in production capacity between Korea and China will widen after the mass production of 10.5G large-size panels by BOE and other Chinese companies.

Exports in 2022 are forecast to reach USD 25.3 billion, up by 2.4% from the previous year. With the global panel market expected to shrink in size in 2022, the growth of the industry has been driven by OLED panels. Therefore, despite shrinking LCD panel exports, display panel exports are predicted to grow thanks to a good performance to be put up by OLED panels, which account for about 60% of Korean panel exports.

2.1.2. Computers and Peripherals

Table 1-6 Computers and Peripherals Production and Exports

(Production in KRW 100 millions, exports/imports in USD millions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Production	149,785	167,457	174,161	11.8	4.0
Exports	13,907	17,387	18,639	25.0	7.2
Imports	13,425	16,747	18,121	24.7	8.2

Source: MSIT, KAIT and KEA data for production, MSIT and IITP data for exports and imports, and KISDI forecasts for 2021 and beyond

Computers and peripherals production in 2021 is estimated to have increased by 11.8% from a year earlier to KRW 16,745.7 billion. The prolonged COVID-19 pandemic accelerated digitization both at home and in business, raising demand for computers and peripherals considerably. Demand for server SSDs from Korean and overseas companies, including Google, Amazon, Microsoft and Facebook, increased greatly particularly because sharing and delivering content and data online has been growing in importance. The spread of “contactless culture”, such as remote work, remote schooling and telemedicine, also increased demand for laptops and tablets as tools for coping with the prolonged pandemic.

Exports in 2021 are estimated at USD 17.39 billion, posting a year-on-year increase of 25.0%. The prolonged pandemic accelerated digitization, boosting demand for auxiliary memory units and consequently driving growth in computers and peripherals exports. The share of auxiliary memory units in total exports of computers and peripherals in 2021 reached 74.5%, leading the growth of exports in this segment. Exports have been growing across all specific products under the category of computers and peripherals, such as laptops, computer parts and monitors.

Production in 2022 is projected to move up by 4.0% to KRW 17,416.1 billion. As Internet-based services expand beyond traditional IT services to banking, medical services, education, and other diverse fields, data center markets at home and abroad have been growing rapidly, maintaining demand for high-capacity SSDs and other auxiliary memory units. However, the growth rate of computers and peripherals production in 2022 is forecast to be lower than that of 2021 due to the effects of delayed demand.

Exports in 2022 are forecast to increase 7.2% from the previous year to USD 18.64 billion. With digitization advancing across all corners of society, demand for computers and peripherals as a whole is expected to continue. However, the growth rate in terms of export value is expected to be reduced to a single digit in 2022 due to the high growth rate of the previous year.

2.1.3. Communications and Broadcasting Equipment

Table 1-7 Communications and Broadcasting Equipment Production and Exports

(Production in KRW 100 millions, exports/imports in USD millions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Production	374,177	387,811	399,204	3.6	2.9
Exports	13,677	16,585	17,533	21.3	5.7
Imports	14,509	16,012	16,797	10.4	4.9

Source: MSIT, KAIT and KEA data for production, MSIT and IITP data for exports and imports, and KISDI forecasts for 2021 and beyond

Communications and broadcasting equipment production in 2021 is estimated to have grown 3.6% year-on-year to KRW 38,781.1 billion. Global 5G commercialization drives

resumed after being delayed by the COVID-19 pandemic, boosting communications equipment production and releasing pent-up demand for mobile phones. As a result, total production is expected to report positive growth. In the global smartphone market, demand contracted due to the pandemic but started to pick up fast, mainly in emerging markets. However, with semiconductors and other components in short supply, the market is expected to post only a single-digit growth rate, with total shipments falling short of the 2019 level.

Communications and broadcasting equipment exports in 2021 are estimated at USD 16.6 billion, a 21.3% jump from the previous year. Exports by network equipment manufacturers increased after global investments in 5G networks resumed, and demand also increased for mid-/low-priced smartphones, foldable and other premium models, and smartphone parts. As a result, this segment is expected to have achieved a double-digit growth rate.

Production in 2022 is forecast to go up by 2.9% year-over-year to KRW 39,920.4 billion. Although increasing investments by network operators pushing forward with 5G commercialization as well as continued demand for smartphones will boost production of communication equipment, the growth rate is predicted to slow down as the base effect from the pandemic will wear off.

Exports in 2022 are projected to rise 5.7% year-on-year to USD 17.5 billion. Network carriers' earnest investments in 5G services will improve demand for network equipment and lead to the downward stabilization of the global smartphone market. Nevertheless, export growth is likely to stagnate as a result of continued overseas production and intensifying competition.

■ Mobile Handsets

Table 1-8 Mobile Handset Production and Exports

(Production in KRW 100 millions, exports/imports in USD millions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Production	250,084	255,567	260,281	2.2	1.8
Export	11,228	13,944	14,807	24.2	6.2
Import	9,067	10,125	10,661	11.7	5.3

Source: MSIT, KAIT and KEA data for production, MSIT and IITP data for exports and imports, and KISDI forecasts for 2021 and beyond

Mobile handset production in 2021 is estimated to be KRW 25,556.7 billion at a growth rate of 2.2% from a year earlier. The pandemic is believed to have increased pent-up demand for not only mid-/low-priced smartphones but also premium models, and domestic production is likely to report positive growth due to lock-downs of major overseas production hubs including Vietnam and India.

Mobile phone exports in 2021 are estimated to have risen 24.2% from the previous year to USD 13.9 billion. Samsung Electronics saw demand increasing for not only its mid-/low-cost models but also its foldable smartphones, Galaxy Z Fold 3 and Flip 3 series, in both advanced markets including the US and Western Europe and emerging markets including India, and Central and Latin Americas. Samsung's premium models, especially foldable models, as well as components, particularly camera modules for iPhones are expected to have driven a two-digit growth for exports in this segment.

Production in 2022 is forecast to nudge up 1.8% year-on-year to KRW 26,028.1 billion. Pent-up demand from the pandemic will continue, and there will also be replacement demand mostly for 5G-enabled and foldable smartphones. However, the upward trends of domestic production are predicted to become slower as Korean companies resume overseas production to secure price competitiveness and achieve localization.

Exports in 2022 are forecast to rise by 6.2% compared with the previous year to USD 14.8 billion. New products, such as foldable smartphones and 5G smartphones, will certainly raise expectations, but Korean manufacturers will increase overseas production as the pandemic starts to subside. Furthermore, competition will become fiercer as Chinese companies have strengthened competitiveness, from low-/mid-cost to premium smartphones, whereas there will be continued concerns about semiconductor supply chain issues. These factors will combine to slow down the overall growth rate.

2.2. Communications/Broadcasting/Information Services

2.2.1 Communication Services

Table 1-9 Communications Services Revenue Forecasts

(In KRW trillions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Fixed communication service	10.1	10.2	10.2	0.4%	0.4%
Wireless communication service	24.8	25.5	26.2	2.8%	2.6%
Others	2.1	2.3	2.3	6.0%	2.0%
Total	37.1	37.9	38.7	2.3%	2.0%

Source: MSIT, KAIT and KEA. KISDI forecasts for 2021 and beyond

Communication services revenue in 2021 is estimated to have grown by 2.3% year-on-year to KRW 37.9 trillion. After posting negative growth (-2.2%) in 2019, this market started to recover gradually from the impact of the Selective Contract Discount system (20%→25%, September 2017 to record a growth rate of 1.7% in 2020. In 2021, it is expected to show a sustained growth trend (2.3%) thanks to rising demand for fixed and wireless Internet access services in the pandemic situation.

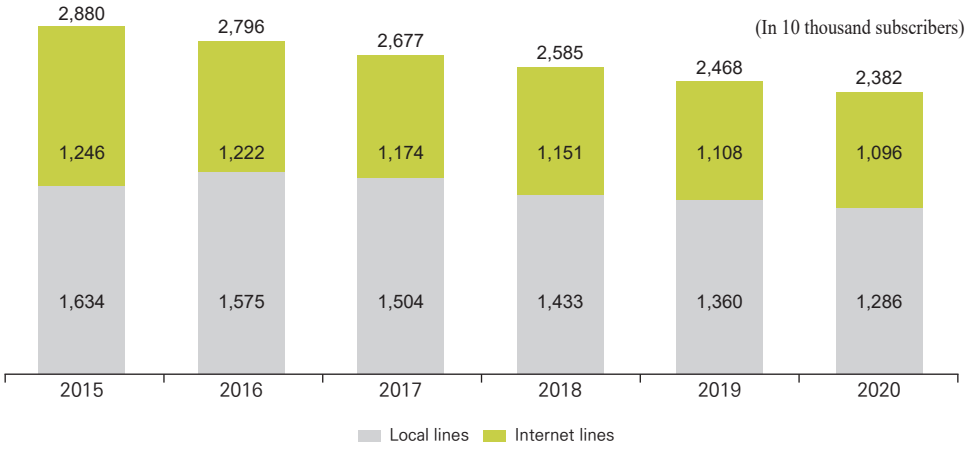
In 2022, the communications services market is anticipated to achieve a substantial growth of 2.0% on the strength of rising demand from digital transformation. The pandemic is expected to accelerate digital transformation further, which in turn will boost demand for higher-quality Internet services, such as 5G and Giga Internet. With the world transitioning to 5G rapidly, wireless communication services are forecast to drive growth across the communications market. In the meantime, fixed communication services are expected to stay on a slight but upward trajectory as broadband network services will offset falling fixed telephony revenues.

■ Fixed Telephony

Fixed telephony services have continued trending downwards in terms of call volumes and subscriptions, for such reasons as the substitution of mobile calls for fixed-line calls plus the spread of unlimited price plans for voice calls. Although the fixed-line subscriber base

kept contracting, the total number of landline subscriptions continued to increase modestly until 2013, thanks to growing subscriptions for Internet phone services. However, the total number of fixed-line phone service subscribers has continued to shrink since 2014 when even Internet phone subscriptions took a downward turn.

Figure 1-1 Trends of Fixed Telephony Services Subscriptions

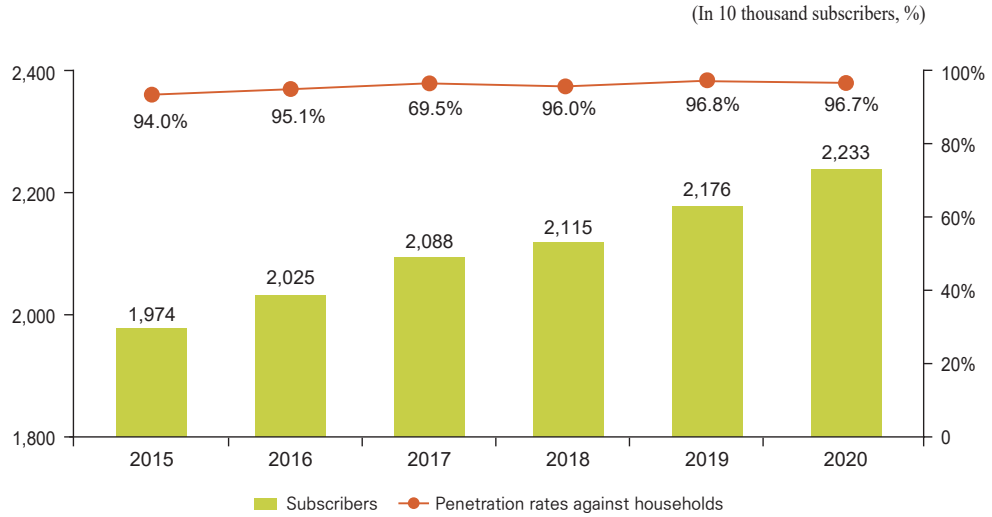


Source: Ministry of Science and ICT (MSIT), *Wired Communications Services Statistics,* yearly issues

■ Broadband Network Services

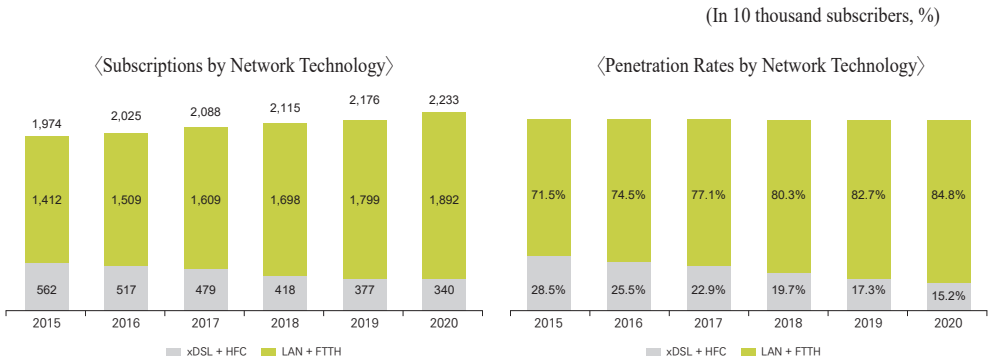
Subscriptions to broadband network services have been stagnating as the penetration comes close to 100%, but revenue is expected to grow slightly owing to the expansion of Giga Internet services. This segment has been struggling with stagnant growth, with its penetration rate as of the end of 2020 approaching the saturation level (96.7% against the number of households). Yet the slow but upward trends continue backed up by the invigoration of Internet-based services such as IPTV and the increasing uptake of Giga Internet services. The total number of subscribers as of December 2020 is 22.33 million, with its penetration rate against the number of households at 96.7%. The expansion of Giga Internet services has been accelerating the shift of focus from xDSL and HFC to LAN and FTTH technologies.

Figure 1-2 Subscriptions and Penetration Rates for Broadband Network Services



Source: (Number of subscribers) MSIT, *Wired Communications Services Statistics,* yearly issues (Number of households) Ministry of the Interior and Safety, Number of resident-registered households by administrative divisions (city, county, district) in "Resident-Registered Population Statistics"

Figure 1-3 Subscriptions and Penetration Rates for Broadband Network Services, by Network Technology

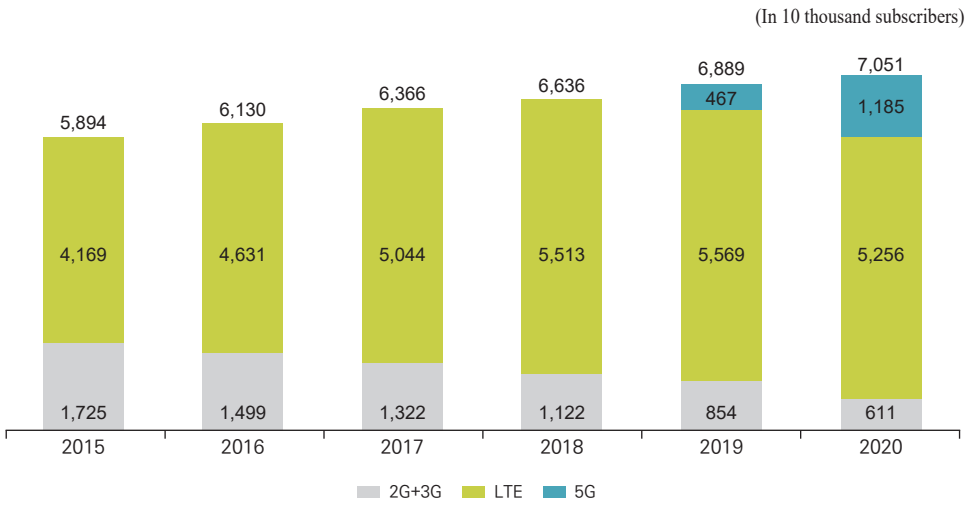


Source: Ministry of Science and ICT (MSIT), *Wired Communications Services Statistics,* yearly issues

■ Wireless Communications Services[2)]

The wireless communication services market is poised to continue trending upwards thanks to the expansion of 5G and M2M communications. Subscription growth has been slowing down since the penetration exceeded 100%, but this segment's overall subscriber base remains on a moderate growth path, supported by invigorated IoT services. The total number of subscriptions to mobile communication services as of December 2020 is 70.51 million, with its penetration (against the projected population of 51.78 million) at 136.2%. Total LTE subscriptions as of December 2020 are 52.56 million, down by 5.6% from the previous year, and the share of LTE subscribers also decreased slightly due to increases in 5G subscriptions (11.85 million as of December 2020, 16.8%), while 2G and 3G subscriptions are on the continuous decline. Meanwhile, the total number of M2M/IoT lines as of December 2020 stands at 10.05 million (accounting for 14.3% of total mobile communications service lines) and growing. IoT services take up 121.4% of the net increases in total mobile service lines for 2020, which demonstrates its contributions to raising the number of mobile service subscriptions.

Figure 1-4 Trends of Subscriptions for Mobile Phone Services



Source: Ministry of Science and ICT (MSIT), *Wired Communications Services Statistics,* yearly issues

2) Descriptions in this section are based largely on mobile communication services, which accounts for 99.5% of all wireless communications services as of 2020.

2.2.2 Broadcasting Services

Table 1-10 Broadcasting Services Revenue Forecasts

(In KRW 100 millions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Terrestrial broadcasting	35,740	37,338	37,897	4.5	1.5
Pay channels	67,504	69,755	72,118	3.3	3.4
Program providers	70,742	70,743	70,862	0.0	0.2
Program production and other broadcasting services	21,073	21,888	22,747	3.9	3.9
Total	195,060	199,724	203,624	2.4	2.0

Note: 1. Pay channels include cable broadcasting, satellite broadcasting, IPTV services and relay cable.
2. IPTV content providers in the *Broadcasting Industry Survey Report for 2019* published by the MSIT and the KCC are excluded to avoid duplication with program producers.

Source: The figures for 2020 are from the *Broadcasting Industry Survey Report for 2021*, published by the MSIT and the KCC, except for program production and other broadcasting services for which KAIT data was used. KISDI projections for 2021 and beyond.

Broadcasting services revenue in 2021 is estimated to have climbed by 2.4% to KRW 19,972.4 billion year-over-year. In 2020, terrestrial broadcasting services saw advertising revenues tumble amid the pandemic-caused economic downturn, but are expected to report a significant growth for 2021 thanks to a favorable base effect coupled with an increase in the total amount of advertising allowed. An amendment to the Enforcement Decree of Broadcasting Act, effective in July 2021, allows commercial breaks for terrestrial broadcasters, increasing the total amount of advertising that can be aired per show. The cable broadcasting segment faces the problem of deepening revenue decline due to the continued shrinkage of the subscriber base. On the contrary, IPTV is expected to show a continuous revenue growth trend as IPTV integrated with mobile devices, AI-enabled services, and OTT services boosted subscriptions and subscriber quality. As for program providers (PPs), the market continued to expand in size to reach KRW 7,091.8 billion in 2019, but is anticipated to maintain a similar level without significant changes for the next five years.

Broadcasting services revenue in 2022 is projected at KRW 20,362.4 billion, with a YoY growth rate of 2.0%. Terrestrial broadcasters are expected to have achieved revenue growth to a certain extent on the strength of increases in re-transmission services revenues stemming from increasing subscriptions to digital pay channels as well as the expansion of

content distribution channels through domestic and foreign OTT service providers. However, advertising revenues are predicted to slide back on a downward path as the audience share of terrestrial channels dwindles. As for cable broadcasting, license fee income will continue to drop as its subscriber base keeps shrinking, which will also make it hard to break away from the downward spiral in revenue from device installations and terminal device loans. On the contrary, IPTV will continue its growing tendency in revenue due to increasing license fees from growing subscriptions as well as transmission fees for home shopping channels. Differentiated content enabled by AI as well as the provision of OTT services and strengthened IPTV-on-mobile services is expected to sustain growth in content revenue. As for PPs, they will be able to keep revenues from T-commerce channels growing. They will also be able to generate revenues through the provision of programs via pay channels as well as through programs sales to OTT and other new platforms. Overall, PPs are anticipated to maintain revenues in the range of KRW 7 trillion.

■ Terrestrial Broadcasting Services

Revenue from terrestrial broadcasting services in 2021 is estimated at KRW 3,733.8 billion, with a year-on-year growth rate of 4.5%. Advertising revenue, which accounts for the biggest share of terrestrial broadcasting service revenues, is expected to have picked up to the 2019 level on the strength of the base effect from the sharp drop in 2020 as well as increased stay-at-home hours due to the pandemic and the introduction of commercial breaks. As social distancing practices were strengthened further to cope with the pandemic, people spent more time at home watching various media channels and viewing increasingly more VODs on OTT or pay channel platforms. This raises expectations about good revenues from sales of terrestrial TV programs.

Revenue in 2022 is forecast to nudge up 1.5% year-on-year to KRW 3,789.7 billion. The share of program sales in terrestrial broadcasting service revenues has been growing gradually, posing the possibility that the share of program sales will overtake that of advertising revenue within the next five years. With pay channel subscriptions rising steadily and the share of subscriptions to digital offerings on the increase, re-transmission revenue has been recording a growth rate of 10% or higher every year. The share of re-transmission revenue entered the 10% range in 2019, which is expected to cause change in the revenue structure of terrestrial broadcasting service revenues.

Table 1-11 Itemized Revenues of Terrestrial Broadcasters[1] and Their Shares

(In KRW millions, %)

	2016	2017	2018	2019	2020	2016-2020 CAGR
Broadcasting license fees[2]	891,426	929,015	1,006,492	1,060,577	1,108,885	5.6
Percentage change	10.6	4.2	8.3	5.4	4.6	
Share	22.3	25.2	26.5	30.2	31.1	
Advertising	1,622,820	1,412,146	1,300,688	1,099,929	1,001,343	11.4
Percentage change	-15.1	-13.0	-7.9	-15.4	-9.0	
Share	40.6	38.3	34.3	31.3	28.1	
Sponsorship	418,063	406,242	369,200	376,767	385,257	-2.0
Percentage change	2.2	-2.8	-9.1	2.0	2.3	
Share	10.5	11.0	9.7	10.7	10.8	
Program sales	787,589	642,947	817,924	708,903	781,876	-0.2
Percentage change	15.2	-18.4	27.2	-13.3	10.3	
Share	19.7	17.5	21.5	20.2	21.9	
Other broadcasting businesses	278,846	293,396	302,175	270,590	289,115	0.9
Percentage change	-4.1	5.2	3.0	-10.5	6.6	
Share	7.0	8.0	8.0	7.7	8.1	
Total	3,998,744	3,683,746	3,796,479	3,516,766	3,566,477	-2.8
Percentage change	-2.5	-7.9	3.1	-7.4	1.4	
Share	100.0	100.0	100.0	100.0	100.0	

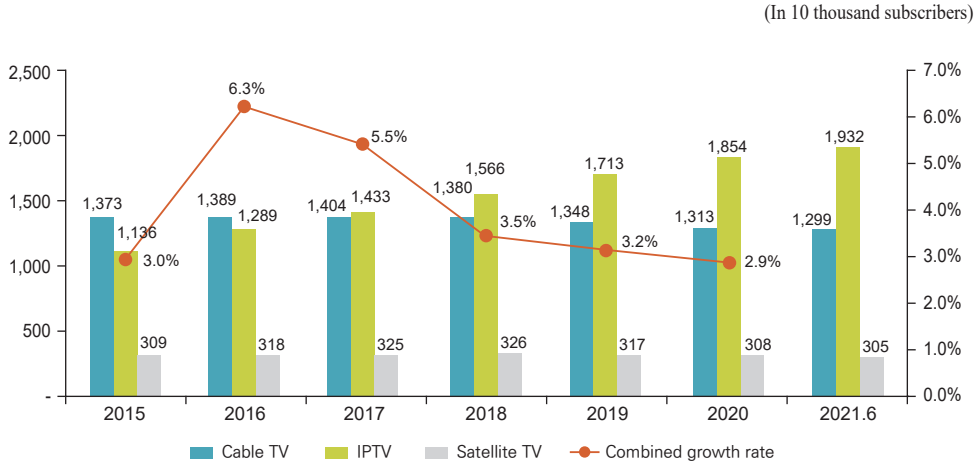
Note: 1) Based on revenues generated by terrestrial broadcasters, excluding the three terrestrial DMB broadcasters.
2) Broadcasting license fees include license fee revenue, re-transmission revenue, and program provision revenue.
Source: MSIT and KCC, *Broadcasting Industry Survey Report for 2021*.

■ Pay Channels

Pay channels' revenues in 2021 are estimated to have grown 3.3% over the previous year to KRW 6,975.5 billion. The Korean pay channel market continued to grow steadily, backed up mostly by continuous digitization efforts and IPTV, but is now reaching a growth plateau. Both cable and satellite broadcasting services are expected to report negative growth for 2021 because they continued trending downwards with an increasing number of subscribers churning to IPTV. IPTV is expected to continue to post high growth rates as the releases of wired-wireless bundled services and AI-enabled services as well as the provision of OTT services boosted subscriptions and subscriber quality.

Revenues in 2022 are projected to rise 3.4% from the previous year to KRW 7,211.8 billion. The cable broadcasting services market will most likely continue to suffer revenue drops as its license fee revenues keep declining due to decreasing subscriptions, while it is hardly reasonable to expect high growth in the home shopping market either, considering fierce competition with wired and wireless Internet services and social commerce. Besides this, the segment is at a competitive disadvantage in negotiations for home shopping fees due to their diminishing subscriber base. The IPTV segment is anticipated to stay in its upward revenue trajectory because net subscriptions will continue to grow thanks to increases in subscribers moving in from cable channels as well as the provision of OTT services. The expanding subscriber base will not only help bring in more license fees but also push up home shopping transmission fees.

Figure 1-5 Pay Channel Subscriptions



Source: MSIT and KCC (2021), *Broadcasting Industry Survey Report for 2021.* The figures for June 2021 are from the MSIT (November 10, 2021), "Announcement of Pay Channel Subscribers and Market Shares for the First Half of 2021."

Table 1-12 Itemized IPTV Broadcasting Services Revenue Trends

(In KRW 100 millions)

	2017	2018	2019	2020	Percentage growth 2019-2020
IPTV broadcasting services revenue (total)	29,251	34,358	38,566	42,836	11.1%
Broadcasting license fees	19,916	22,345	24,348	26,027	6.9%
Advertising	994	1,161	1,232	1,029	-16.5%
Home shopping transmission fees	4,890	7,127	9,064	11,086	22.3%
Subscriptions and installations	905	527	525	495	-5.9%
Terminal device loans (sales)	1,701	2,649	2,813	3,519	25.1%
Other broadcasting businesses	845	549	583	681	16.8%

Source: MSIT and KCC (2021), *Broadcasting Industry Survey Report for 2021.*

■ Program Providers

Program providers' estimated revenue for 2021 comes to KRW 7,074.3 billion, drawing very close to that of the previous year. PPs have continued to show a growing trend since reaching the KRW 7 trillion range in 2019 by expanding the size of home shopping channels and general programming channels, but they are now experiencing stagnant growth due to falling advertising revenues. Although general programming channels' ad revenue recovered, the total ad revenue of all PPs combined is expected to post a lower growth rate than that of the previous year on account of sluggish ad revenues by PPs other than general programming channels.

PPs' revenue in 2022 is forecast to edge up 0.2% year-over-year to KRW 7,086.2 billion. Home shopping channels' revenue, which takes up the largest share (53.9% as of 2020) of the revenue of PPs combined, declined modestly in 2018, but has turned around since 2019 when T-commerce (data home shopping) channel operators expanded investment and size. On the other hand, ad revenue, which accounts for the second biggest share (20.7% as of 2020) of total revenue after home shopping revenue, is showing a downward tendency. Consequently, the growth rate of total PP revenue is likely to slow down gradually only to maintain the current level.

Table 1-13 Program Providers' Broadcasting Business Revenues

(In KRW 100 millions, %)

	2018		2019		2020		2018-2020 CAGR	Percentage growth 2019-2020
	Revenue	Share	Revenue	Share	Revenue	Share		
Provision of broadcast programs	8,016	11.7%	8,317	11.7%	8,749	12.4%	4.5%	5.2%
Advertisements	16,167	23.6%	15,904	22.4%	14,637	20.7%	-4.8%	-8.0%
Sponsorship	3,736	5.5%	4,132	5.8%	4,283	6.1%	7.1%	3.7%
Program sales	2,610	3.8%	2,725	3.8%	2,732	3.9%	2.3%	0.2%
Broadcasting facility rentals	70	0.1%	77	0.1%	80	0.1%	6.9%	3.4%
Events	842	1.2%	981	1.4%	428	0.6%	-28.7%	-56.4%
Home shopping channels	34,938	51.1%	37,111	52.3%	38,108	53.9%	4.4%	2.7%
Other broadcasting businesses	2,023	3.0%	1,671	2.4%	1,726	2.4%	-7.6%	3.3%
Total	68,402	100%	70,918	100%	70,742	100%	1.7%	-0.2%

Source: MSIT and KCC (2021), Broadcasting Industry Survey Report for 2021.

2.2.3 Information Services

Table 1-14 Information Services Revenue Forecasts

(In KRW trillions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Information services	24.1	27.3	29.2	13.2	7.1

Note: Information services are divided into information infrastructure services, information media (web search portals), and information provision services.
Source: MSIT, KAIT and KEA. KISDI projections for 2021 and beyond

Revenue from information services in 2021 is estimated at KRW 27.3 trillion, with a growth rate of 13.2% over the previous year. The web search portal services segment is expected to post a YoY growth rate of 16.0%, whereas Internet information services including publication, education, news, audio and video information services are likely to post 14.3%, with information provision services including remote control, electronic payment and credit card search estimated at 7.4% on average. Among information provision services, content services such as digital music, movies, publications and animations have continued to grow in revenue since the outbreak of COVID-19. Measured by 2020 revenue, the digital ad market takes up about 82.1% and 32.3% in the 'web search portal services'

and 'Internet information provision services' categories, respectively. Overall, digital ads account for about 30% of all "information services" combined, with mobile ads driving the digital ad market. The information provision and application services segment is estimated to have grown in revenue across all areas, including remote control and online booking services, electronic payment services, and credit card search services, in the aftermath of the pandemic.

In 2022, information services are forecast to achieve a year-on-year growth of 7.1% and bring in about KRW 29.2 trillion in revenue. As contactless activities spread in the wake of the pandemic, the e-commerce, online advertising and domestic content industries have been growing across the board, allowing the information services market to continue to grow in terms of revenue.

2.3. Software

Table 1-15 Software Production and Exports–Current Status and Outlook

(Production in KRW 100 millions, exports/imports in USD millions, %)

	2020	2021	2022	Percentage growth 2020-2021	Percentage growth 2021-2022
Software packages	131,326	143,277	153,449	9.1	7.1
Game software	141,106	145,339	152,316	3.0	4.8
IT services	392,045	425,761	447,474	8.6	5.1
Software production total	664,477	714,377	753,239	7.5	5.4
Software export total	14,862	17,769	19,188	19.6	8.0

Software production in 2021 is projected at KRW 71,437.7 billion, up by 7.5% compared with the previous year. The estimated production of packaged software for 2021 shows a YoY growth rate of 9.1% owing to rising demand for security-related software (system software) as well as expanding growth of industry-specific software (application software). Game software production is expected to post a meager 3% growth against the previous year because of the poor performance of large game companies. IT services production is estimated to report a YoY growth of 8.6% as demand for new system integration projects rose after being delayed by the pandemic.

Software exports in 2021 are estimated to have jumped by 19.6% year-on-year to USD 17.8 billion as IT services exports took a favorable turn. Software package exports are expected to post a higher growth rate than the previous year, thanks to increased demand for software packages in the field of 5G communications and security. As for the game industry, the expansion of the "living with COVID-19" policy increased face-to-face activities, slowing down global demand for games, while China's restrictions on issuing version numbers continued. As a result, game exports are likely to report a slower growth, although some of Korean games successfully increased exports to North America. IT services exports are expected to have grown significantly over the previous year, driven by increased orders by subsidiaries of large companies after being delayed by the pandemic as well as rising demand in logistics, communications, security, cloud computing, and other new industries.

Software production in 2022 is forecast at KRW 75,323.9 billion, up by 5.4% from the previous year. The packaged software market is anticipated to grow by 7.1% year-on-year on the strength of rising demand for system software and from the public sector, while game software will grow by 4.8% year-on-year as the growth of both social/casual games and PC games slows down. When it comes to IT services, corporate investments in IT to facilitate digital transformation as well as demand from the public sector will increase, but new demand will be limited due to the economic slowdown. Overall, the IT services market is expected to grow by 5.1% over the previous year.

Software exports in 2022 are forecast at USD 19.2 billion, rising 8.0% from the previous year. The packaged software market will expand, mostly driven by rising demand, particularly from emerging economies, for cloud-based enterprise and security software as well as communications software to support the transition to 5G. Game software exports will grow, spurred by increasing releases of mobile-oriented big-name games as well as the diversification of game platforms, such as VR games. However, the latest version of the International Classification of Diseases (ICD) has included "gaming disorder" on its list to come into effect after a grace period of five years from January 2022. This will limit the extent of export growth for the game industry. Lastly, the IT services industry is expected to see its markets for smart factory, cloud, big data and logistics systems expand, in addition to its traditionally strong e-government market.

Part Ⅱ

International Comparisons of Competitiveness for the Korean ICT Sector

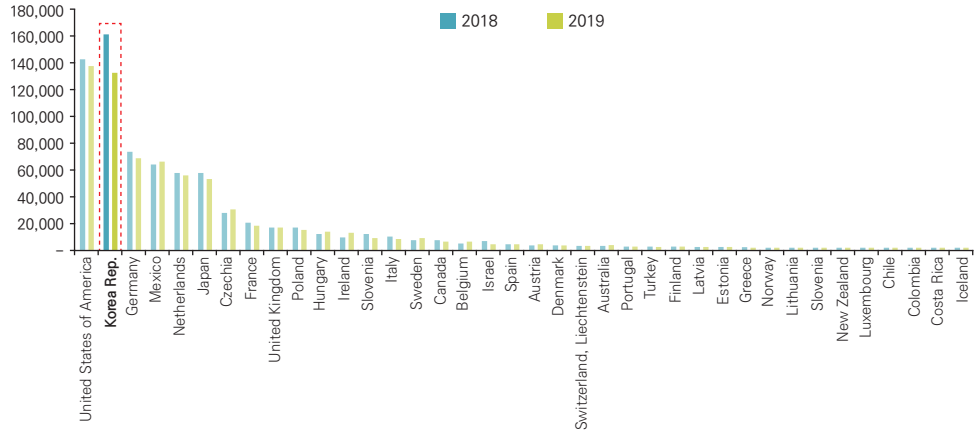
This part assesses Korea's competitiveness in the ICT sector through comparisons with other advanced countries in the following six areas: ICT export competitiveness, technology development investments and innovation levels, human resources environment, financial and entrepreneurial environment, ICT infrastructure levels and its utilization, and industry-friendly policies and laws.

1. ICT Export Competitiveness

On the export front, it turns out that Korea's ICT sector continues to maintain a high level of competitiveness for ICT products but the competitiveness for ICT services remains low. In 2019, Korea's ICT goods exports dropped 17.0% year on year to USD 139,727 million, taking second place among 38 OECD countries–one step down from its top ranking in 2018. The US moved up from the second place in 2018 to head this year's list at USD 143,744 million, recording a 3.0% year-on-year decline. It is followed by Germany, which took third place in 2019 for two consecutive years at USD 73,181 million, down by 5.6% from the previous year. Korea's ICT product exports are among the highest of the OECD countries, but they account only for 21.2% of those of China, the world's No. 1 country in this category at USD 662,177 million in 2019.

Figure 2-1 Total ICT Goods Exports, 2018 and 2019

(In USD millions)

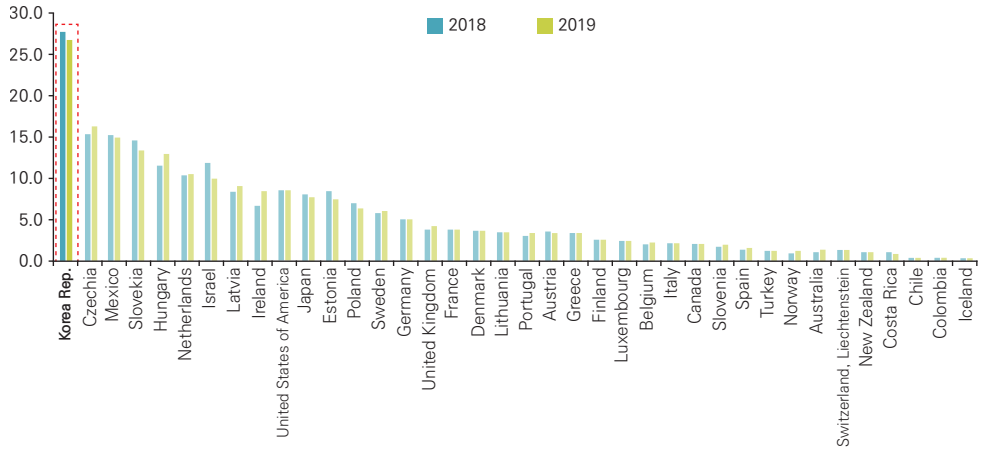


Source: UNCTAD, Information Economy (database), https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx (accessed December 2021)

In terms of the share of ICT goods as a percentage of total trade, Korea turns out to be the highest among the 38 OECD members in 2019 for two consecutive years. As of 2019, the share of Korea's ICT goods in its total trade is 25.8%, down by 2.1%p from 2018. Korea is followed by the Czech Republic, Mexico, Slovakia, Hungary, the Netherlands, and Israel.

Figure 2-2 Share of ICT Goods as Percentage of Total Trade, 2018 and 2019

(In %)

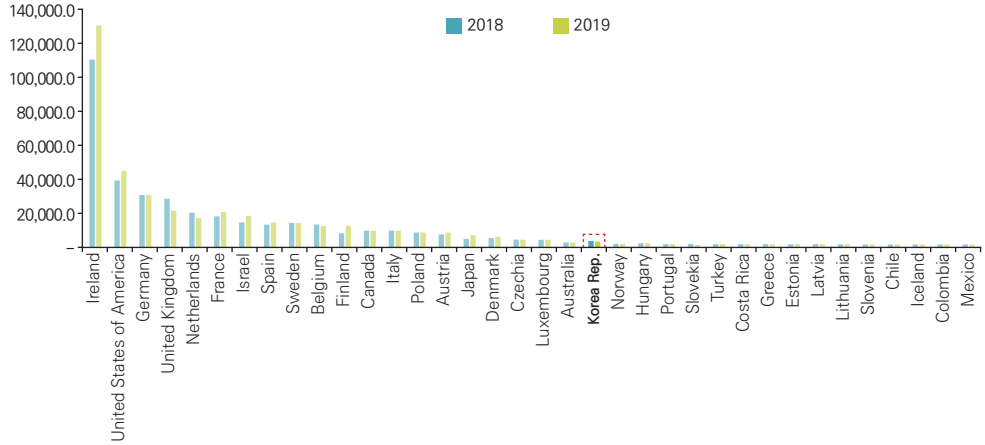


Source: UNCTAD, Information Economy (database), https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx (accessed December 2021)

Next, Korea's ICT service exports in 2019 decreased by 1.3% year on year to USD 3,400.8 million, placing the country in 21st place among the lower-ranking group of 36 OECD countries. This accounts for a mere 2.6 percent of that of Ireland, which topped the list with USD 129,721.3 million. Also, the ratio of ICT service exports to total service exports in 2019 is 4.4%, ranking 30th among 36 OECD countries. This proves that the ICT services sector's contributions to total exports have not improved.

Figure 2-3 Total ICT Services Exports, 2018 and 2019

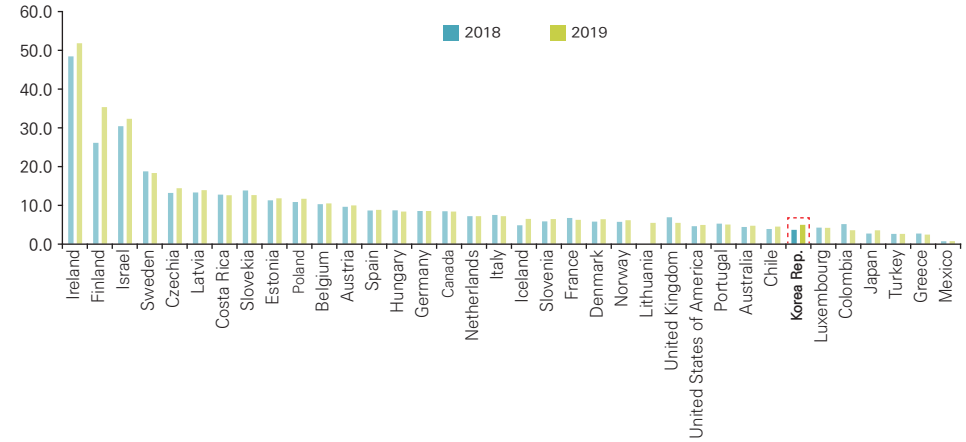
(In USD millions)



Source: UNCTAD, Information Economy (database), https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx (accessed December 2021)

Figure 2-4 Share of ICT Services in Total Exports of Services, 2018 and 2019

(In %)



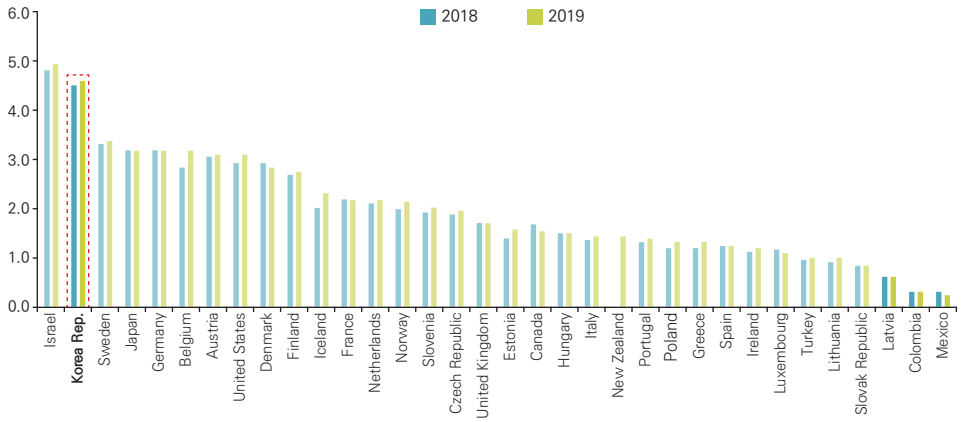
Source: UNCTAD, Information Economy (database), https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx (accessed December 2021)

2. Technology Development Investments and Innovation Levels

Korea's R&D investments in ICT turn out to be among the highest in the OECD. The ratio of gross domestic expenditure on R&D: GERD to GDP as of 2019 increased 0.1%p to 4.6%, ranking second after Israel (in both 2018 and 2019) among 34 OECD countries. Also, the share of ICT (computers, electronics, and optical industry) in business expenditure on R&D (BERD) accounts for 51.7%, putting Korea in first place among 24 OCED members.

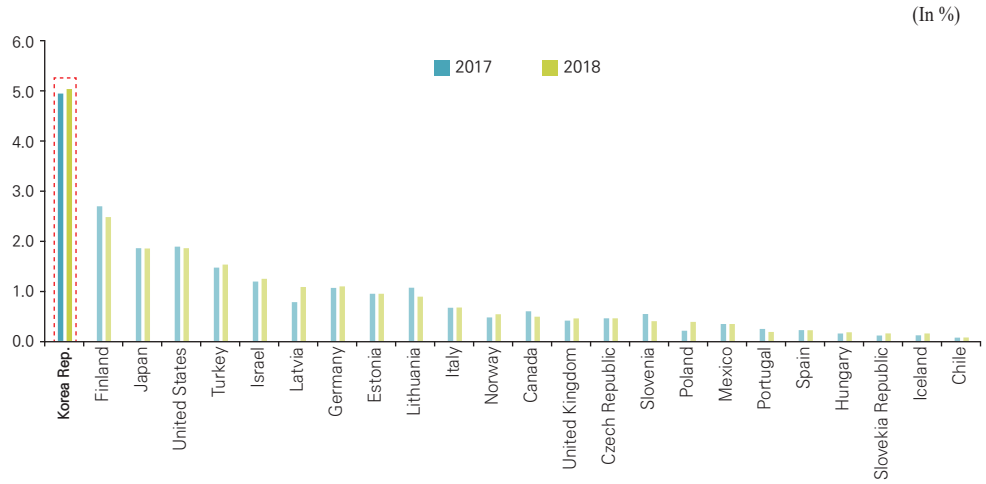
Figure 2-5 GERD as a Percentage of GDP, 2018 and 2019

(In %)



Source: OECD, Main Science and Technology Indicators (database), http://oecd/msti (accessed November 2021)

Figure 2-6 Percentage of BERD Performed in the Computer, Electronic, and Optical Industry, 2017 and 2018



Source: OECD, Main Science and Technology Indicators (database), http://oecd/msti (accessed November 2021)

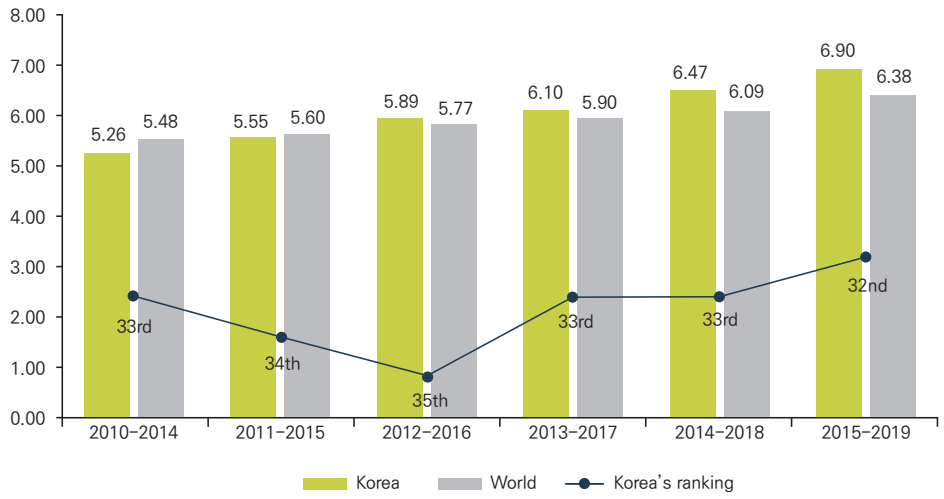
Judging from Science Citation Index (SCI) papers, which can be used as a measure for R&D investment results, Korea's quantitative achievement in the field of ICT R&D is by no means small. In 2019, Korea took 12th place again in 2019 as it did in 2018, producing a total of 69,618 SCI papers, with its share of the world's total number of papers at 3.5%. However, SCI citation count per paper, which is considered as a qualitative measure for a paper, averaged 6.9 between 2015 and 2019, ranking Korea in 32nd place. This is far lower than its quantitative standing.

Table 2-1 Top 20 Countries in Terms of the Number of SCI Papers in 2019

Country	2018		2019				
	Number of publications	Ranking	Number of publications	Ranking	Share of the world's total papers (%)	Percentage change (YoY, %)	Ranking in terms of percentage change
China	401,727	2	491,960	1	24.37	22.46	1
US	467,112	1	484,819	2	24.02	3.79	27
UK	147,799	3	154,906	3	7.67	4.81	25
Germany	124,561	4	130,817	4	6.48	5.02	24
Japan	86,657	5	89,896	5	4.45	3.74	28
India	79,852	8	88,124	6	4.37	10.36	8
Canada	80,411	7	86,241	7	4.27	7.25	20
Italy	79,403	9	85,162	8	4.22	7.25	19
France	82,782	6	84,811	9	4.20	2.45	30
Australia	78,013	10	84,436	10	4.18	8.23	13
Spain	67,528	11	73,240	11	3.63	8.46	12
South Korea	64,179	12	69,618	12	3.45	8.47	11
Brazil	54,364	13	58,663	13	2.91	7.91	14
Netherlands	47,142	14	50,223	14	2.49	6.54	21
Iran	40,377	16	46,593	15	2.31	15.39	4
Russia	42,291	15	45,002	16	2.23	6.41	22
Switzerland	36,526	17	38,093	17	1.89	4.29	26
Turkey	31,133	20	36,800	18	1.82	18.20	3

Note: Science Citation Index (SCI) refers to a database where Clarivate Analytics (formerly known as Thomson Reuters) lists indexes of papers published in academic journals in the field of science and technology. The areas covered include materials science, engineering, computer science, pharmacology and toxicology, microbiology, chemistry, physics, and biology and biochemistry.
Source: Korea Institute of Science and Technology Evaluation and Planning (KISTEP) (2021)

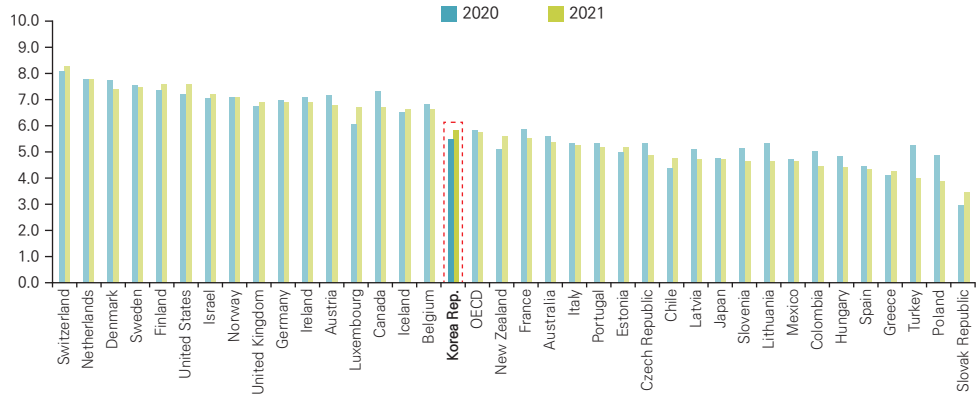
Figure 2-7 Korea's SCI Citation Counts per Paper and International Rankings



Note: Citations per paper are determined by accumulating citations of a paper from the year of its publication until the end of 2019.
Source: KISTEP (2021)

Next, the level of cooperation among R&D players turns out to be not very high in Korea. In a 2021 survey on industry-university technology transfers conducted by the International Institute for Management Development (IMD), Korea comes in 17th place among 37 OECD members, which is the OECD average and two steps higher than its ranking in 2020. In terms of how actively public and private sector ventures are supporting technological development, the country also ranks 24th among the same countries surveyed. This indicates that it has hardly succeeded in invigorating technological development and commercialization through cooperation among R&D organizations.

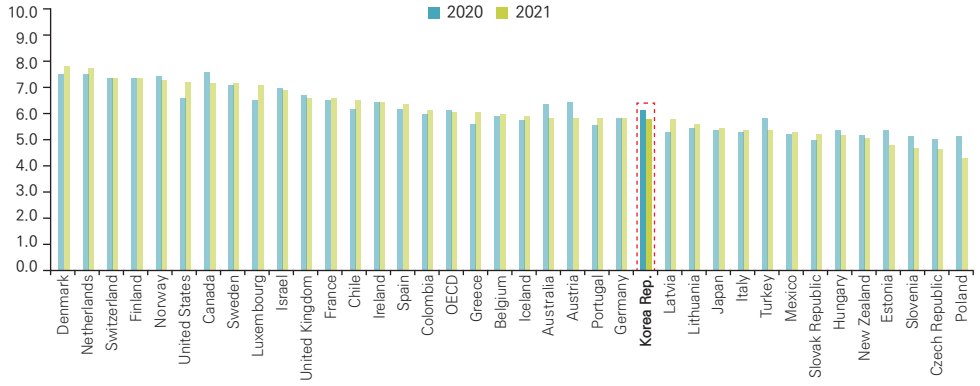
Figure 2-8 Knowledge Transfer, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Knowledge transfer is highly developed between companies and universities)

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

Figure 2-9 Public and Private Sector Ventures, 2020 and 2021



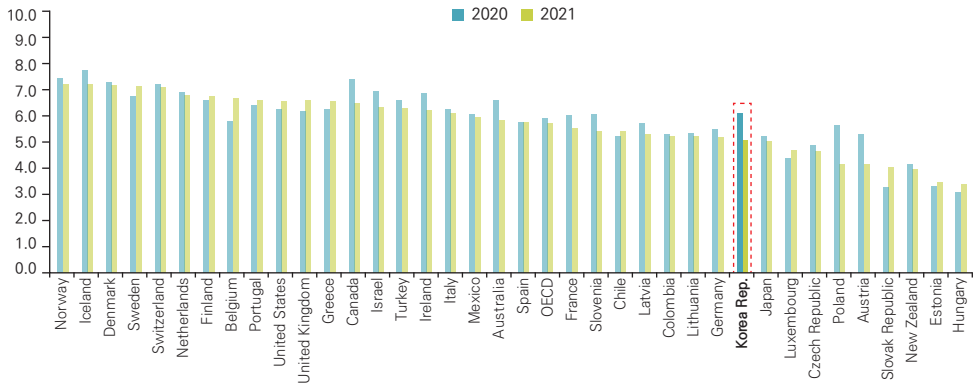
Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Public and private sector ventures are supporting technological development)

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

3. Human Resources Environment

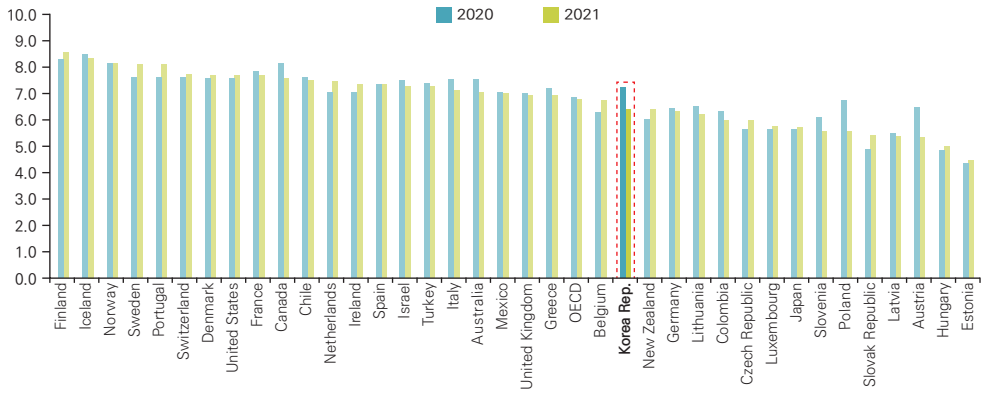
The Korean human resources environment turns out to be in the middle/low ranks among OECD countries. On the questions about the availability of skilled labor, qualified engineers, and digital technology skills from which we can tell the overall availability of ICT resources as of 2021, Korea ranked 28th, 23rd and 21st, respectively, among the 37 OECD countries surveyed.

Figure 2-10 Skilled Labor, 2020 and 2021



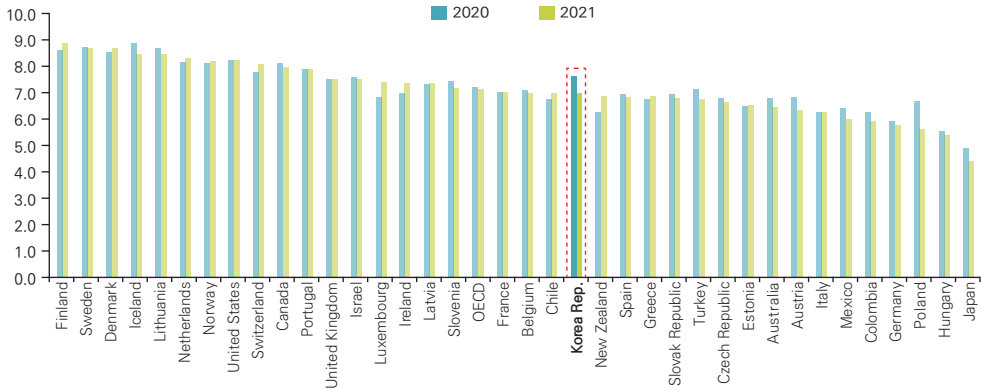
Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Skilled labor is readily available)
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

Figure 2-11 Qualified Engineers, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Qualified engineers are available in your labor market)
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

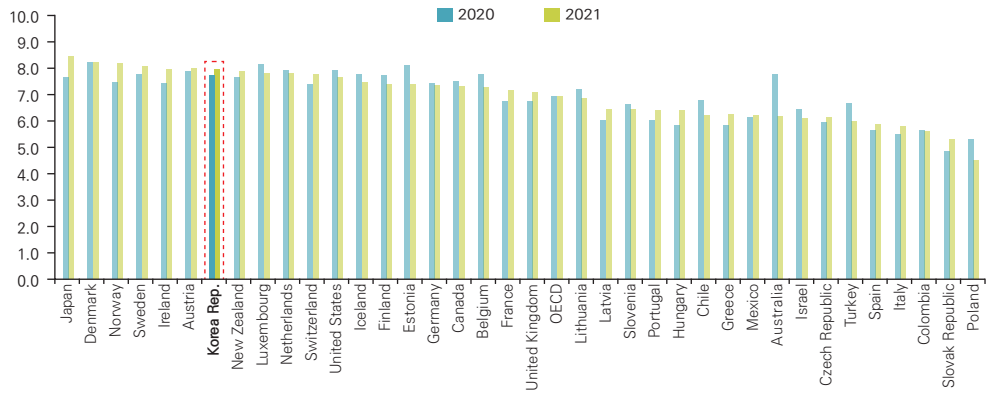
Figure 2-12 Digital/Technological Skills, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Digital/technological skills are readily available)
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

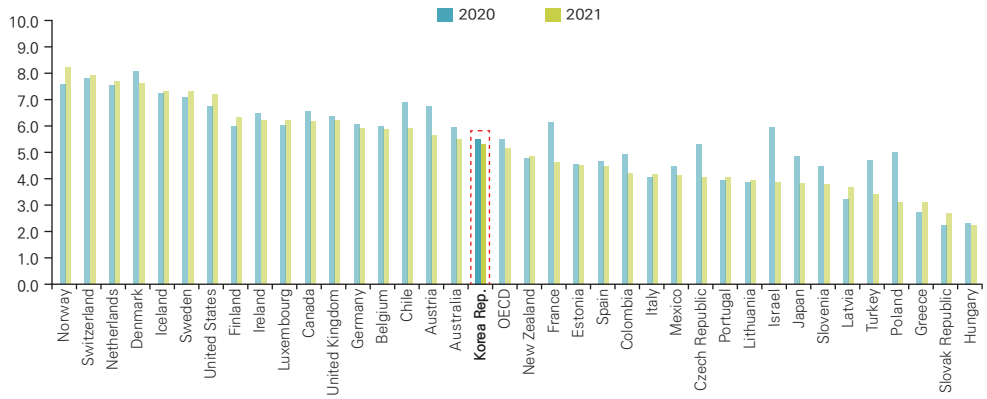
The survey also asked questions to assess how readily the environment allows for securing and nurturing ICT resources: whether attracting and retaining talents is a priority in companies, foreign highly-skilled personnel are attracted to the country's business environment, and brain drain is a hindrance to competitiveness. On these indicators, Korea came in 7th, 29th and 18th places, respectively. This indicates not only that the possibility of brain drain is not low, despite companies' high priorities on talent retention, but also that the business environment is not adequate enough yet to attract foreign skilled resources.

Figure 2-13 Attracting and Retaining Talents, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Attracting and retaining talents is a priority in companies)
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

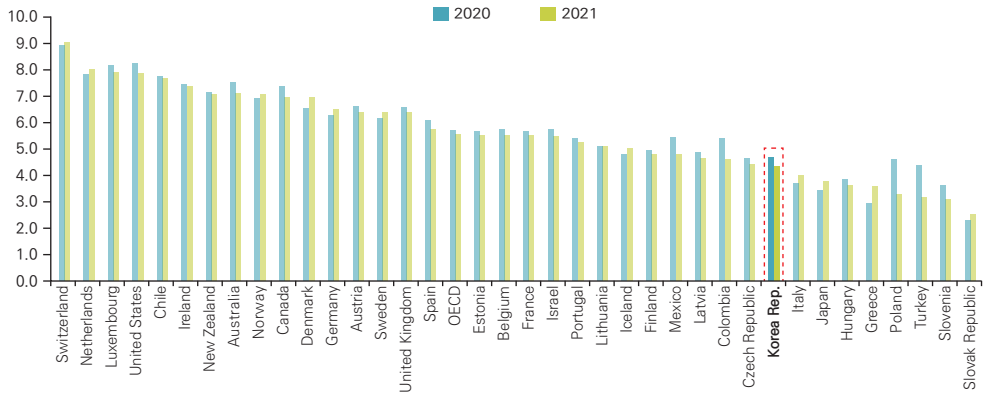
Figure 2-14 Brain Drain, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Brain drain (well-educated and skilled people) does not hinder competitiveness in your economy)

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

Figure 2-15 Foreign Skilled Labor, 2020 and 2021



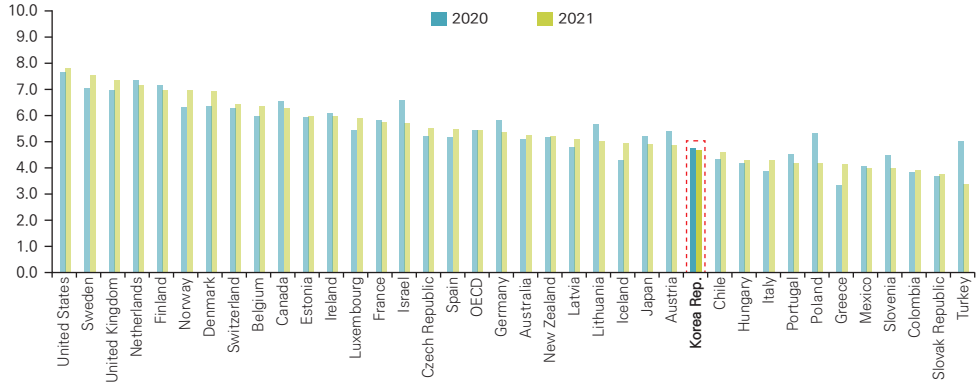
Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Foreign highly-skilled personnel are attracted to your country's business environment)

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

4. Financial and Entrepreneurial Environment

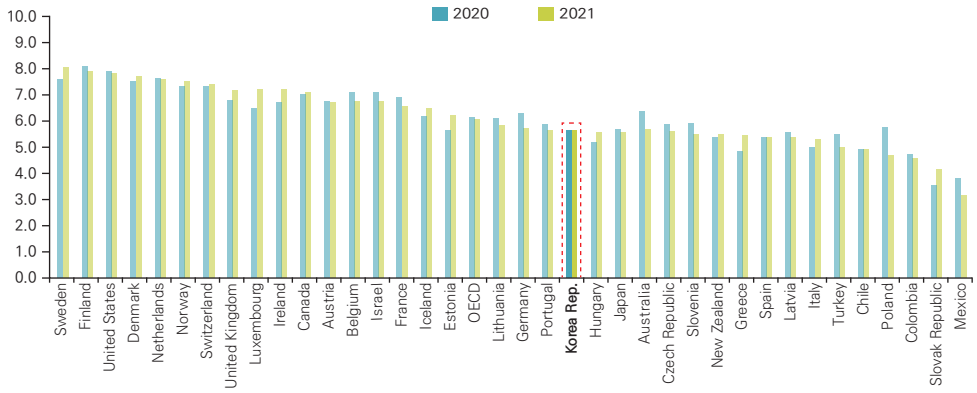
Compared with other OECD countries, Korea's funding environment still remains inadequate in terms of venture capital, technology development funding, and credit availability. In a 2021 IMD survey on these three categories, Korea ranked 26th, 21st and 27th near the bottom of the list of the 37 countries surveyed.

Figure 2-16 Venture Capital, 2020 and 2021



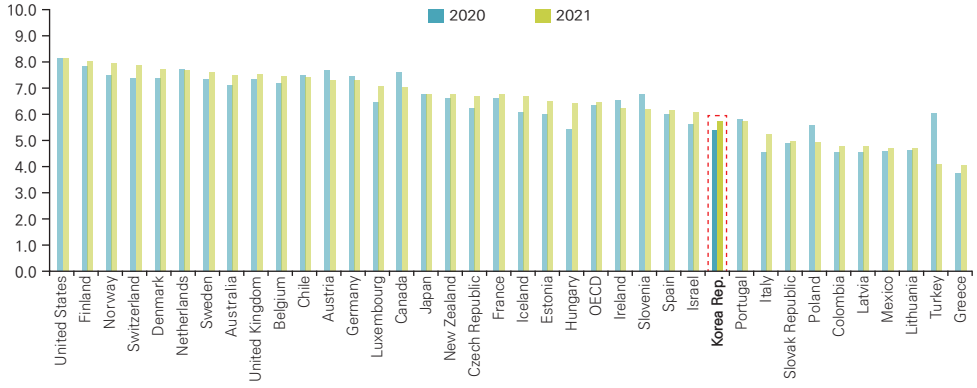
Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Venture capital is easily available for business)
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

Figure 2-17 Funding for Technological Development, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Funding for technological development is readily available)
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

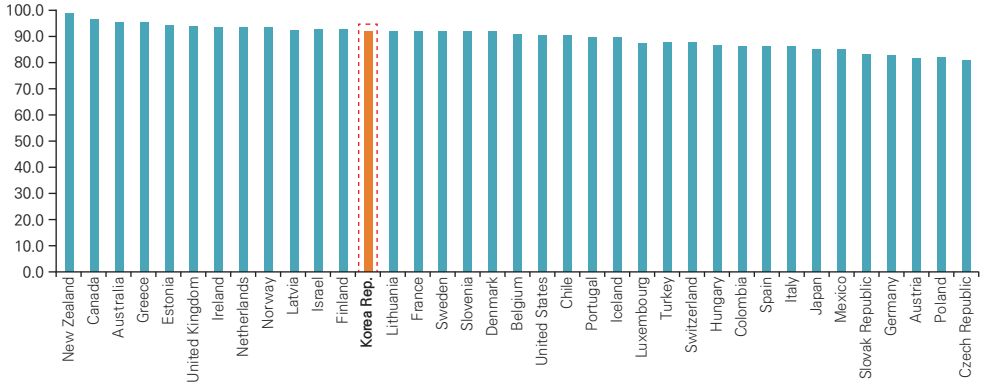
Figure 2-18 Credit Availability, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Credit is easily available for business)
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

By contrast, Korea came out close to the top on the indicator for administrative support to facilitate business startups. The World Bank ranks 190 economies based on their regulations for business operations. On the index of "starting a business" among 10 specific indexes addressed by the Doing Business project, Korea ranks 13th among 37 OECD countries surveyed. This indicator consists of four quantitative measures: procedures (number), time (days), cost (% of income per capita), and minimum capital (% of income per capita).

Figure 2-19 Starting a Business, 2019



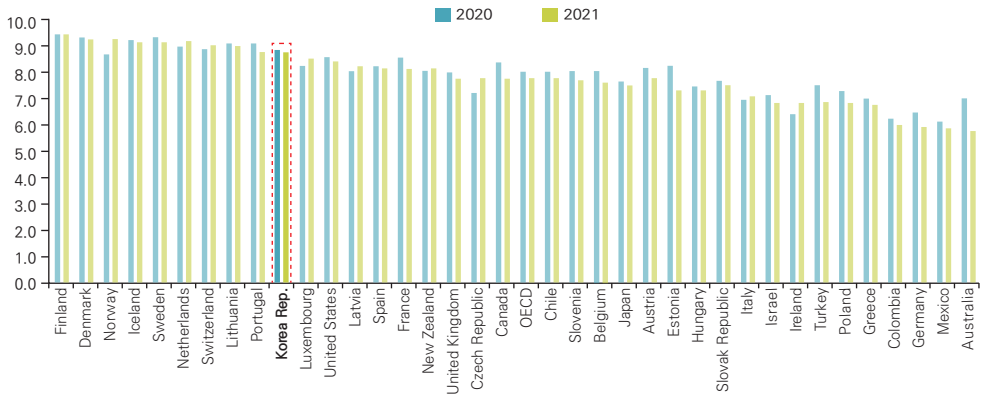
Note: Based on the Distance to Frontier measure, which shows how far an economy is from the best performance achieved by any economy on World Bank's Starting a Business indicators.

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

5. ICT Infrastructure and its Utilization

A comparison of 37 OECD countries' ICT infrastructure levels using IMD's 2021 data shows that Korea continues to maintain high levels of ICT infrastructure and adoption. Results of the international comparison based on a 2021 survey on whether communications technology (voice and data) meets business requirements as well as Internet bandwidth speed (2020), mobile broadband (4G and 5G) subscribers (2020), and Internet users per 1,000 inhabitants (2020) ranked Korea in 10th, 9th, 8th, and 5th place, respectively.

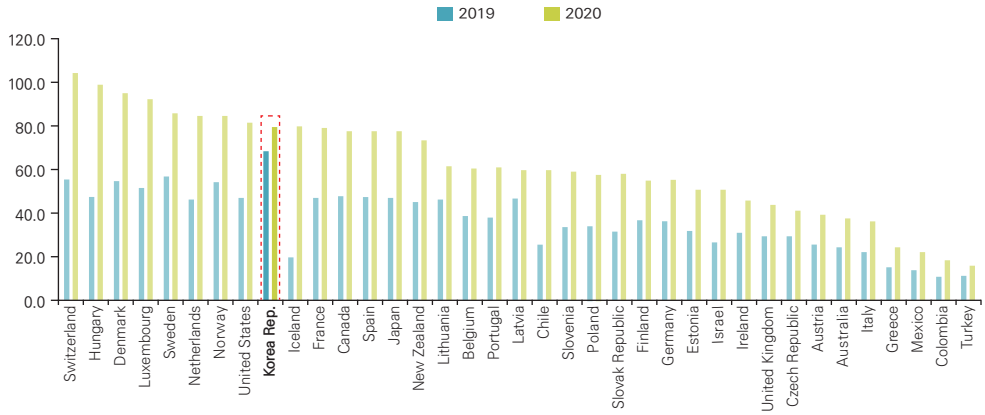
Figure 2-20 Communications Technology, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Communications technology (voice and data) meets business requirements)

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

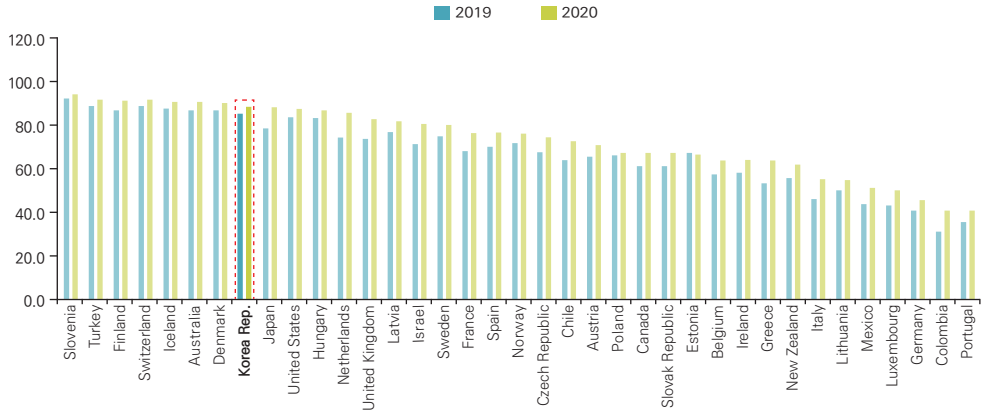
Figure 2-21 Internet Bandwidth Speed, 2019 and 2020



Note: Average speed

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

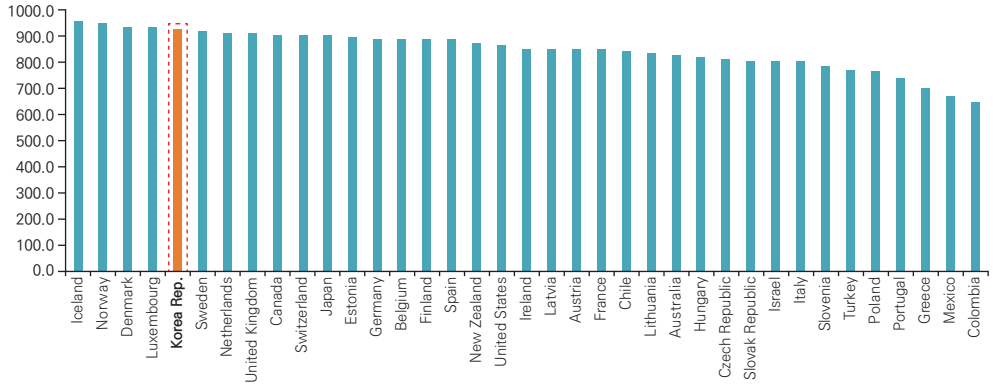
Figure 2-22 Mobile Broadband Subscribers, 2019 and 2020



Note: 4G and 5G market, % of mobile market

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

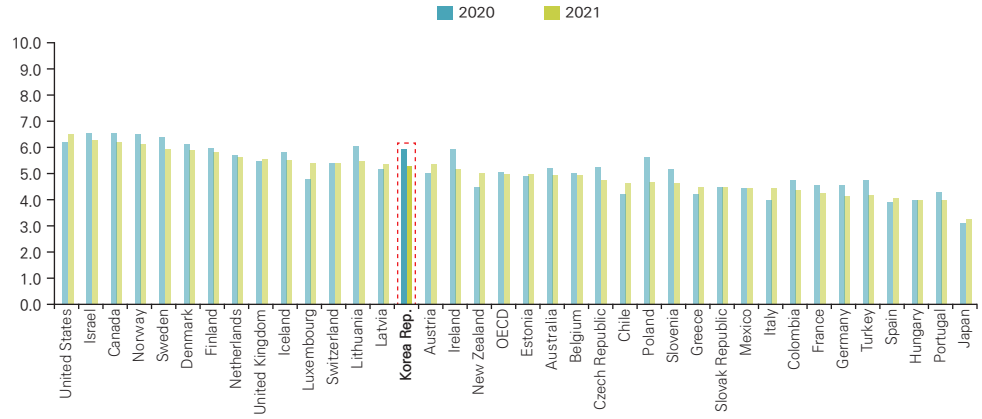
Figure 2-23 Internet Users, 2020



Note: Number of internet users per 1,000 people
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

In Korea, both businesses and individuals have a high level of utilization of ICT infrastructure, which is in the highest rank among OECD countries. For businesses, a 2021 IMD survey conducted with 37 OECD countries on the use of big data in business management and the level of digital transformation put Korea in 15th and 6th place, respectively. To understand how good individuals are at using ICT infrastructure, the survey also looked into Internet retailing in 35 OECD countries. The percentage of online purchases among Koreans recorded 63.3% in 2019, exceeding the OECD average of 59.5%. In terms of the dollar amounts of Internet purchases per 1,000 people, Korea came in second place after the US.

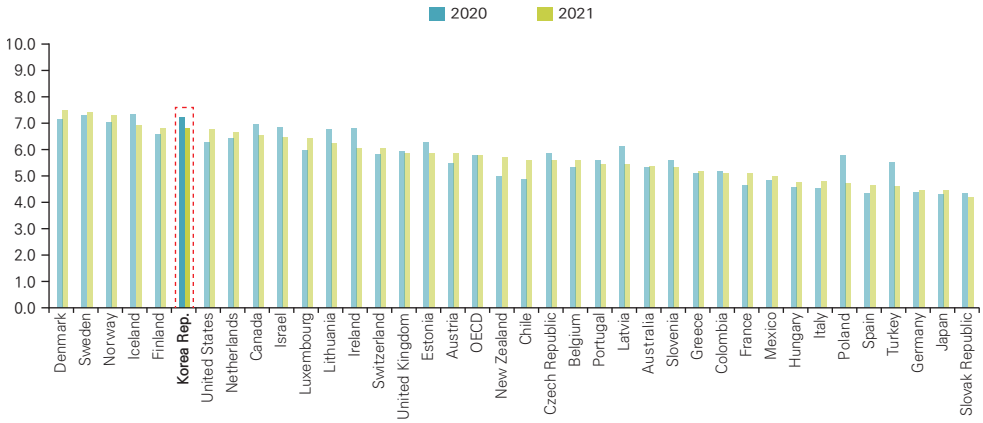
Figure 2-24 Use of Big Data and Analytics, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Companies are very good at using big data and analytics to support decision-making)

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

Figure 2-25 Digital Transformation in Companies, 2020 and 2021

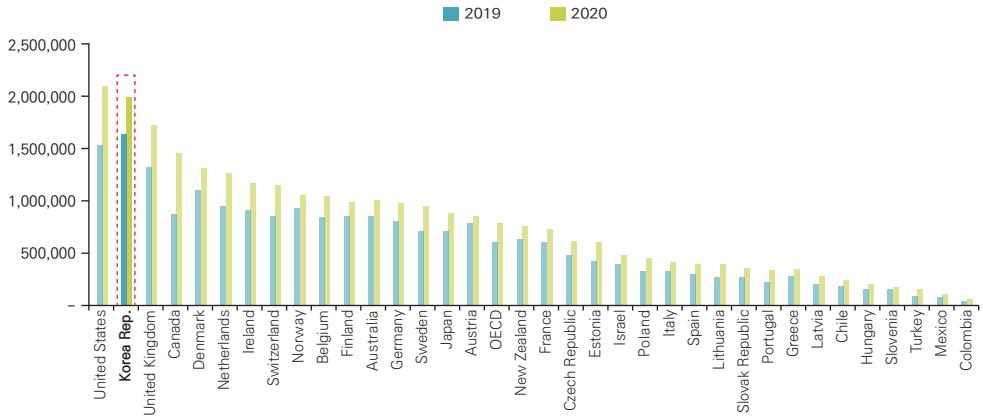


Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Digital transformation in companies is generally well implemented)

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

Figure 2-26 Internet Retailing, 2019 and 2020

(In USD)



Note: US$ per 1,000 people

Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

6. Industry-Friendly Policies and Legislation

The United Nations E-Government Survey allows us to assess the level of government policy for facilitating advances in ICT development. On the E-Government Development Index (EGDI) of the 2020 survey, Korea took second place, one step higher than in the previous survey, while it came out on top on the E-Participation Index (EPI) as it did in the previous survey. Since 2002, the UN has biennially conducted this survey that assesses the digital government development of the 193 UN member states. This survey uses two indexes, which are announced at the national level: EGDI and EPI. The EGDI is a composite measure of e-government services, communication infrastructure and educational level, while the EPI evaluates how actively people participate in policy making online.

Table 2-2 E-Government Survey Results for Korea

Classification	Ranking in 2016	Ranking in 2018	Ranking in 2020
E-Government Development Index	**3**	**3**	**2**
Online services	5	4	1
Communication infrastructure	2	3	4
Human capital	18	20	22
E-Participation Index	**4**	**1**	**1**
Online information provision	97 points	100 points	100 points
Online policy participation	100 points	100 points	100 points
Online policy making	86 points	100 points	100 points

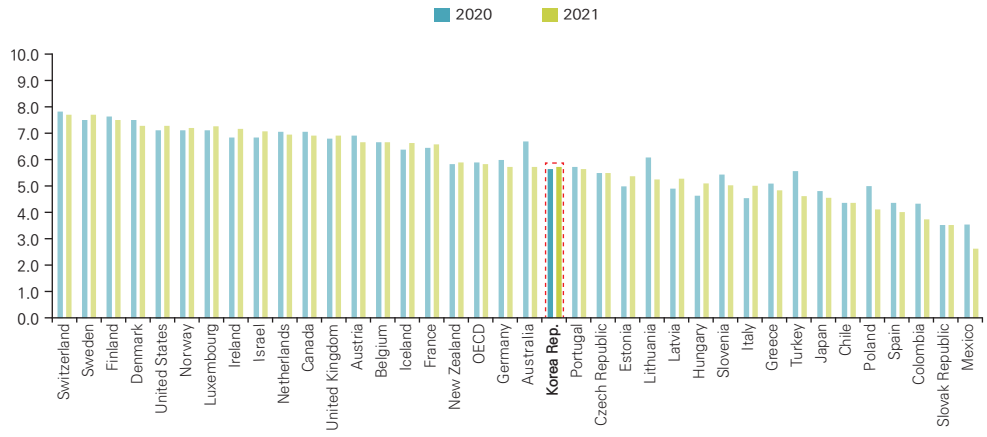
Source: Ministry of the Interior and Safety (July 11, 2020)

According to an evaluation of the regulatory environment, however, Korea still remains in the mid/low rankings, indicating that it has not improved to the extent that market participants can actually feel the improvement. First, for the survey questions on whether the legal environment supports the development and application of technology and whether laws encourage innovation, Korea was considered to be low, taking 30th and 20th place out of 37 OECD countries, respectively. The 2021 survey also rated Korea low on the adequacy of the enforcement of intellectual property rights by ranking it in 27th place among the 37 countries surveyed.

Figure 2-27 Development and Application of Technology, 2020 and 2021

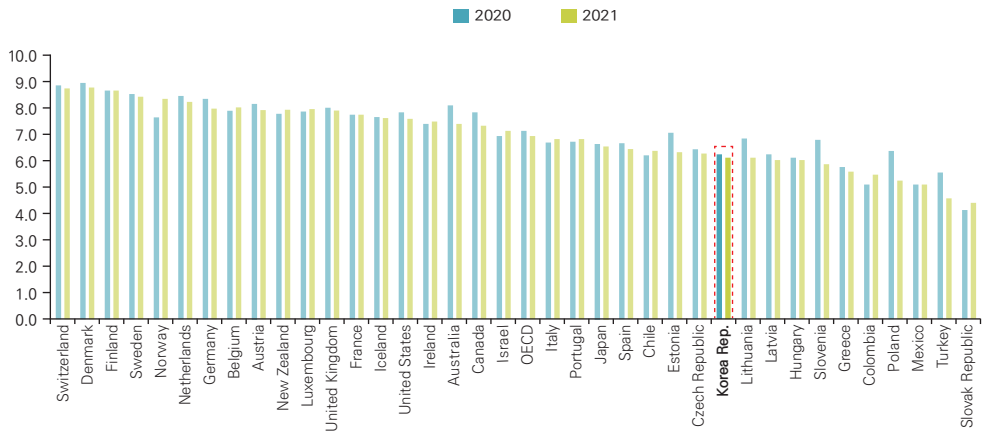
Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Development and application of technology are supported by the legal environment))
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

Figure 2-28 Scientific Research Legislation, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Laws relating to scientific research do encourage innovation
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/customsearch/KR/wcy/ (accessed November 2021)

Figure 2-29 Intellectual Property Rights, 2020 and 2021



Note: IMD WCY Executive Opinion Survey based on an index from 0 to 10 (Intellectual property rights are adequately enforced)
Source: Author's calculations based on IMD, World Competitiveness Online (database), https://worldcompetitiveness.imd.org/custom-search/KR/wcy/ (accessed November 2021)

Part Ⅲ

Current State of the AI Semiconductor Industry and Policies in and out of Korea[3)]

1. Background of the Emergence of AI Semiconductor and Its Concept

Digital transformation triggered by the Fourth Industrial Revolution and COVID-19 has been advancing the industrial structure across all industries and providing momentum to increase the use of data and artificial intelligence (AI) in creating innovative services. With big data analytics and AI being widely adopted across all industries, AI semiconductor, one of the underlying technologies that enable practical implementation, is emerging as a new next-generation growth engine.

Developing advanced AI services involves learning large amounts of data. This means that it is essential to use high-performance computing resources that enable high-speed parallel computation. An AI semiconductor is a type of advanced system semiconductor that plays a key role in making machines learn huge volumes of data. System semiconductors are used across the entire process of "data collection → transmission → computation", whereas an AI semiconductor is used to run AI's key operations, such as "learning data and making inferences" from it.

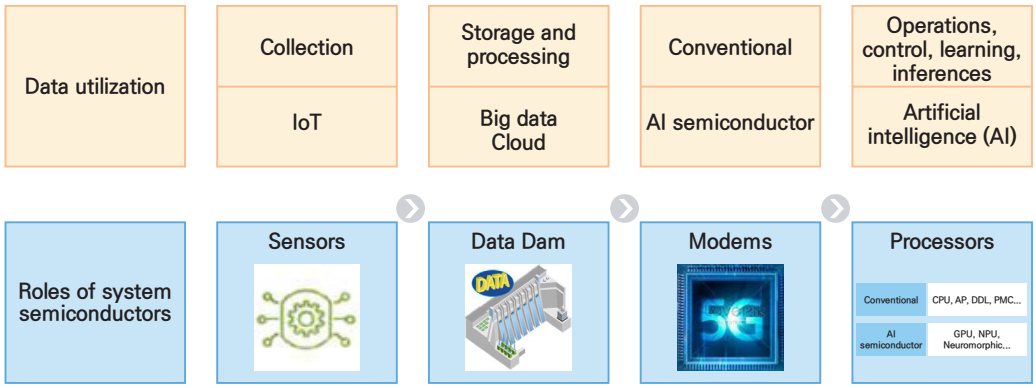
Table 3-1 Classification of Semiconductors (memory vs. non-memory (system semiconductors))

Semiconductor category			Features and characteristics	Flagship products
Memory			• Data storage	DRAM NAND flash
Non-memory	System semiconductor	Micro components	• Brain of computing equipment, including PCs, mobile devices, and servers	Microprocessor (CPU), microcontroller
		Logic IC	• Composed of logic circuits (NOT, OR, AND), it controls specific parts of a product.	AP*, DDI**
		Analog IC	• Analogue signals	Power Management IC (PMIC)
	Optoelectronics and discrete semiconductors	Discrete devices	• Individual components that perform simple functions	Transistor
		Sensors	• Data acquisition, con version and amplification (optical and physical signals → electrical signals)	Image sensor

Note: 1) World Semiconductor Trade Statistics (WSTS) classifies semiconductors into memory, micro components, logic IC, analog IC, discrete devices, optoelectronics, and sensors.
2) *Application processor (AP) is the brain of a smartphone that supports applications running in an operating system. It comes out in the form of a system on a chip (SoC) where memory, graphic processing unit (GPU), and communication modem chip are integrated.
**A display driver IC (DDI) produces colors by adjusting pixels.
Source: Overseas Economy Research Center under the Export-Import Bank of Korea (December 2020)

3) This part is based on a summary of a paper published by Sungwook Yoon, et al. (December 2021).

Figure 3-1 Data Utilization Process and Roles of System Semiconductors

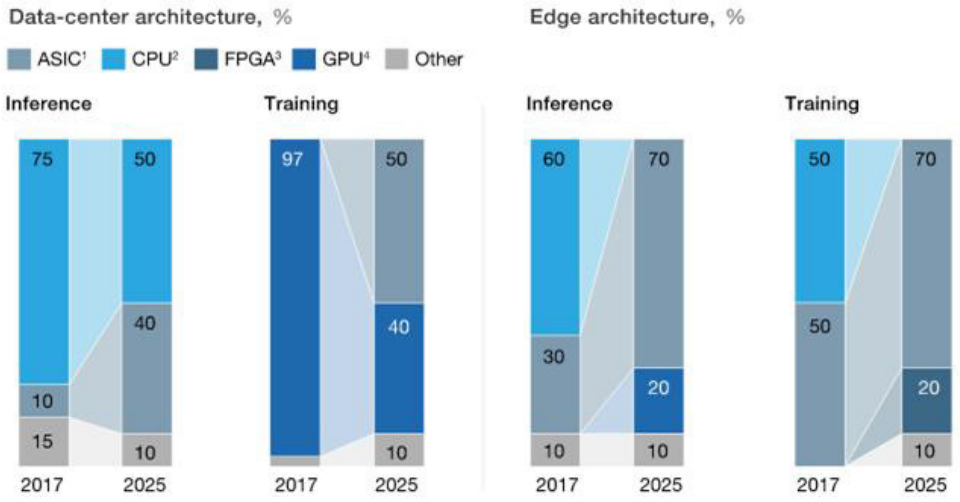


Source: Prepared jointly by related ministries and departments (October 12, 2020)

Semiconductor hardware for running AI algorithms includes GPU, FPGA, ASIC (NPU) and CPU. To make an AI system work efficiently, an accelerator processor called AI semiconductor is set to run AI algorithms, with sequential operations allocated to CPUs. This approach boosts computational speed while ensuring the efficient management of power consumption. Currently, not only established semiconductor manufacturers but also cloud companies and device suppliers are playing to their respective strengths to develop and market AI semiconductors.

A graphic processing unit (GPU), also called visual processing unit (VPU), is a computer chip that renders graphic output to a display device by performing rapid mathematical calculations. GPUs provide better performance for AI algorithms as they are excellent at parallel processing and able to process a huge number of commands per second. Although a GPU is high in calculation efficiency, it has a lower internal memory capacity than CPU. Consequently, when a GPU has to perform a number of calculations that exceeds its internal memory capacity, it may experience a sharp drop in efficiency as it takes a lot of time to access the external memory. Up until recently, GPUs are most widely used as hardware for enabling learning for AI. NVIDIA has the largest share of the GPU market, while companies traditionally focusing on CPUs, such as Intel, ARM and AMD, have also developed their own GPUs to offer product lines with CPU-GPU and software all integrated together.

Figure 3-2 Types of AI Semiconductors Used for Learning and Inference in Datacenter and Edge Architectures



Source: McKinsey & Company (2019)

A field-programmable gate array (FPGA) is a semiconductor device based on a matrix of configurable logic elements and programmable internal circuits. As FPGAs are reprogrammable, they offer the advantage of being able to incorporate design corrections after being programmed once, which means that they can be used for prototyping or ASIC design tests. FPGAs are good for a broad range of AI models, considering the fact that AI models have different structures for different applications and therefore optimized hardware structures are also different. FPGAs provide high throughput per unit of time, low latency, and high energy efficiency. This is why FPGA development has been pursued steadily by many companies, most prominently Xilinx, Intel and Microsoft.

An application-specific integrated circuit (ASIC) is an IC chip customized for a particular use, rather than intended for general-purpose use. On the other hand, an integrated circuit designed as an AI-specific processor is generally called a neural processing unit (NPU). Despite being widely used for AI systems, GPUs were not originally developed to perform computations for AI-based applications. Therefore, they are not optimized for AI implementation in terms of area, power efficiency and run time. In order to resolve this problem, many companies are striving to develop an NPU–ASIC for artificial intelligence–

even though it takes lots of time and money to produce an NPU. Leading NPU developers are Google, Tesla, Amazon, GraphCore, ARM, Intel, Habana Labs (Intel), and Cerebras.

A central processing unit (CPU) refers to the core computer control unit that controls a general-purpose computing system and executes and processes program operations. A CPU offer a higher performance per core than a GPU, but in some cases, it is not even classified as AI semiconductor because of its limitations in parallel processing. Nevertheless, it plays a key role as hardware for AI algorithms, in that it is inexpensive, high in internal memory capacity, and highly accessible as it is included in all devices. Leading CPU design companies including Intel, ARM and AMD are developing solutions for deep learning by continuously improving the performance of their flagship CPUs.

2. AI Semiconductor Market Status and Outlook

2.1. Overall Status and Outlook of the Semiconductor Market

The global semiconductor market reached USD 466.2 billion in size in 2020, and is forecast to grow at a CAGR of 8.2% to USD 692.5 billion by 2025. The general-purpose semiconductor market to which memory belongs is expected to grow by a GAGR of 7.6% from USD 314.3 in 2020 to USD 453.6 in 2025. The custom semiconductor market centered on system semiconductors is projected to grow at a CAGR of 9.5% from USD 151.9 billion in 2020 to USD 238.9 billion in 2025.

Table 3-2 Global Semiconductor Revenues and Forecasts (2020-2015)

(In USD millions)

		2020	2025	2020-2025 CAGR
Total general-purpose	Total analog	24,646	36,036	7.9%
	Total discrete	22,422	38,873	11.6%
	Total memory	124,542	197,639	9.7%
	Total micro-components	82,369	87,291	1.2%
	Total optoelectronics	36,822	56,214	8.8%
	Non-optical sensors	10,088	16,429	10.2%
	Total general-purpose logic	13,412	21,143	9.5%
	General-purpose total	314,301	453,626	7.6%
Total application-specific	Discrete application/multimedia processors	29,440	44,863	8.8%
	Discrete cellular baseband	7,066	5,836	-3.8%
	Discrete graphics processing units (GPUs)	10,309	20,337	14.6%
	Integrated baseband/application processors	15,861	32,795	15.6%
	RF front-end and transceivers	13,288	25,372	10.8%
	RF front-end and transceivers	13,288	25,372	10.8%
	Wireless connectivity (NFC, Wi-Fi, BT, GPS, Combo)	23,651	22,237	7.6%
	Wired connectivity (all interface functions and controllers)	13,387	34,053	13.6%
	Power management	12,122	16,486	6.3%
	Other application-specific	26,812	36,929	6.6%
	Application-specific total	151,936	238,909	9.5%
	All semiconductor devices	466,237	692,534	8.2%

Source: Gartner (2021a)

When measured by semiconductor revenue in 2021, Samsung Electronics (first), Intel (second), SK Hynix (third), Micron (fourth) and Qualcomm (fifth) took the top rankings. The gap in market share between Samsung and Intel in particular is very narrow, at 13.0% and 12.5%, respectively. Intel's revenue in 2020 was USD 72.8 billion, far outpacing that of Samsung (USD 57.7 billion), with their market shares showing a gap of 3.2%p at 15.6% and 12.4%, respectively. Samsung Electronics' semiconductor revenue in 2021 is estimated to have risen 31.6% to USD 76 billion year-on-year, securing a lead over Intel, which reported USD 73.1 billion at a growth rate of 0.5%. Forty eight percent of Samsung's semiconductor revenue is estimated to come from DRAM sales. Meanwhile, Intel managed to achieve a mere 0.5% YoY growth rate as it lost a large portion of its market share to AMD, its competitor in microprocessor, which is expected to report a growth of 64.4% over the same period.

Table 3-3 Semiconductor Vendors by Revenue, Worldwide, 2021

(In USD millions)

2020 rank	2021 rank	Vendor	2020 revenue	2021 revenue	2020-2021 growth	2021 market share
2	1	Samsung Electronics	57,729	75,950	31.6%	13.0%
1	2	Intel	72,759	73,100	0.5%	12.5%
3	3	SK Hynix	25,854	36,326	40.5%	6.2%
4	4	Micron Technology	22,037	28,449	29.1%	4.9%
5	5	Qualcomm	17,632	26,856	52.3%	4.6%
6	6	Broadcom	15,754	18,749	19.0%	3.2%
8	7	MediaTek	10,988	17,452	58.8%	3.0%
7	8	Texas Instruments	13,619	16,902	24.1%	2.9%
10	9	NVIDIA	10,643	16,256	52.7%	2.8%
14	10	AMD	9,665	15,893	64.4%	2.7%
9	11	Apple	10,710	14,529	35.7%	2.5%
13	12	Infineon Technologies	9,848	12,548	27.4%	2.2%
12	13	STMicroelectronics	9,848	12,548	27.4%	2.2%
11	14	KIOXIA	10,374	12,377	19.3%	2.1%
16	15	NXP	8,391	10,740	28.0%	1.8%

Note: The figures for 2021 are estimates.
Source: Gartner (2021b)

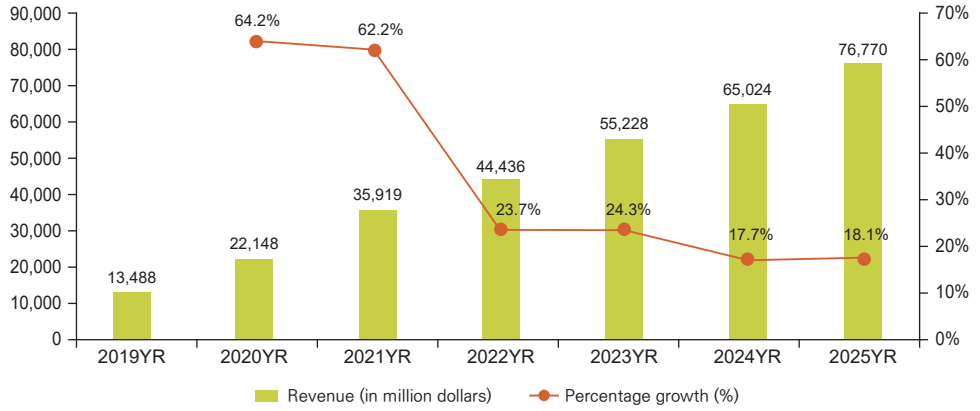
Looking specifically by semiconductor type, the memory market is dominated by DRAM and NAND, with a combined share of over 96%. The DRAM market is being monopolized by three players– Samsung Electronics, SK Hynix and Micron – whereas NAND has a more competitive market structure than DRAM, with one strong player (Samsung Electronics) and five other players (KIOXIA, Western Digital, Micron, SK Hynix, Intel) competing for market share. On the other hand, the system semiconductor market is dominated by American players, such as Intel, Qualcomm, Broadcom, TI, NVIDIA and AMD, who combine to account for more than 70%, with the EU and Taiwan also having a major presence. By comparison, Korean companies do not have a strong competitiveness in the system semiconductor market as they do in the memory market, with their combined share only at 2.9%. This share drops to less than 1% if large companies are excluded, indicating that Korean companies' competitiveness still remains feeble in this field.[4)]

2.2. AI Semiconductor Market Status and Outlook

The memory market has been contracting as technological advances have been driving market players to compete on price. On the contrary, the system semiconductor market has been growing continuously as the use of large volumes of data expands from conventional PCs to the full range of electronics including automobiles, mobile devices and home appliances, and as a result, sources of demand are diversified. AI semiconductors are expected to continue steady growth, supported by the expanding use of AI expands. The AI semiconductor market in 2021 is estimated at USD 35.9 billion to post a year-on-year growth of 62.2%, and is forecast to continue to grow at a CAGR of 28.2% to reach USD 76.8 billion by 2025.

4) Korea Semiconductor Industry Association (June 7, 2021)

Figure 3-3 Semiconductor Market Forecasts



Source: Gartner (2021c)

Looking into revenues by application, AI semiconductors used in communication devices are estimated to have grown 59.3% to USD 24.1 billion in 2021 year-on-year, accounting for 67% of the total revenue of AI semiconductors.

Table 3-4 AI Semiconductor Market Forecasts, by Applications

(In USD millions)

	2020	2021	2022	2023	2024	2025	CAGR 2020-2025
Automobiles	1,703	2,745	3,386	4,458	6,308	8,409	37.6%
Communication devices	15,139	24,114	28,225	31,551	32,584	32,976	16.8%
Computer devices	5,139	8,588	11,597	16,308	21,102	27,487	39.8%
Consumer devices	81	255	723	1,690	2,997	4,659	124.7%
Industrial machinery	82	212	490	1,179	1,949	3,113	106.7%
Storage devices	3	6	16	42	84	126	115.6%
Total	22,148	35,919	44,436	55,228	65,024	76,770	28.2%

Note: Consumer electronics include camcorders, set-top boxes, TV sets, game consoles, smart watches, and media players.
Source: Gartner (2021c)

Looking at revenues by type of AI semiconductor, integrated baseband/application processors are estimated to have grown 98.6% year-on-year to USD 14.21 billion, taking up 39.6% of the total, while discrete application/multimedia processors are estimated at USD 14.23 billion with a 39.6% share.

Table 3-5 AI Semiconductor Market Forecasts, by Type

(In USD millions, %)

Sum of value						
Device	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Digital signal processor	6	14	32	67	106	165
Application/multimedia processor	10,676	14,207	14,288	16,767	17,584	17,975
Graphics processing unit	2,667	4,426	5,404	6,674	8,271	10,105
FPGA	115	212	421	867	1,360	1,773
Integrated baseband/application processor	7,166	14,229	19,366	22,177	25,071	28,705
Microcontroller	19	45	97	199	271	449
Microprocessor - Compute	1,125	2,047	3,409	5,663	7,305	10,127
Microprocessor - Embedded	39	84	162	302	484	685
Others	335	654	1,258	2,513	4,571	6,786
Grand total	22,148	35,919	44,436	55,228	65,024	76,770
Semiconductor Revenue Growth						
Device	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Digital signal processor	88.8%	144.6%	121.6%	111.7%	58.4%	55.8%
Application/multimedia processor	44.4%	33.1%	0.6%	17.4%	4.9%	2.2%
Graphics processing unit	110.7%	65.9%	22.1%	23.5%	23.9%	22.2%
FPGA	127.8%	85.0%	98.5%	105.8%	56.9%	30.4%
Integrated baseband/application processor	79.2%	98.6%	36.1%	14.5%	13.0%	14.5%
Microcontroller	80.6%	138.3%	117.6%	105.6%	36.4%	65.5%
Microprocessor - Compute	93.2%	82.0%	66.5%	66.1%	29.0%	38.6%
Microprocessor - Embedded	73.2%	113.4%	92.3%	86.5%	60.2%	41.5%
Others	109.4%	95.5%	92.3%	99.8%	81.9%	48.5%
Grand total	64.2%	62.2%	23.7%	24.3%	17.7%	18.1%

Source: Gartner (2021c)

3. AI Semiconductor Policies at Home and Abroad

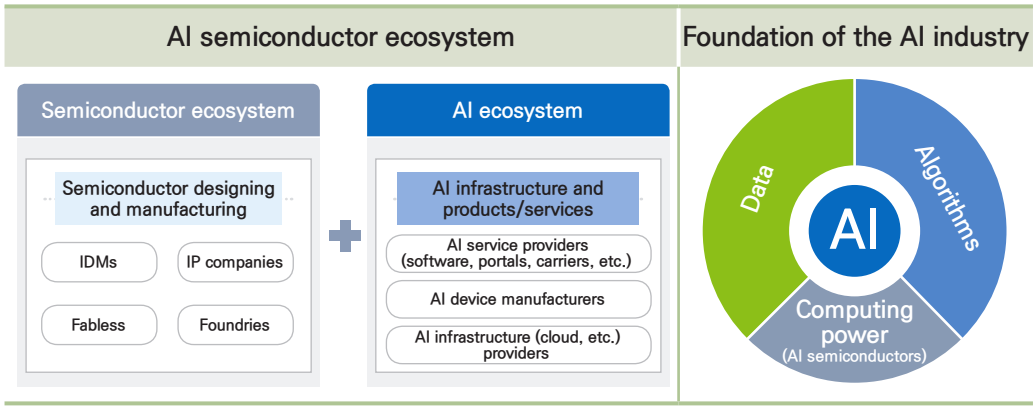
3.1. Korea

Over the years, the Korean government has been formulating and implementing comprehensive and multifaceted strategies to sharpen Korea's industrial competitiveness and take off as a leader in the semiconductor sector. It has continued to unveil cross-departmental master plans and implement specific projects intended to provide support for R&D, nurture talent, bring large companies and SMEs into win-win partnerships, create ecosystems, raise funds, offer tax credits, and improve the commercial environment.

The Korean semiconductor memory industry has an oligopolistic structure based on cutting-edge technologies. It has been driven by large companies, mostly integrated device manufacturers (IDMs) who are required to make micro-fabrication R&D investments and highly-capital-intensive facility investments. The government has also been providing support through tax benefits and deregulation. With semiconductor foundries growing in importance and market size, the government is putting in more efforts to help enhance the competitiveness of the foundry industry.

By contrast, the Korean system semiconductor industry has a number of innovators and SEMs in each field, including fabless manufacturing, testing, and packaging, and the government has been implementing a range of policies to support growth and create ecosystems, such as providing R&D support, facilitating technology commercialization, finding investors, and creating infrastructure. As the technological capabilities and features of AI semiconductors as the basis of AI technologies and data ecosystems are becoming the key to strengthening competitiveness in various industries including communications, IoT, automobiles, and home appliances, the government has embarked on investing intensively to foster the AI semiconductor industry strategically.

Figure 3-4 Semiconductor Ecosystem



Source: Prepared jointly by related ministries and departments (October 12, 2020)

Table 3-6 Korea's Strategies for Nurturing the (AI) Semiconductor Industry and Their Main Contents

Strategy	Date announced	Descriptions
Strategy to Nurture System Semiconductor and Equipment Industries	September 2010	• Connect demand-side companies with fabless companies, foster system semiconductor and equipment SMEs, create semiconductor clusters, and implement talent nurturing policies in order to foster both the system semiconductor industry and the semiconductor equipment industry systematically[5]
Another Leap Forward for the Semiconductor Industry	October 2013	• Concentrate support on the fields of memory, system semiconductors, equipment and materials, and human resources and infrastructure to continuously foster the semiconductor industry as a growth engine[6]
Program for Nurturing Intelligent Semiconductor Professionals	2016	• Create an ecosystem where an employment-linked program trains MSc-level semiconductor specialists in accordance with demand from businesses and the completion of the training leads directly to employment[7]
Semiconductor Hope Fund	2016	• Samsung Electronics, SK Hynix, and policy financing institutions raised a semiconductor fund worth KRW200 billion to invest in fabless, and materials and equipment companies[8]

5) Ministry of Trade, Industry and Energy (July 31, 2010)
6) Ministry of Trade, Industry and Energy (October 23, 2013)
7) Ministry of Trade, Industry and Energy (September 29, 2016)
8) Ministry of Trade, Industry and Energy (October 27, 2016)

Strategy	Date announced	Descriptions
Plan for Strengthening Competitiveness of the System Semiconductor Industry	March 2017	• Take off as a leader in the system semiconductor industry, carry out system semiconductor R&D and talent nurturing, and support efforts to tap into global demand[9]
System Semiconductor Vision and Strategy	April 2019	• Foster the full range of system semiconductors and take off as a strong power in the field of integrated device manufacturing (IDM) as well as build the foundation for fabless companies to grow and enhance competitiveness of foundries[10]
National Artificial Intelligence Strategy	December 2019	• This master strategy proposes nine strategies to achieve innovation across the Korean economy and society in order to go beyond an IT power to become an AI power. It includes strategic investments particularly in the development of AI semiconductors and a new-concept semiconductor (PIM)[11]
AI Semiconductor Industry Development Strategy	October 2020	• Grow into an AI and IDM power by strengthening the R&D of AI semiconductor technology, facilitating technology commercialization, nurturing talent, providing financial support, building the foundation, and supporting the creation of ecosystems[12]
Support for System Semiconductor Technology Innovation	December 2021	• Support growth of Korean fabless companies, preoccupy promising markets, challenge new markets (AI semiconductor, PIM semiconductor), and push ahead with feasibility test preparations ("K-sensors", next-generation PIM semiconductor)[13]
K-Semiconductor Strategy	May 2021	• Build the world's largest and most advanced semiconductor supply chain by constructing "K-Semiconductor Belt", and maintain the "super gap" through private investments of more than KRW 510 trillion by 2030, and train 36,000 semiconductor professionals[14]

Source: Sungwook Yoon, et al. (2021)

9) Ministry of Trade, Industry and Energy (March 30, 2017)
10) Jointly by related ministries and departments (April 30, 2019)
11) Ministry of Science and ICT (December 17, 2019)
12) Jointly by related ministries and departments (October 12, 2020)
13) Jointly by related ministries and departments (February 1, 2021)
14) Republic of Korea Policy Briefing (May 13, 2021)

3.2 Other Countries

■ United States

The US is pushing ahead with restructuring the supply chain in order to place itself at the center as it views its high-tech industries' heavy reliance on China as a threat to national security. The US is striving to increase its semiconductor manufacturing competitiveness and reduce its dependence on China through legislative bills intended to expand R&D, investments and incentives as well as protect US-made products and technologies.

In addition to this, the US takes issue with unfairness in the Chinese government's national strategies to nurture the semiconductor industry as well as its innovation policies and practices and is imposing tough trade sanctions against China using its trade laws. The Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA) expanded the jurisdiction of the Committee on Foreign Investment in the United States (CFIUS) to review even non-controlling foreign investments and strengthened its authority to prevent the transfer of critical technologies to China as well as the acquisition of controlling interests by China's high-tech industries.

Table 3-7 Major US Legislative Bills and Reports Supporting the Semiconductor Industry

	Innovation and Competition Act[15]	Building Resilient Supply Chains[16]	CHIPS for America Act[17]
Purpose	• To hold China in check in the fields of cutting-edge science and technology including semiconductors, AI, batteries and robotics and secure a global competitive edge for the US	• To enhance domestic manufacturing capabilities and reduce reliance on hostile nations based on the results of evaluating and diagnosing the supply chain structures of critical industries	• To provide a large amount of federal funds to initiatives for rebuilding the foundation for US semiconductor manufacturing capabilities and securing a competitive edge for the future
Details of semiconductor-related support and target recipients	• (Semiconductor manufacture) provide financial support for the production, assembly, inspection and packaging of commercial semiconductors as well as the establishment, expansion and modernization of R&D facilities • (Semiconductor R&D) develop advanced semiconductor technologies and human resources • (International cooperation for semiconductors) to support international cooperation to secure a stable supply chain, manage exports, and resolve political issues	• To support the CHIPS for America Act, it recommends that at least USD50 billion should be allocated to construct and expand domestic manufacturing facilities, support R&D and create a multilateral fund. • Recommended to invest in infrastructure for key semiconductor areas, support private investments, and support the production of chips required for national security • To select promising semiconductor SMEs and support them through the Small Business Administration (SBA)	• Financial support for semiconductor manufacturing facilities and equipment investments • Facilitate the establishment of a business consortium on public-private partnerships and create a national semiconductor R&D network • Create a Multilateral Semiconductor Security Fund • (Next-generation semiconductor R&D) establish a subcommittee on semiconductor leadership, an industrial advisory committee, a national semiconductor technology center, a national advanced packaging manufacturing program, and Manufacturing USA Institute specializing in semiconductor manufacturing

Source: Sungwook Yoon, et al. (December 2021)

15) S.1260: United States Innovation and Competition Act of 2021
16) Report released by the White House (June 8, 2021)
17) H.R.6396 (116th): National Defense Authorization Act for Fiscal Year 2021

■ China

China designated semiconductor as one of the key focus areas in its national strategic policies to boost national competitiveness and announced specific industries to nurture in order to secure competitiveness in the semiconductor sector. Semiconductor has been selected as a strategic area by a series of national strategic policies: Made in China 2025 (2015), National 13th Five-Year Plan for Scientific and Technological Innovation (2016), National 13th Five-Year Plan for the Development of Strategic Emerging Industries (2016), and National 14th Five-Year Plan (2021).

Furthermore, central government agencies and departments as well as local governments have detailed policies in place to provide tax benefits, financial support or technology protection. Central government agencies, such as the Ministry of Finance, State Taxation Administration, National Development and Reform Commission, Ministry of Industry and Information Technology, and State Council, develop tax breaks and other support policies, while financial institutions and businesses raise industrial investment funds. To cope with US-China trade tensions, the Ministry of Commerce and the Ministry of Science and Technology are formulating policies to protect China's semiconductor technologies. Local governments such as Chengdu and Xiamen offer diverse subsidies to support semiconductor R&D and attract talents.

Table 3-8 China's Semiconductor Policies as Part of Its National Strategies (2015-2020)

Date	Responsible	Policy	Main content
May 2015	State Council	Made in China 2025	• The 10 key sectors highlighted by this initiative include "new-generation information technology" under which semiconductor is listed as the first priority. • (Semiconductor as an area of focus) improve China's semiconductor design competitiveness and levels and expand the scope of the production and use of key semiconductors
July 2016	State Council	National 13th Five-Year Plan for Scientific and Technological Innovation	• Core technologies to be pursued by key projects include technologies for essential components, advanced semiconductors, basic software, and IC equipment. • (Focus areas for semiconductors) develop key technologies for high-performance and low-power semiconductors as well as domestic development of key semiconductors and high-end general-purpose chips

Date	Responsible	Policy	Main content
November 2016	State Council	National 13th Five-Year Plan for the Development of Strategic Emerging Industries	• One of the six strategies listed in the Plan is "strengthening key IT industries". This strategy in turn includes a plan for strengthening China's supply capabilities for key semiconductors. • (Focus areas for semiconductor) develop chips for new applications, accelerate the industrialization of 16/14nm production processes and the construction of memory production lines, and promote the research and development of key technologies in smart sensors, etc.
February 2017	National Development and Reform Commission	Guiding Catalogue of Key Products and Services in Strategic Emerging Industries	• The information technology industry, which is one of the eight strategic industries listed in the Catalogue, includes semiconductors as one of its core technologies. • (Focus areas for semiconductor) IC chip design and services, semiconductor design platform (EDA tools), IP libraries, etc.
March 2021	State Council	National 14th Five-Year Plan	• Semiconductor was selected as one of seven national strategic technologies. • (Focus areas for semiconductor) semiconductor design tools, key materials, advanced manufacturing technologies

Source: Sungwook Yoon, et al. (December 2021)

■ Taiwan

Taiwan also fosters its semiconductor industry by designating it in national strategic policies. In 2020, the National Development Council (NDC) announced the National Development Plan, a four-year plan aimed at implementing the New Economic Development Strategy 2.0, nurturing new-generation talent, and providing stable living. This plan includes R&D on next-generation semiconductor technologies, R&D on advanced technologies including 5G and semiconductor, and the localization of semiconductor materials and equipment as focus areas in the information and digital, cybersecurity, public welfare and strategic stockpile industries. In 2021, Taiwan unveiled an implementation plan for the Six Core Strategic Industries to implement its national development strategies focusing on nurturing future industries and achieving technology innovation. This plan selected semiconductor technology as a focus area for the information and digital, and public welfare and strategic stockpile industries, including the development of advanced semiconductor manufacturing processes and the localization of semiconductor equipment and materials.

As specific semiconductor policies, Taiwan seeks to maintain its technological advantages in semiconductor manufacturing, localize materials and technologies by taking another leap forward in key equipment and material technologies, and take the lead in building an advanced manufacturing process ecosystem. In 2019, the country also announced an Action Plan for Welcoming Overseas Taiwanese Businesses to Return to Invest in Taiwan, a reshoring initiative aimed to lure Taiwanese companies under pressure from rising US-China trade tensions to shift production back to Taiwan from China by assisting their smooth return and investments. As policy to secure talent, Taiwan announced the High-Quality Talent Nurturing Plan for Industries of Focus in 2020, and also enacted the Ordinance on Industrial-Academic Cooperation and Talent Nurturing in National Focus Areas in 2021, which was the first to introduce a regulatory sandbox to facilitate industrial-academic cooperation and nurture master-level and doctor-level talent in the fields of semiconductor and AI.

Table 3-9 High-tech Areas for Which Taiwan Is Strengthening Research, and Directions for Implementation

Classification	Research plan	Main content
Silicon semiconductor	Generation A Semiconductor Plan (2021-2025)	• Accelerate the approval of key 12-inch pre-process equipment and 3D chip packaging equipment in customers' final tests • Subsidize localization efforts for export-restricted materials and support the development and application of high-speed, low-consumption computing devices
Compound semiconductor	Compound Semiconductor Plan (2021-2025)	• Connect the upstreams and downstreams/high and low nodes of the semiconductor industry chain, accelerate the development of key 8-inch manufacturing process equipment, and localize silicon carbide (SiC, a third-generation semiconductor material) particulates and 8-inch SiC wafers • Application of high-power devices in electric vehicles (motor bikes, electric buses) and eco-friendly energy (wind power), and application of high-frequency devices in communication (5G/6G) and low-orbit satellites
Quantum	Quantum Science Research Plan (2021-2025)	• Focus on quantum computing and quantum communication. Advance silicon-based technology • Respond to demand for computing in 10 years from now. expand the space for the future of Taiwan's semiconductor industry

Source: Yunmi Oh (2021)

Conclusion

Uncertainty in the external environment will continue in 2022, including prolonged US-China trade disputes and China's economic slowdown. Coupled with this, the base effect from the big increases in 2021 is expected to slow down demand, reducing the growth of ICT production and exports. Given the vulnerabilities of the Korean ICT industry to the external environment, it is necessary to secure sustainable growth engines by creating new industries to respond to changes in ICT demand in the post-pandemic era in order to keep the ICT sector on the upwards trajectory in the future. On the software front, demand is expected to rise for all its industries. However, Korea definitely needs to sharpen its competitive edge further in this field because its software competitiveness is not very strong, relative to other industries, while software is expected to grow in importance. On the other hand, hardware industries need support to develop technologies and find demand for devices whose production is expected to slow down. Next, we need a shift in R&D investment. We need to establish a policy framework that not only leads to the development of new technologies but also the creation of new services and industries and the expansion of markets through the application of the new technologies. In order to support digital transformation, we also need to strengthen policies for creating new markets in response to digital transformation, along with efforts to secure key and original ICT technologies over the mid-/long-term. Also, the foundation should be laid to enable all convergences and innovations across the ICT sector to be internalized in order to achieve the structural improvement of the ICT sector.

In addition to this, dramatic improvements are needed to resolve the following issues: the concentration of R&D on ICT equipment and devices, insecure the human resources environment, the startup funding environment that falls short of administrative services for startups, and legal systems governing ICT that fail to facilitate the emergence of innovative ICT industries. These improvements are essential for Korea to ensure that its top-level ICT infrastructure and ability to use it, which has continued to prove highest among OECD countries through a number of international comparisons, will contribute to enhancing its ICT competitiveness.

AI semiconductors are considered to have a huge growth potential. As such, not only leading global companies but also major countries are expressing commitments to large-scale semiconductor investments, preparing a legal basis, and pushing ahead with long- and mid-term AI-related R&D projects in order to maintain global leadership as a way of

securing their economic and security interests. When it comes to semiconductor memory, Korea is leading the global market with the world's best technology, but its technology level in the field of system semiconductors, such as fabless manufacturing, is rather low relative to that of the US or other major countries. In terms of AI semiconductors in particular, its technological gap with leading countries is showing signs of narrowing, but there still remains a technology gap with leading countries in this promising field. Korea recognizes the importance of AI semiconductors as both a future growth engine and a key factor in national security, and is striving to take a leap forward as a semiconductor powerhouse banking on the world's best memory technology, but it has yet to achieve many tangible results. As major countries are launching national-level initiatives to rebuild semiconductor supply chains around their own countries, Korea needs to diagnose and make up for weaknesses in its semiconductor ecosystems, including AI semiconductors. To this end, it should accelerate its efforts to enhance domestic semiconductor R&D and manufacturing capabilities on the strength of its semiconductor capabilities by creating technology innovation ecosystems, constructing end-to-end supply chains for AI semiconductors, nurturing human resources who meet the needs for software convergence, and continuously pursuing semiconductor industry nurturing strategies.

References

〈Korean〉

Jointly by related ministries and departments (April 30, 2021), “System Semiconductor Vision and Strategy ”.

Jointly by related ministries and departments (October 12, 2020), “AI Semiconductor Industry Development Strategy”.

Jointly by related ministries and departments (February 1, 2021), “System Semiconductor Technology Innovation Support”.

Korea Semiconductor Industry Association (June 7, 2021), “Silicon Times”.

Lee, Hakki, et al. (December 2021), *ICT Industry Long-Term Forecasts (2022-2026) and the Strategy,* KISDI.

Ministry of Science and ICT (December 17, 2019), “Beyond an IT Powerhouse to an AI Powerhouse ! ”.

Ministry of the Interior and Safety (July 11, 2020), “2020 United Nations e-Government Development Index has been published”.

Ministry of Trade, Industry and Energy (July 31, 2010), “Semiconductor Korea: A Second Leap Forward”.

Ministry of Trade, Industry and Energy (October 23, 2013), “Semiconductor Industry Rebound Strategy”.

Ministry of Trade, Industry and Energy (September 29, 2016), “Businesses and universities work together to produce semiconductor designers”.

Ministry of Trade, Industry and Energy (October 27, 2016), “Living Together initiative for semiconductor – raising 20 billion won for Semiconductor Hope Fund”.

Ministry of Trade, Industry and Energy (March 30, 2017), “Taking off as a system semiconductor leader in the era of the Fourth Industrial Revolution”.

Oh, Yunmi (2021), “Key contents and outlook of Taiwan’s Semiconductor Strategy”, *World Economy Focus* 4-47, Korea Institute for International Economic Policy.

Overseas Economy Research Center of the Export-Import Bank of Korea (December 2020), “System Semiconductor Industry Status and Outlook”, *2020 Issue Report.*

Republic of Korea Policy Briefing (May 13, 2021), “K-Semiconductor Belt Strategy, with the private sector investing 510 trillion won and government providing a full range of support”.

Yoon, Sungwook, et al. (December 2021), *Research on Development of AI Semiconductor Industry,* KISDI.

〈Overseas〉

Gartner (2021a), "Semiconductor Forecast Database, Worldwide, 4Q21 Update."

Gartner (2021b), "Market Share Analysis: Semiconductors, Worldwide, Preliminary 2021."

Gartner (2021c), "Forecast: AI Semiconductors, Worldwide, 2019-2025, 4Q21 Update."

H.R. 6395 (116th): National Defense Authorization Act for Fiscal Year 2021, https://www.govtrack.us/congress/bills/116/hr6395.

IMD, World Competitiveness Online Database, http://www.worldcompetitiveness.com/online.

McKinsey & Company (2019), "Artificial-intelligence hardware: New opportunities for semiconductor companies."

OECD, Main Science and Technology Indicators (database), http://oe.cd/msti.

S.1260: United States Innovation and Competition Act of 2021, https://https://www.congress.gov/bill/117th-congress/senate-bill/1260.

The White House (June 8, 2021), "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth.", https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

UNCTAD, Information Economy (database), https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx.

About the Korea Information Society Development Institute

The Korea Information Society Development Institute (KISDI) was established in January 1985 as the only professional research organization specialized in policy studies regarding the information and communications sector. KISDI has conducted extensive research on the trend of IT industry, and the transformation of the traditional economic structure in the emerging information society. KISDI also carried out studies on a regulatory framework for fair competition in the telecommunications service market. Along with development of the information and communications sector in Korea, KISDI has contributed to the overall competitiveness of the nation by providing the vision and policy direction to the government to gear up for the knowledge-based society.

For More Information, Please Contact

Joonbae Lee Ph.D. in Economics / joonbae@kisdi.re.kr

Jungsook Oh / redrock5@kisdi.re.kr