– Research Report – APRC-FY2022-RR-07

Asia and Pacific Research Center

South Korea's Science and Technology in the era of the Fourth Industrial Revolution

March 2024

Japan Science and Technology Agency

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Executive Summary

South Korea is an important cooperation partner for Japan especially around science and technology.

This report summarized the recent science and technology policies and strategies of South Korea, in other words, during 2017 to 2023, from Moon to Yoon administration, we call this period as the era of the Fourth Industrial Revolution.

The reason for focusing on the 4th Industrial Revolution is that it has been an important keyword in South Korea since the 4th Industrial Revolution was on the agenda at the World Economic Forum's annual meeting in 2016. And due to the AlphaGo shock the 4th Industrial Revolution have quickly become a hot key word.

Around 2016-2017, at the beginning of the 4th industrial revolution, South Korea's science and technology was not at a high level. in 2016, South Korea placed 25th place in the Swiss investment bank UBS's "Ranking of Countries Ready for the 4th Industrial Revolution". However, South Korea had been working earnestly to resolve the challenges it faced and achieved an innovative progress of science and technology.

This report aims to clarify which policies and projects have led to South Korea's remarkable achievements. Followings are the details of each chapter.

Chapter 1 "Characteristics of South Korea's Science and Technology in the Era of the Fourth Industrial Revolution" analyzed South Korea's weaknesses and strengths at the begging of the Fourth Industrial Revolution.

Chapter 2 "Strategies for Winning the 4th Industrial Revolution" descripted the strategies taken by South Korea`s government, around the legal system, basic research, human resource, and new industries.

Chapter 3 "The current state of science and technology in South Korea and evaluation of strategies" presented the status of South Korea's science and technology by various indicators and evaluated the strategies described in Chapter 2.

Chapter 4 "Prospects for Science and Technology in South Korea" introduced new administration's Key science and technology policies and important strategies. And also, the challenges facing the Ministry of Science and ICT (MSIT).

We hope that this report will be useful one for Japan's policy for science and technology.

Table of Contents

Introduction

This paper focuses on South Korea's science and technology polices and trends from 2017 to the present day.

According to NISTEP's Science and Technology Indicators 2022, South Korea ranked 11th by the number of top 10% most cited papers (average 2018–2020), surpassing Japan, and has experienced remarkable growth and development in recent years. It is thought that South Korea's science and technology development strategies and strategies for fostering talent could serve as a reference for improving Japan's research capabilities and for its science and technology development.

South Korea has continued its generous investment in and support for science and technology; its R&D expenses went from 1.2 billion won in 1963 to 102 trillion won in 2021, showing a steady increase. These expenses increased 9.7% in 2021 compared to the previous year, reaching 100 trillion won for the first time. The continuous investment in science and technology has meant that on a global scale, South Korea is ranked fifth for its R&D expenses (2021), second for R&D expenses as a percentage of GDP (2021), first for the number of researchers relative to the population (2021), and third in IMD's science and technology infrastructure (2022). It has made great strides toward becoming a scientific and technological power.

South Korea emphasizes science and technology to such an extent that Article 127 of the Constitution obliges the state to strive for innovation in science and technology. Every five years, the country sets out a Science and Technology Basic Plan and a Basic Plan for Nurturing and Supporting Scientific Talents, as it works to promote various programs associated with science and technology and to foster talent. Through such efforts, South Korea has become a country with over 580,000 researchers (2021), ranking fourth in terms of the number of FTE researchers (470,000 people) after China, the US, and Japan. In South Korea, 9.1 people per 1,000 are researchers, making it the top country in the world in this respect. Its number of papers has grown year on year, exceeding 76,000 papers in 2020. According to "Analytical Research on the Outcomes of Science and Technology Papers 2011 to 2020" by the Korea Institute of Science & Technology Evaluation and Planning (KISTEP), in 2016 the average number of citations for each South Korean paper fell to 5.13, below the world average of 5.35, but in 2020 it rose to 6.36, higher than the world average of 6.04. It is clear that in those few years the quality of papers rose considerably. Moreover, when it comes to patents, the number of PCT patent applications is increasing each year; in 2021, South Korea was ranked fourth after China, the US, and Japan. Up until 2019, Germany had been ranked fourth, but South Korea overtook Germany in 2020. Academic papers and patents are a key indicator of a nation's research capacity and show that South Korea has experienced steady growth.

This report will focus on the Fourth Industrial Revolution as its keyword, and develop discussions based on its chronology. Moreover, at the start of the Fourth Industrial Revolution, South Korea did not have a high level of science and technology, so this report keeps in mind the question of what kind of strategies and policy promotion enabled its development, and mainly focuses on exploring the policies and programs of the Moon Jae-in and Yoon Suk Yeol administrations. However, the Yoon Suk Yeol administration was established only a year or so ago, so it must be noted that the information covered in this paper is limited to policies and programs that have been promoted predominantly within this year. Furthermore, the author wishes to make it clear that science and technology is the accumulation of day-to-day efforts, and the outcomes and issues touched upon in this report are also evaluated based on the efforts of past administrations, not just those of Moon Jae-in and Yoon Suk Yeol.

South Korea is a nation with a comparatively short history of scientific and technological development, and has a scarcity of resources, but by continuing to emphasize science and technology and focus its investment, it has come to have a global presence, not just an Asian one. Although one cannot say that South Korea's science and technology exceeds that of Japan, the gap between the two countries is closing, and it is undeniable that certain technology fields are demonstrating more development than in Japan. It is hoped that the content of this paper will be of some use in promoting cooperative science and technology projects between Japan and South Korea in the future and help the formulation of Japan's science and technology strategy.

1 Characteristics of South Korea's Science and Technology in the Era of the Fourth Industrial Revolution

First, this chapter will briefly cover the definition and characteristics of the Fourth Industrial Revolution, then analyze South Korea's reaction to the Fourth Industrial Revolution, the changes it caused in South Korean Society, and the position and role of science and technology within this. It will also summarize South Korea's strengths and weaknesses at the time of the arrival of the Fourth Industrial Revolution.

1.1 The characteristics of the Fourth Industrial Revolution and South Korea's reaction

South Korea first started to pay attention to the Fourth Industrial Revolution when it became the topic of discussion of the 2016 World Economic Forum (WEF) Annual Meeting.[1] Therefore, this chapter will cover the situation in South Korean society in around 2016.

In November 2011, the government of Germany, a manufacturing power, published "Industrie 4.0" as a policy for its High-Tech Strategy 2020 Action Plan.[2] This policy was the first to note the idea of the Fourth Industrial Revolution, and advocated for cyber-physical systems (CPS) and smart factories, the core of the Fourth Industrial Revolution. It could be said that Germany's Industrie 4.0 was the trigger for the Fourth Industrial Revolution later becoming a global trend.

Then, in December 2015, Klaus Schwab, Executive Chairman of WEF, published an article in *Foreign Affairs* titled "The Fourth Industrial Revolution."[3] In January the following year, "Mastering the Fourth Industrial Revolution" became the theme of the WEF Annual Meeting, and the definition of this term was discussed for the first time; the Fourth Industrial Revolution was raised as a significant factor that will bring great change to the economy and the structure of industry in the future.

WEF defines the Fourth Industrial Revolution as an age in which physical society, virtual space, people, and things are combined based on IT technologies and the digital revolution. To paraphrase: the Fourth Industrial Revolution refers to a great change moving toward an age in which everything is connected to the Internet and the data accumulated there is analyzed by artificial intelligence, leading to the development of new products and services.

1 See Jang Yoonjong "The Fourth Industrial Revolution: Tasks Facing Korean Industries," *KIET Monthly Industrial Economies June Edition* (June 2016), p8.

2 See Ministry of Internal Affairs and Communications "Information and Communications in Japan White Paper 2018," supplementary report "Industry 4.0." https://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h30/html/nd135210.html
Industrie 4.0, which started at definition level in 2011, rapidly expanded and deepened, and in 2015 a strategy for Industrie 4.0 was outlined in a logical manner through the development of an Industrie 4.0 reference architecture and strategies were published toward the formation of an international standard.

3 Klaus Schwab "The Fourth Industrial Revolution," *Foreign Affairs* (December 2015), https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution.

Table 1-1: Comparison of Industrial Revolutions

Revolution	Details
First Industrial Revolution	Took place in the second half of the 18th century; economic development and changes in the economic structure, mainly in light industries powered by steam and coal. The steam engine was invented in the UK, and factory-based machine industry began.
Second Industrial Revolution	Took place in the second half of the 19th century; economic development and changes in social structure, mainly in heavy industries newly powered by electricity and oil. Together with Edison's invention of the lightbulb and the development of logistics networks, etc., an age of mass production, mass transportation, and mass consumption arrived.
Third Industrial Revolution	Took place in the second half of the 20th century; a revolution in microelectronics that use electronic technology and robotics technology, such as computers, facilitated automation.
Fourth Industrial Revolution	Began in the 2010s; the development of digital technology and the growth of the IoT, in which everything is connected to the Internet, mean that marginal costs and transaction costs can be lowered, and researchers argue that this will invite new changes in economic development and social structure.

Source: Created by the author with reference to "Analysis of industrial structure during the Fourth Industrial Revolution and research survey on the currents state of and issues concerning the development of the IoT and AI (2017)"[4] by the Ministry of Internal Affairs and Communications.

The three characteristics of the Fourth Industrial Revolution are said to be: (1) A connected society (hyperconnectivity): all devices becoming automated as a result of the development of the IoT based on ICT, strengthening person-to-person, person-to-thing and thing-to-thing connections (networks). (2) A super-smart society (superintelligence): links with and use of artificial intelligence (AI) and Big Data become more advanced, and technology, services, and industrial structures become smart. (3) A fusion society: as a result of the formation of networks and technology, etc. becoming smarter, the boundary lines between people, things, technology, and industry disappear, and a great fusion society that spans industries appears.

After the WEF Annual Meeting, the South Korean government introduced the WEF's analysis of the IoT, robotics engineering, Big Data, AI, 3D printers, nanotechnology, biotechnology, quantum computing, and other technologies as key technologies[5] that would lead the era of the Fourth Industrial Revolution, and positioned **data, networks and AI (known as D.N.A.) as the vital technologies that would spearhead innovation in the South Korean economy and**

4 See https://www.soumu.go.jp/johotsusintokei/linkdata/h29_03_houkoku.pdf.

5 WEF "The fourth industrial revolution: what it means, how to respond" *global agenda* (January 14, 2016), https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.

society as a whole.[6] It was widely predicted that there would be tectonic shifts in conventional industrial structures in South Korea, based on the example of ICT companies founded on data and advanced technology entering the top 10 in the global market capitalization rankings (Apple, Microsoft, Google, Amazon, Facebook, etc.).[7]

During this period, there was a dramatic increase in people's interest in the Fourth Industrial Revolution in South Korea, triggered by the AlphaGo shock.[8] This refers to an incident in March 2016, in which famous Go player Lee Sedol was defeated by AlphaGo, an AI developed by Google, four games to one in a Go match. At the time, Lee Sedol was so capable, he was known as humanity's strongest Go player in South Korea,[9] and before the match with the AI the dominant public opinion was that he would be victorious, so his defeat had a huge impact on society, and also served as a catalyst for increased mention of the Fourth Industrial Revolution in the media.

Moreover, the following year saw the 19th presidential election, and each candidate often brought up the Fourth Industrial Revolution in their pledges and during discussions, further increasing interest in the Fourth Industrial Revolution.[10]

At this time, the South Korean Government gave the following reasons for promoting the Fourth Industrial Revolution via its Fourth Industrial Revolution Response Plan.[11] "South Korea faces an economic and social crisis that is both structural and complex due to the chronic low growth of recent years and the increasing seriousness of social issues. However, attention is being drawn to the Fourth Industrial Revolution as new momentum for innovative growth that will enable simultaneous solutions to economic and social structural problems based on an intellectual revolution. Although there has been delayed industrialization in the past, we must make use of our experiences of success in advancing information technology so the Fourth Industrial Revolution can serve as a new opportunity rather than a crisis, leading a tangible Fourth Industrial Revolution and proactively supporting innovative growth based on global science and technology and ICT capabilities, South Korea's strengths, and through this expediting progress toward a human-centered economy in which the fruits of economic growth are distributed among the people."

1.2 The role of science and technology in the Fourth Industrial Revolution

What role does science and technology play in the Fourth Industrial Revolution?

Professor Song Sungsoo of Pusan National University's Department of Physics Education has analyzed previous industrial revolutions in "A Theory of Industrial Revolutions Learned from History: The Fourth Industrial

6 See Digital Today, "The Development of the Fourth Industrial Revolution centered on government and D.N.A." (January 2018).

7 See the top 10 companies by market capitalization, published in August 2016. Seven of the ten (Apple, Google, Microsoft, Amazon, Facebook, GE, China Mobile) were ICT companies.

8 See "South Korean AI research ignited by the AlphaGo Shock: President orders greater investment and large companies get involved," *The Nikkei* (April 10, 2016) (https://xtech.nikkei.com/dm/atcl/mag/15/00150/00075/).

9 See "Strongest in humanity Lee Sedol, shock defeat," *KDX* (March 19, 2016) (https://kdx.kr/ai/video/view/2082).

10 For each candidate's pledges, see "19th Presidential Election/Candidates" (https://namu.wiki/w/%EC%A0%9C19%EB%8C%80%20%EB%8C%80%ED%86%B5%EB%A0%B9%20%EC%84%A0%EA%B1%B0/%ED%9B%84%EB%B3%B4).

11 Joint announcement by relevant ministries, "Human-centered Fourth Industrial Revolution Response Plan for Innovative Growth" (November 2017), https://www.jetro.go.jp/ext_images/world/asia/kr/ip/gov/movement/201804-2.pdf.

Revolution,"[12] and as a result believes that the conditions for an industrial revolution include the following four points. (1) The appearance of innovative technology that will spearhead the revolution; (2) The innovative technology leads to technological innovation, causing a chain reaction; (3) The structure of the economy changes with the industrial revolution; and (4) There is also great change in society and culture. He also suggests that it is the **development of science and technology that leads this sequence of change**, and that the Fourth Industrial Revolution is the product of the combined development of basic science and technology such as math, physics, and biology and the development of ICT such as AI and the IoT.

It can be said that the integration of ICT and the manufacturing industry is a major characteristic of the Fourth Industrial Revolution. In other words, this is the advancement from an era in which machines move according to programing to one in which machines can make decisions through mutual communication. ICT such as the IoT, cloud computing, Big Data, and 5G is used for all kinds of processes, from production schedules to production and distribution processes, and manufacturing systems have become smarter. Furthermore, consumers can check the status of purchased products in real-time through IoT technology, and it can be said that the Fourth Industrial Revolution has led the change from "machines becoming automated and forming smart networks" to "the digitalization of manufacturing processes" and "making products into services."

According to the Executive Chairman of WEF, Klaus Schwab,[13] the technological innovation that will lead the Fourth Industrial Revolution is mainly developing in ICT, and when looked at from the perspective of mega-trends, this technology can be divided into physical technology, digital technology, and biology technology. More details are given in Table 1-2.

12 See Song Sungsoo, "A Theory of Industrial Revolutions Learned From History: The Fourth Industrial Revolution," *STEPI Insight* (February 2017), (https://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE07131140), p11–29.

13 See Klaus Schwab, "The Fourth Industrial Revolution: The Future Predicted by the Davos Conference" (Nikkei Inc., October 2016), p35–55.

Table 1-2: The science and technology that will lead the Fourth Industrial Revolution

Mega-trend	Innovative technology	Details
Physical technology	Unmanned logistics	The capabilities of machines have increased due to the development of sensors and AI, and the unmanned operation of drones, trucks, airplanes, and boats has become possible.
	3D printers	These are used for automobiles, space, medicine, implant treatments, wind power generators, and more.
	Robotics engineering	The communication abilities of robots have increased, and systems to divide labor between people and robots as well as networks connected to the surrounding area are being constructed.
	Graphene	New nanomaterials such as graphene are so thin, they measure 1/100th of a hair, but are 200 times stronger than steel and can conduct heat and electricity.
Digital technology	IoT	Technology and platforms have merged, and the relationship between goods/services/space and people has become closer. IoT technology is used in manufacturing processes, logistics, everyday life, cities, energy, clothing and even accessories.
	Blockchain systems	All kinds of encodable transactions will become possible through blockchain systems, including Bitcoin, issuing certificates, insurance claims, medical records, voting, and more.
Biology technology	Genetics	Mapping human genomes once needed more than 10 years and 2.7 billion dollars to complete; now, it is possible with a few hours and around 1,000 dollars.
	Synthetic biology	This could contribute to treatments for cancer, heart disease, and more. It may also be used for agriculture and the production of biofuels.
	Genome editing	This technology accurately manipulates only the target genes among a number of genes. It is used for selective breeding for crops.

Source: "The Fourth Industrial Revolution: The Future Predicted by the Davos Conference"

Table 1-2 includes certain science and technology representative of the Fourth Industrial Revolution, but in reality, there is a great deal of integrated technology that crosses fields, with boundaries becoming ambiguous. Take robotics engineering as an example: here, robotics engineering itself is classed as physics, but gathering and transmitting data via sensors relies on ICT, and analyzing this in real-time and making decisions is accomplished by the power of Big Data and AI. Moreover, calculating the movement and path of robots is achieved through the development of mathematical fields. It goes without saying that ICT is based on the development of math and physics, but one can also say that it was innovation in computing technology that has enabled the realization of progress to date. The development of basic research areas such as math and physics has come together with the evolution of computing technology, and various forms of ICT that were merely theoretical have become reality.

Thus, it is clear that science and technology play a central role in the Fourth Industrial Revolution, and the South Korean government therefore began investing in science and technology and making plans for development strategies so it could win in the era of the Fourth Industrial Revolution. First, it was important to understand the country's strengths and weaknesses to set out a more effective strategy.

1.3 The strengths and weaknesses of South Korea regarding the Fourth Industrial Revolution

Table 1-3: The strengths and weaknesses of South Korea regarding the Fourth Industrial Revolution

Strengths	Weaknesses
· World-class information communication infrastructure · Global leader in accessories such as semiconductors, displays, and batteries · Ability to leverage its strengths in the manufacturing industry to create components and devices for main Fourth Industrial Revolution industries · No. 1 in the world by the number of researchers per 1000 people · Quick to respond to paradigm shifts	· Lack of technological capability and manpower in core technologies · Existing laws and policies causing bottlenecks in regulations for new industries · Main methodology for technological development was to follow advanced countries · A social structure with numerous disparities is a disadvantage to innovation—resources and manpower were concentrated in large companies and metropolitan areas · A decreasing birthrate leading to an aging society

First, what level were South Korea's scientific and technological capabilities in around 2016, when the Fourth Industrial Revolution was first discussed? This is detailed below.

In 2016, the Swiss investment bank UBS ranked South Korea 25th in its national rankings in preparation for the Fourth Industrial Revolution (*Switzerland was ranked first, the US fifth, Japan 12th, and Taiwan 16th).[14] This was a comprehensive evaluation based on five factors—the flexibility of the labor market, technology levels, education levels, infrastructure, and legal safeguards—but South Korea's evaluation was far off that of a global leader, especially with the flexibility of its labor market ranked 83rd and its legal safeguards ranked 62nd. The low evaluation of its labor market flexibility was thought to have been affected by its industrial structure, centered on manufacturing companies, and its economic structure, centered on big companies. Even looking at the growth rate of listed company sale prices connected to the Fourth Industrial Revolution, the yearly average in South Korea was 9.7% between 2006 and 2010, but this fell 1.8% between 2011 and 2015. Meanwhile, the growth rate in leading countries such as the US, Japan, and Germany rose in the 2011–2015 period compared to 2006–2010. Moreover, the appearance of new technologies and services connected to the Fourth Industrial Revolution in these countries meant that there was dramatic corporate change (corporate turnover rates: US 36.6%, China 22.2%, Germany 20.8%), while the corporate turnover rate remained at 14.4% in South Korea; it was clear that the development of new industries was weak.[15] With regard to the legal safeguards, the large number of regulations concerning the promotion of new industries among companies and the inappropriate distribution of resources led to the country's low evaluation.

Moreover, according to the 2016 IMD (International Institute for Management Development) World

[14] "South Korea Ranked 25th in global preparedness for Fourth Industrial Revolution," *HANKYOREH* (August 16, 2016) http://japan.hani.co.kr/arti/economy/24919.html.

[15] Cheonji Ilbo "South Korea's preparedness for the Fourth Industrial Revolution lacking, only 25th in the world," (August 2016), https://www.newscj.com/368923

Competitiveness Yearbook, South Korea was ranked 29th, having fallen from fourth place the previous year. Its scientific and technological infrastructure was 8th, which was also lower than its rank of 6th the previous year. In light of such data, South Korea's scientific and technological competitiveness was not at a level that could be called high.

Before formulating its strategy, South Korea's strengths and weaknesses vis-à-vis the Fourth Industrial Revolution were analyzed by the government's science and technology thinktanks, the Science and Technology Policy Institute (STEPI),[16] KISTEP,[17] the National Research Council for Economics, Humanities and Social Sciences (NRC),[18] and other organizations. Their main findings are summarized below.

1.3.1 Weaknesses

Conventionally, a scarcity of resources, low birth rate, and an industrial structure centered on large companies and the manufacturing industry are continually noted to be challenges for South Korea; the following points can be raised when summarizing the challenges faced by South Korea at the start of the age of the Fourth Industrial Revolution.[19]

1. Based on the fact that South Korea's world competitiveness ranking fell according to IMD and WEF, it can be said that the country had low socioeconomic innovative capacity in general and was not prepared for new industries. It did not reach one of the key indicators of an advanced country (30,000 dollars or more GNI per person) in 2017. It exceeded 20,000 dollars in 2006, and for the next 11 years its economic growth continued at a glacial pace.[20]
2. When it came to scientific and technological innovation, South Korea had achieved development by following advanced countries, but in the era of the Fourth Industrial Revolution, it became clear that merely playing catch-up would not create innovation, so the existing method had reached its limits.[21]

16 STEPI, "The key topic of the challenges of the Fourth Industrial Revolution and national strategy," *STEPI INSIGHT* (June 2017) p20-21.

17 See National Research Council for Economics, Humanities and Social Sciences, "The socioeconomic impact of the Fourth Industrial Revolution and suggested responses" *Collaborative Research Series on Future Society* (November 2017) (https://www.nkis.re.kr:4445/subject_view1.do?currentPage=1&otpId=NRCS00052937&otpSeq=0&eoSeq=66941&otcNm=%ED%98%91%EB%8F%99%EC%97%B0%EA%B5%AC%EB%B3%B4%EA%B3%A0%EC%84%9C&searchSelect=&searchWord=&volId=&returnPage=popularity_list.do&otcCd=RC1&agcCdFilter=&otcCdFilter=&listPerPage=), p20–32.

18 See p9–16 from note 17 above. Some additional information about the NRC: it contributes to national research and development projects and intellectual property projects as a research organization under the Prime Minister. There are 43 research organizations and government thinktanks associated with it, including the Korean Development Institute (KDI) and Korea Information Society Development Institute (KISDI). It mainly makes proposals concerning policies and plans necessary for national development. This research organization also periodically holds research councils, hence its name, but also acts as a thinktank.

19 See p8–10 from note 17 above; KISTEP "Key Science, Technology, and Innovation Policies and Challenges in Response to the Fourth Industrial Revolution" *Issue Paper* (April 2017), (https://search.naver.com/p/crd/rd?m=1&px=612&py=759&sx=612&sy=459&p=hV6R6wp0J14ssnURfClssssst%2Fd-212694&q=4%EC%B0%A8%EC%82%B0%EC%97%85%ED%98%81%EB%AA%85+%EB%8C%80%EC%9D%91%EC%9D%84+%EC%9C%84%ED%95%9C+%EC%A3%BC%EC%9A%94&ie=utf8&rev=1&ssc=tab.nx.all&f=nexearch&w=nexearch&s=Kcv%2Bvj6TOr8O3oUqpOAz0w%3D%3D&time=1656919088343&abt=%5B%7B%22eid%22%3A%22SBR1%22%2C%22vid%22%3A%22225%22%7D%5D&a=web_gen*D.link&r=4&i=a00000fa_36b419a37d44c7a50d7dd09d&u=https%3A%2F%2Fwww.kistep.re.kr%2FboardDownload.es%3Fbid%3D0031%26list_no%3D35327%26seq%3D7881&cr=1), p21–24.

20 In the following year (2018), the GNI per person exceeded 30,000 dollars in South Korea. This significant achievement occurred 12 years after it exceeded 20,000 dollars.

21 While the market share of automobiles, steel, and ships, which were South Korea's main industries, continued to fall, its new industries of Fintech, electric vehicles, and mobile healthcare did not have a strong presence, so maintaining industrial competitiveness on par with advanced counties was an urgent issue.

3. South Korea's technological capabilities in 5G, AI, and the IoT, areas that would lead the Fourth Industrial Revolution, were quite low compared to advanced countries. According to KISTEP's Technology Level Evaluation (2016),[22] if the highest-ranked nation had a technology capacity of 100, South Korea's technology capacity was 85.1 in 5G, 77.3 in Big Data, 80.7 in the IoT, and its AI scored 78.5 in intelligent interactive technology and 83.3 in sensory perception and processing technology, meaning it needed to strengthen its competitiveness, Moreover, it lacked talents with detailed knowledge of these core technology fields. In China, over 2,000 people gained doctorates in AI fields each year, whereas only 30 people did in South Korea (2017).[23]
4. To ensure the growth of new business industries from the fusion of science, technology and ICT, and to avoid a developmental bottleneck in technology and industry caused by regulations from existing laws and policies, the country needed to revise laws concerning data and personal information. It also had to develop platforms and security systems for the appropriate access to and management and use of data.
5. The economic system was centered on large companies that accounted for 52.4% of production but made up only 0.1% of companies numerically. This industrial structure, with extreme disparity between large companies and small and medium-sized enterprises (SMEs), was also a weakness.[24] It resulted in a dropping employment rate, and the employment coefficient recorded in 2016 was a historic low of 17.4.[25]
6. Even though various projects were developing to stimulate local areas, 49.5% of the population was concentrated in metropolitan areas, and the difference in economic development levels and income was increasing day by day.[26]
7. The effects of entrance exam competition, employment competition, sharply rising real estate prices and education fees, and income disparity meant that the number of people remaining single continued to increase; the birth rate recorded in 2016 was the lowest among the OECD 22 nations (total fertility rate: average number of children born to a woman during her lifetime. This was calculated as 1.25 in South Korea, and 1.44 in Japan). It is predicted that in 2026 South Korea will become a super-aging society, exceeding the aging society.[27]

Multiple challenges are stated above, but the sluggish economic growth and decreasing birth rate are not unique to South Korea—they are issues faced by many advanced countries, including Japan. The existence of these challenges does not in itself immediately require pessimism in terms of the future scientific and technological development in South Korea.

22 See KISTEP, "2016 Technology Level Evaluation" (June 2017), p65 onwards. https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201800037416&dbt=TRKO&rn=

23 East Asia BizN "South Korea, 30 AI doctorates in a year, China, 2,000" (March 2017), https://bizn.donga.com/3/all/20170305/83179206/1.

24 This is because it is difficult to quickly and flexibly respond to demand for industrial change and the creation of technological innovation within a structure with such large disparities. Moreover, South Korea's industry is centered on the manufacturing industry, and there were few companies riding the Fourth Industrial Revolution wave of "ICT x manufacturing industry," so there was a sense of a delay in the growth of the manufacturing industry as a whole.

25 The number of people that must be employed for GDP 1 billion won of production (equivalent to 100 million yen).

26 Because large companies and prestigious universities are concentrated in metropolitan areas, the competition for education and entrance exams is fierce, and the university entrance examination, started in 1945, has been revised 19 times before July 2022. The happiness index for young people ranked 20th among the 22 OECD countries (2016).

27 An aging society occurs when the number of people aged 65 and over exceeds 7% of the total population; if they exceed 14%, it is an aged society, and if they exceed 21%, it is a super-aging society.

1.3.2 Strengths

(1) Technology

1. South Korea is a country that boasts a world-class level of information communication infrastructure, and the spread of smartphones and the Internet is on a level that surpasses advanced countries in America and Europe.

The amount of data used per person had already reached three times the world average in 2016.[28] The strength of having such an information communication industry was that there were areas that worked as advantages when shifting to a digital society; there were also sufficient expectations of the creation of new industries through a fusion of ICT and software (SW).

2. South Korea is competitive on a global level in accessories such as semiconductors, displays, and batteries. The country boasts a commanding share of the memory semiconductor market in particular. It can be said that the sales of Samsung Electronics in the semiconductor business rival those of Intel and TSMC.

3. The country's experience and know-how, accumulated over many years in the manufacturing industry, could be used to create components and devices for the main industries of the Fourth Industrial Revolution.[29]

4. South Korea's science and technology was reliant on the method of pursuing advanced countries. This method was a double-edged sword; it also had certain merits. First, there was reduced risk in not having to pioneer new markets, and the country could make use of the infrastructure created by the front runners. If South Korea could make use of the experiences of the pioneering countries, it could eliminate dangerous elements in advance, reducing trial and error. Moreover, using the strengths of leading companies as a benchmark, the country could quickly read the trends in technological development and turn crises into opportunities through timely investment.

(2) Talent

1. The number of researchers per 1,000 people in South Korea is on par with the highest in the world,[30] and the country strives to foster and use research talent.

2. There are many excellent managers with enough ability to handle a paradigm shift.[31]

3. The improvement of national competitiveness and the progress of globalization meant that more and more

28 In 2016, the amount of data per smartphone user in South Korea was 4.9 GB, a number three times the world average.

29 For example, if the automobile, ICT, parts manufacturing, and electricity companies worked together, they could secure the parts and technology needed for electric vehicles and autonomous driving without relying on advanced countries. South Korea has few resources compared to other countries, but even in a challenging environment, it has created competitive products by combining resources, and value of this experience is a major strength.

30 According to OECD data, in 2017 South Korea ranked second to Denmark in the number of researchers per 1,000 people and has ranked first since 2018.

31 Even when South Korea was in the process of transitioning from phones mainly for voice calls to smartphones, Samsung Electronics, LG Electronics, and other companies were able to lead the android market thanks to the work to proactively popularize smartphones. Furthermore, various companies quickly took the chance to make timely investments during the switch from analog to digital, and started overtaking Japanese companies in the semiconductor, LCD, and TV fields. Such a paradigm shift came with changes large enough to overturn common practice, so the leaders of each company took on great risks and responsibilities. On top of this sense of responsibility, these leaders needed the ability to make accurate judgements and be a bold driving force, as well as the ability to respond flexibly. The fact that South Korea came out on top of several paradigm shifts is the proof that it had many companies with excellent management that could quickly read and action trends. In the era of the Fourth Industrial Revolution, and in a time of further paradigm shifts, the search for and establishment of optimal development routes by outstanding company management, taking into account the various circumstances of South Korean society, is a promising area.

South Korean companies were emerging onto the world stage. Research organizations also had more offices in other countries. These companies and research organizations establishing bases around the world were creating a vital network to support the development of the South Korean economy and its science and technology. Furthermore, according to data from South Korea's Ministry of Education,[32] the number of South Korean exchange students researching in higher education institutions around the world was consistently over 20,000 each year—and to South Korea, exchange students are a vital source of talent to lead the future of society, and a network that can be put to use.

(3) Markets

1. South Korea's domestic market is sensitive to trends and fashions, and is interested in new products and services, with a lot of so-called "early adaptor" customers, making it a testbed for new technology.

2. In the global market, on top of existing products such as smartphones, home appliances, and automobiles, Korean wave content (dramas, manhwa, K-POP, etc.) and messengers (such as KakaoTalk) are well-loved around the world, meaning there are many reliable customers and the economic outcomes from the power of this content are significant.[33]

To conclude, this section has summarized the outcomes of contemporary analysis carried out by South Korea about its strengths and weaknesses regarding its scientific and technological capabilities during the initial stage of the Fourth Industrial Revolution; the following chapter shows how the government responded in order to overcome these issues once it was aware of and had taken in the situation.

[32] According to year-by-year data in the Ministry of Education's "2021 Statistics concerning South Korean students studying in foreign higher education institutions," the number of South Korean exchange students in other countries was 220,000 in 2016, 230,000 in 2017, 220,000 in 2018, and 210,000 in 2019, so there were no major changes over these years. However, there were 190,000 in 2020, and a record low of 150,000 in 2021, thought to be due to the effects of COVID-19. See https://www.moe.go.kr/boardCnts/viewRenew.do?boardID=350&boardSeq=90124&lev=0&searchType=null&statusYN=W&page=1&s=moe&m=0309&opType=N.

[33] With the Korean wave boom in Japan, the global expansion of South Korean fashions and cosmetics also increased. The boom was not limited to culture, as it also served as an important economic driver. Thus, one of South Korea's great strengths was that it maintained a wide range of customers, both domestic and foreign.

2 Strategies for Winning the Fourth Industrial Revolution

This section describes the actions taken by the South Korean government to win in the era of the Fourth Industrial Revolution.

"Challenges for the Next Administration to Lead the Era of the Fourth Industrial Revolution," published by the government in 2022, introduces the strategies that the government enacted and the projects it promoted between 2017 and 2022 to lead the era of the Fourth Industrial Revolution. These are mainly split between the legal system, basic research fields, nurturing talent, and support for industries. In this vein, this paper will first introduce South Korea's science and technology administration, then look at how the industrial revolution was promoted, the development of policies and the legal system, measures to strengthen basic research, measures to develop new industries, and measures to foster digital talent. Evaluations of the efforts made toward these policies and projects (outcomes and issues) can be found in the following chapter 3.

Before delving into this topic, this chapter will touch upon South Korea's science and technology administration system and decision-making process to aid in an understanding of South Korea's science and technology situation.

2.1 South Korea's science and technology administration system and decision-making process[34]

2.1.1 South Korea's science and technology administration system

South Korea is a country that emphasizes science and technology to such an extent that Article 127 of the Constitution obliges the state to strive for innovation in science and technology. In contrast to Japan, the tendency in South Korea is to take the opportunity of a change in government to carry out wide-ranging organizational change, so the ministry that is responsible for science and technology changes a lot depending on the administration. Following various twists and turns, including integration with and separation from the Ministry of Education, science and technology **has been the responsibility of the Ministry of Science and ICT (MSIT)** since 2017 under the Moon administration. This is the equivalent of the Japanese Ministry.

A concise summary of South Korea's administration system for science and technology: it **mainly operates based on the Presidential Advisory Council on Science and Technology (PACST),[35] which functions as the highest decision-**

[34] For the details of 2.1, see KISTEP, "Administration Systems for Science, Technology, and Innovation in America and Japan and Their Implications" (2022); KISTEP, "The Current Diagnosis of Science and Technology Administration Systems and Research on the Direction of Their Development" (2021); and KISTEP, "Innovation Challenges for the Strategic Improvement of the Government's R&D Budget Compilation" (2018).

[35] Presidential Advisory Council on S&T

making organization, MSIT, as the ministry responsible for science and technology, and MSIT's Office of Science, Technology and Innovation Coordination. Moreover, the Aid of Science and Technology is part of the Office of the President of the Republic of Korea, and is involved in activities to advise and discuss science and technology policy. A special aid can also be appointed at the discretion of the President, but this is an honorary position without financial remuneration. Despite this, such secretaries have played major roles in some administrations.[36] Under the Yoon administration, a special secretary rose to the rank of a minister and was appointed Special Aide of Education and Science and Technology, but resigned after around one month for health reasons and the position is, as of March 2023, still vacant.

PACST has an advisory role, making suggestions to the President, and also coordinates and deliberates key science and technology policies. It holds discussions on necessary matters through its Advisory Council, Deliberative Council, and General Meetings.

MSIT is responsible for scientific and technological R&D, cooperation, promotion and programs to promote the information communication field.

The Office of Science, Technology, and Innovation Coordination under MSIT pulls together science and technology policy. This office is the secretariat for PACST's Deliberative Council and is simultaneously responsible for bringing science and technology policy together, discussing and adjusting the R&D budget, and evaluating outcomes.

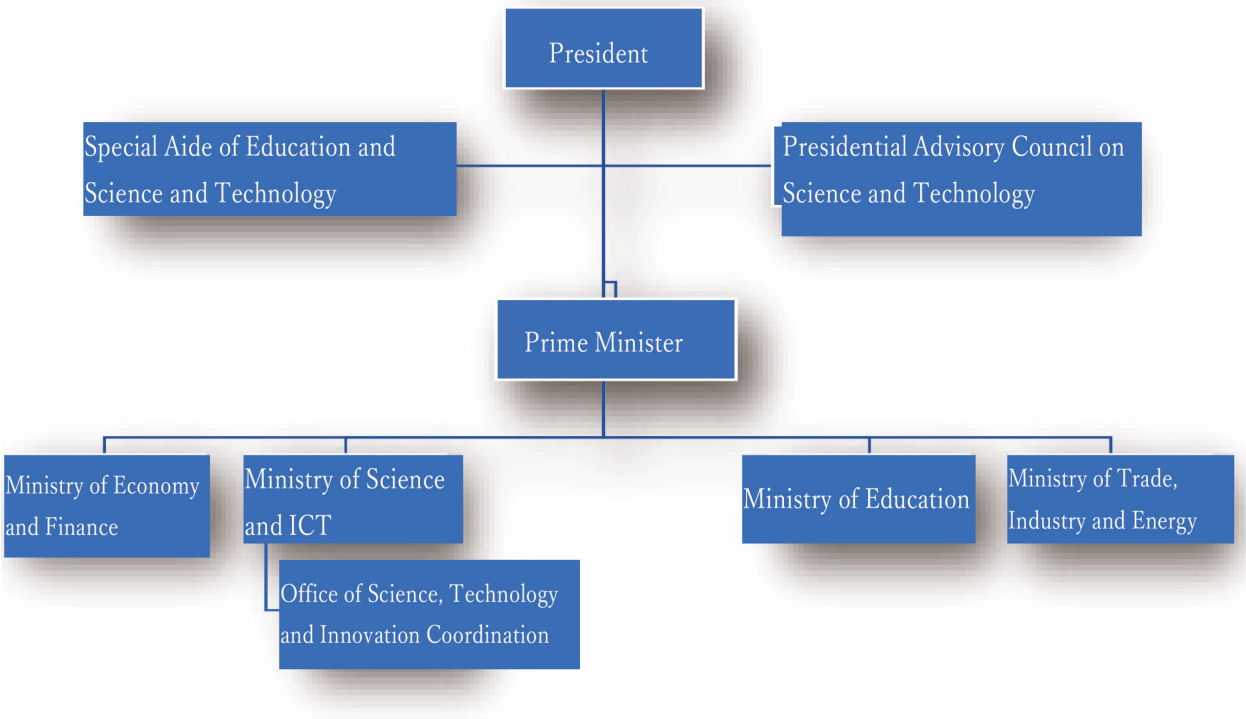


Figure 2-1: The administration system for science and technology under the Yoon administration

Source: Created by the author based on various documents

[36] Notably, there were eight special aides under Lee Myung-bak's administration, and two of these were employed full time; their role was so large that a separate office was created for them. At the time, there were also articles introducing the special aides as people with real power. A relevant article: http://www.ilyoseoul.co.kr/news/articleView.html?idxno=110025

(1) Presidential Advisory Council on Science and Technology (PACST)

In the past, this was split into the Presidential Advisory Council on Science and Technology and the Presidential Deliberative Council on Science and Technology. These were combined in 2018,[37] and became the present-day PACST. The President acts as the Chairperson of PACST, and the Council is made up of around 30 members, including the Vice Chairperson. These members include heads of universities and professors; directors of research institutions; civilian experts in areas such as science and technology, politics, and economics, e.g. directors of corporate technology research institutes; and people from government ministries involved in science and technology.[38] PACST engages in deliberations on topics such as policies connected to science and technology; human resource policies linked to innovation and industrialization; the coordination of science, technology and innovation in regional areas; coordination connected to R&D plans and projects; and matters concerning the management of R&D budgets.

It is divided into the Advisory Council, Deliberative Council, and General Meeting, but various committees exist under the umbrella of the Advisory and Deliberative Councils. PACST is organized as follows:

37 The Act on the Presidential Advisory Council on Science and Technology was revised on April 17, 2018, and both organizations merged. The aim of the merger was to strengthen the connection between functions such as science and technology advice, deliberation, and coordination.

38 For a list of members, see https://www.pacst.go.kr/jsp/adv/advMember.jsp.

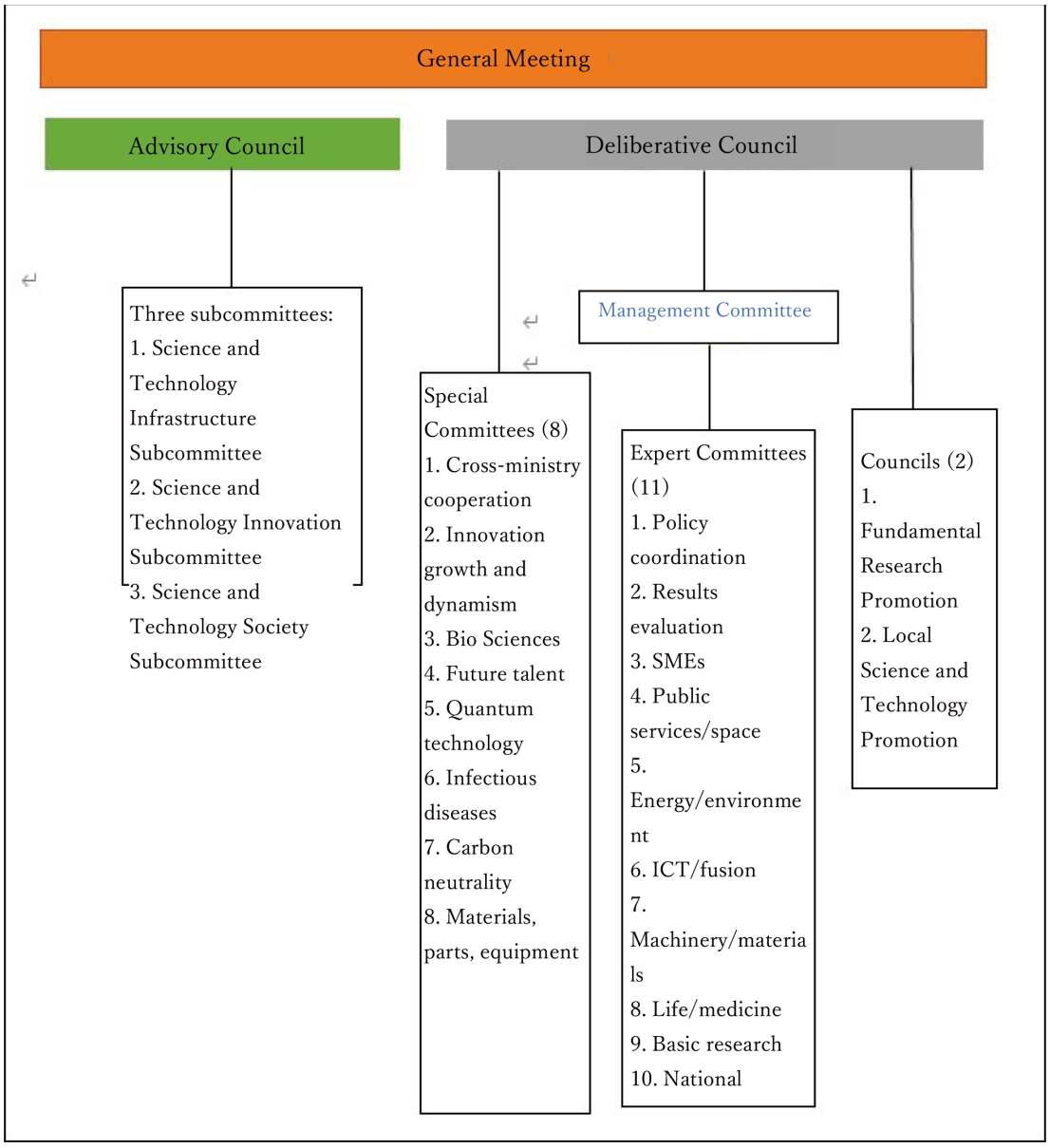


Figure 2-2: Organization chart of the Presidential Advisory Council on Science and Technology

Source: Presidential Advisory Council on Science and Technology website

1. Advisory Council

The Advisory Council consists of the President (Chairperson), Vice Chairperson, 11 civilian committee members, and one supervising member, and runs subcommittees for the preliminary review of matters. Depending on the nature and type of matter, one or more subcommittees may be held—the Science and Technology Infrastructure Subcommittee, the Science and Technology Innovation Subcommittee, and the Science and Technology Society Subcommittee. The content deliberated by the Advisory Council is mainly science and technology innovation and development strategies, policy direction, and matters associated with improvements to the science and technology system.

2. Deliberative Council

The Deliberative Council consists of the President (Chairperson), Vice Chairperson, nine civilian committee members, five government council members, and one supervising member. A Management Committee, special committees, expert committees, and councils operate under this Council, which also carries out preliminary reviews of matters

and consults/coordinates between ministries. The expert committees consider budgets and policies based on the technological field. The special committees develop focused investigations and discussions about the most important core technologies and the eight so-called key strategic areas. In addition to promoting key science and technology policies and coordinating relevant polices, the Deliberative Council deliberates matters relating to the distribution, coordination, and management of R&D budgets, and matters concerning the investigation, analysis, and evaluation of R&D projects.

3. General Meeting

The General Meeting is, as its name suggests, composed of all council members of PACST, and is held when there are matters for which the opinions of all council members must be heard or communicated.

(2) MSIT and its Office of Science, Technology, and Innovation Coordination

As its name suggests, MSIT is the ministry that manages science, technology, and information communication. MSIT's work is divided between the 1st Vice Minister, 2nd Vice Minister, and the Office of Science, Technology and Innovation Coordination, with the 1st Vice Minister responsible for work relating to science and technology, the 2nd Vice Minister responsible for work relating to information communication, and the Office responsible for the work of bringing together and coordinating science, technology, and innovation policy.

To give further details, the 1st Vice Minister's work involves general scientific and technological research and development, international cooperation, and fostering and employing science and technology talents. The 2nd Vice Minister's work is related to information communication, the digital world. software, AI, networks, broadcasting, and more.

The Office of Science, Technology and Innovation Coordination was established in 2004, but at this time the head of the Office was the same level as the head of a ministry[39] (equivalent to a cabinet minister in Japan). After the change of government, the head went down one rank to the level of vice minister in 2008. Since then, the rank of vice minister has been maintained, but in light of the importance of the role, the head has participated in meetings of ministers and is involved in determining various policies. The Office, as the command center that brings together actual science and technology policy, is involved in establishing and coordinating science and technology policy, distributing and coordinating the R&D budget and evaluating projects and organizations, preliminary feasibility studies, and more.[40]

The Office of Science, Technology and Innovation Coordination has its head, a coordinator, and the Science and Technology Policy Bureau, R&D Investment Coordination Bureau, and the Performance Evaluation Policy Bureau fall

[39] As the deputy prime minister for science and technology system was introduced with the aim of promoting science and technology during the Roh Moo-hyun administration, the Office of Science, Technology and Innovation Coordination under them was also at the level of a minister. The deputy prime minister system was abolished during the Lee Myung-bak administration, and with this the level dropped to vice minister.

[40] A preliminary feasibility study is a preliminary investigation of the feasibility of a project that is to receive money from the national budget. The system was introduced in 1999 to reduce wasted budget and project risks. Until the Moon Jae-in administration, these surveys were carried out for projects of 50 billion won or more (30 billion won or more in the case of financial support), but since the Yoon Suk Yeol administration, they have been carried out for projects of 100 billion won or more (50 billion won or more in the case of financial support). The Ministry of Trade, Industry and Energy has reduced the regulations surrounding the process for private-sector companies to carry out R&D, which has clarified that the aim of this revision is to facilitate innovation. Preliminary feasibility studies were introduced more than 20 years ago, and during this time GDP has increased by a factor of 3.3 and prices by a factor of 1.6, but the amounts for the surveys have not been altered at all; the average survey time is 18.4 months, far beyond the survey guidelines of nine months. In light of the characteristics of South Korean society, with private-sector R&D expenses exceeding 70% (76.8% in 2020), these revisions are conceivably appropriate measures to facilitate corporate R&D and innovation.

under its management.

1. Science and Technology Policy Bureau

The main duties of the Science and Technology Policy Bureau include establishing medium- and long-term policy aims and direction for science and technology development; unifying, planning, and coordinating national science and technology policy; formulating and promoting the Science and Technology Basic Plan, organizing various meetings to coordinate science and technology policy, and identifying and responding to the topics of discussion in meetings.

2. R&D Investment Coordination Bureau

The R&D Investment Coordination Bureau is responsible for distributing and coordinating the R&D budget, formulating medium-and long-term investment strategy, formulating technology development strategies in key fields, optimizing R&D investment systems, etc.

3. Performance Evaluation Policy Bureau

The Performance Evaluation Policy Bureau is engaged in evaluating national R&D projects and organizations; investigating, analyzing, and carrying out preliminary feasibility studies of national R&D projects, and working to improve systems relating to R&D.

(3) Korea Institute of Science & Technology Evaluation and Planning (KISTEP)

KISTEP supports the work of PACST and MSIT's Office of Science, Technology and Innovation Coordination. KISTEP has fallen under the authority of the ministry responsible for science and technology[41] (currently, MSIT) since 1999, and supports the formulation and coordination of policies and plans for science and technology, and the evaluation of R&D projects.

According to KISTEP's annual report 2021,[42] its budget is 74.4 billion won, and it has 295 members of staff (of these, 205 people are research staff). It publishes 62 reports each year, and the organization holds at least 30 online seminars a year.

KISTEP is a subsidized organization (public organization for research objectives) directly under MSIT, and is made up of six offices (Office of S&T Policy Planning, Office of Strategic Technology Planning, Office of National R&D Coordination & Evaluation, Office of National R&D Evaluation & Analysis, Office of R&D Budget and Feasibility Analysis, Office of Planning and Management) and two centers (the Ministry's Integrated R&D Information System IRIS Management Group and the Innovation Coordination Project Promotion Center).

The main role of KISTEP is to support PACST's work and MSIT command center functions across science and technology policy overall; more specifically, it supports a wide range of work, including formulating and coordinating science and technology policy and planning; distributing the budget for, coordinating, and evaluating R&D projects; preliminary feasibility studies, and improving systems for R&D.

41 With the changes in administration, the name of the ministry responsible for science and technology was changed multiple times and included the Ministry of Science and Technology and the Ministry of Education, Science and Technology. It is now MSIT.

42 See https://www.kistep.re.kr/board.es?mid=a10201060000&bid=0032&act=view&list_no=42719.

2.1.2 Decision-making Process

(1) Decision-making process

In the science and technology field, **a Science and Technology Basic Plan is created once every five years, and one can say that this is the highest-level plan.** The medium and long-term policy aims, and direction for the next five years are decided through this plan. This plan is based on Article 7 of the Framework Act on Science and Technology, and has been formulated for periods of five years from 2003. MSIT's Office of Science, Technology and Innovation Coordination proposes a draft of the Basic Plan, which is established and published after deliberation by PACST. The Basic Plan includes science and technology goals and policy direction; implementation strategies for policies and projects connected to industry, talent and regional innovation; strategies to strengthen innovation in universities, research institutions, companies, and other organizations; and details relating to the promotion of basic research.

PACST holds deliberations concerning the government plans and strategies that have been submitted; more opinions are expressed in deliberations after submission than during preliminary coordination before active submission. Moreover, **PACST does not determine all policies—policies and projects relating to science and technology are discussed in many different meetings, including secretariat meetings concerning science and technology or economics. Projects relating to science and technology are developed in many ministries, not just MSIT.**[43] For example, the Ministry of Education is involved when it comes to nurturing talent, and the Ministry of Trade, Industry and Energy and Ministry of SMEs and Startups are involved in industry. Looking at a breakdown of the 2021 R&D budget, MSIT received 1.9%, the Ministry of Trade, Industry and Energy 18.1%, the Defense Acquisition Program Administration 15.8%, the Ministry of Education 8.6%, and the Ministry of SMEs and Startups 6.3%.

According to KISTEP data, over the four years from June 2017 to July 2021, there were more than 800 subjects relating to science and technology that were discussed/established, and 30% of these were decided after deliberation by PACST councils.

The more ministries are involved in science and technology projects, the more pluralistic the decision process for science and technology policy becomes. The country had attempted to create a unified system for science, technology, and innovation centered on PACST, but in fact there are diverse decision-making organizations, and many policies are implemented by each ministry themselves, being considered and formulated in meetings with the science and technology minister, ministers involved in economics, and ministers involved in the New Deal, etc.[44] Moreover, these decision-making organizations do not have a system through which they share information with each other, so it is said that there are limits to plans and coordination brought together by the ministries.

However, similar to many advanced countries, in the R&D field Japan's Ministry of Education, Culture, Sports, Science, and Technology promotes basic and academic R&D mainly through universities and public research

[43] To add to this: as the times have changed, science and technology areas have widened, and so rather than just technology, industry and information have become important parts of science and technology; this is one cause. The emphasis on science and technology from the Kim Dae-jung administration to the Roh Moo-hyun administration was accompanied by an emphasis on science and technology development in the country as a whole, so many ministries started to focus on R&D projects, beginning the decentralization trend and leading to the present situation with a lack of command center.

[44] Groups involved in policy determination include meetings between the science and technology ministers, meetings between ministers involved in economics, meetings between ministers involved in the New Deal, the future talent special committee, the biosciences special committee, the Innovative Growth Big 3 Promotion Conference, the council to strengthen the competitiveness of materials, parts, and equipment, and the Carbon Neutrality Commission.

organizations, with other ministries such as the Ministry of Economy, Trade and Industry promoting application, in the R&D field, development, and commercialization of R&D based on their various jurisdictions, and there are no issues caused by the fact that the technology being research by different ministries overlaps.

(2) R&D budgeting process

MSIT has the authority to create R&D budgets for science and technology, but these are ultimately determined after deliberation by the Ministry of Economy and Finance (MOEF) and National Assembly (the Budget and Accounts Committee (Special Committee) thereof). Therefore, the Ministry of Economy and Finance also plays an important role, in addition to MSIT, in R&D budgeting.

First, MSIT's Office of Science, Technology and Innovation Coordination decides the general direction of R&D investment, and the MOEF determines the upper limit for the budget and the policy for budgeting. Next, each ministry submits a draft budget request and the Office of Science, Technology and Innovation Coordination and MOEF coordinate budget distribution and create a draft of a government bill for the budget (budget draft). Finally, MOEF submits the draft and a financial management plan to the National Assembly. The National Assembly holds deliberations and approves them after appropriate revisions, and the budget is confirmed. The timeline is as follows.

Table 2-3: R&D budgeting process

Period	Process
October to December (previous fiscal year)	Each ministry submits their opinions on priorities for national R&D projects to MSIT. MOEF notifies each ministry of its policy behind creating the financial management plan.
January to March	Each ministry submits a medium-term project plan to MOEF and MSIT. MIST determines the general direction of government R&D investment for the next fiscal year, and PACST deliberates and makes a decision on this. MOEF sets an upper limit for the R&D budget for the next fiscal year, and notifies each ministry of the budgeting policy.
May to August	Each ministry submits a draft budget request to MOEF and MSIT. Each ministry provides explanations of the validity of their budget request and their project promotion plans, etc. to MOEF and MSIT. MSIT and PACST prepare a draft of the budget distribution/coordination for national R&D projects for the next fiscal year.
September to October	MOEF submits a government R&D budgeting draft and national financial management plan to the National Assembly.
November to February (following year)	The final budget is confirmed after it is deliberated in the National Assembly.

(3) Evaluation process for R&D outcomes

Once every five years, MSIT's Office of Science, Technology and Innovation Coordination creates a Basic Plan for R&D Performance Evaluation for national R&D projects and implements, the management and evaluation of outcomes in accordance with this. The Basic Plan for R&D Performance Evaluation sets out the direction of evaluation, the

subjects and methods, establishes goals and indicators for outcomes, and matters concerning the use of outcomes that have been evaluated.

During the performance evaluation process, the organization carrying out the R&D project first carries out its own evaluation, then the Office of Science, Technology and Innovation Coordination implements a further evaluation of the self-evaluations of each organization in accordance with the evaluation guidelines. Some projects, for example, projects for important policies and/or require collaboration or coordination with multiple organizations, do not carry out self-evaluations, and are directly evaluated by the Office of Science, Technology and Innovation Coordination.

2.1.3 Characteristics and issues of the administration system for science and technology in South Korea

The following is a summary of the characteristics and issues of the administration system for science and technology in South Korea, based on the above analysis.

First, although PACST is the highest-level decision-making organization, it lacks functions to formulate policy, instead focusing on the functions of advice and deliberation; it can't be called a command center.

MSIT's Office of Science, Technology and Innovation Coordination is engaged in work such as the creation of policy across ministries, the distribution and coordination of budgets, and R&D performance evaluation, and with this it brings together actual science and technology policy, but as it falls under the umbrella of MSIT, it does not have sufficient authority, and its limitations are clear, especially in cases when coordination and unification across ministries are needed. In short, organizations such as MSIT and MOEF are at ministerial level and the Office of Science, Technology and Innovation Coordination is at vice-ministerial level, and in reality, it is difficult for a subordinate organization to bring together higher-ranking organizations, so the work actually carried out by the Office of Science, Technology and Innovation Coordination and its authority do not conform with each other.

South Korea does not have an organization that can be called a "command center" for science and technology.

Furthermore, there are multiple decision-making organization other than PACST, and the organizations that deliberate science and technology policy and projects are decentralized, so there is a tendency for confusion and the efficiency of their work is low. There is a need to unify decision-making organizations or to create a system in which information is shared between them.

It can be said that the frequent organizational reforms with administration change have played a large part in this state of affairs. The Moon Jae-in administration established the Presidential Committee on the Fourth Industrial Revolution (PC4iR) and restored the previously scrapped council of ministers involved in science and technology, which further increased the number of decision-making organizations, and also increased the number of overlapping and similar projects. Of course, this committee and council were set up from the perspectives of promoting science and technology and emphasizing science and technology, and have yielded their own outcomes and contributions, so their establishment is not necessarily an issue in itself. However, fields associated with science and technology are wide-ranging, so even if management organizations are divided by field, it is impossible to avoid some overlap. For example, it was decided that the PC4iR is responsible for matters concerning the Fourth Industrial Revolution, but matters concerning the Fourth Industrial Revolution cover a great deal of ground, and it was unavoidable that its work would overlap with that of the existing council of ministers concerned with the economy, the special committee for bioscience, the Innovative Growth Big 3 Promotion Conference, the council to strengthen the competitiveness of

materials, parts, and equipment, and the Carbon Neutrality Commission.

The Yoon Suk Yeol administration has attempted to streamlined this and create a decision-making system for science and technology policy by integrating and getting rid of decision-making organizations. It has already discontinued the PC4iR,[45] and is considering the removal of several additional committees, including the council of ministers involved in science and technology.

Finally, **there is no organization that brings together policy at a national level and evaluates policy.**

Although the Science and Technology Basic Plan, the highest-level plan in the field of science and technology, is formulated once every five years, there is no organization with the role of coordinating the policies and projects of every ministry, and, if necessary, bringing together the different ministries. Consequently, each year each ministry's performance is checked, and implementation plans are made, but there are inadequate budgets, evaluations, and collaboration. Furthermore, there are no methods that enable policy evaluations or comprehensive consideration of science and technology outside of the R&D project evaluations, so in many cases science and technology projects are carried out by each ministry independently.

To aid the reader's understanding, the author has added an explanation with comparisons to Japan.

Table 2-4: Comparison of administrative systems for science and technology in Japan and South Korea

	Japan	South Korea
Political system	Parliamentary system	Presidential system
Organization(s) that functions as a command center to promote science and technology	CSIT (Prime Minister, Chief Cabinet Secretary, Minister of State for Science and Technology Policy, ministers from relevant ministries, experts, etc.)	There is no organization in South Korea that serves as a command center. PACST is the highest-level decision-maker, but does not possess the function of policy creation, and instead focuses on advisory and deliberative functions.
Command center advisory organization	Various meetings of CSTI (statements of opinions and reports in response to advice)	PACST's Advisory Council
Administrative organization (affiliation)	Secretariat of Science, Technology and Innovation Policy (Cabinet), relevant ministries such as the Ministry of Education, Culture, Sports, Science and Technology (MEXT)	Office of Science, Technology and Innovation Coordination (Ministry of Science and ICT), other related offices
Key administrative organization thinktanks	NISTEP, etc.	KISTEP, etc.

[45] The Digital Platform Government committee was newly established and took over the work previously carried out by the PC4iR. Although the PC4iR was the predecessor to the Digital Platform Government committee, the aims with which they were established differed, so when the decision-making organizations were later simplified, the goal was to concentrate much of the work in this committee, and gradually integrate and unify the decision-making organizations.

Characteristics of command center-style organization	Under the leadership of the prime minister, CSTI acts as command center to promote science, technology, and innovation policy, forming, planning, and ensuring the overall coordination comprehensive and basic policies.	PACST is mainly responsible for advice and deliberation. The Office of Science, Technology and Innovation Coordination's role is to bring together and coordinate the substance of policies, etc.
Formation of basic plan	CSTI creates (reports) a draft of the Science, Technology and Innovation Basic Plan (5-year plan) and the Plan is determined by the Cabinet. The basic plan sets out comprehensive measures to promote R&D, and policies that should be put comprehensively and systematically put in place.	The draft of the basic plan is created under the leadership of the Office of Science, Technology and Innovation Coordination and the plan is created by the government after deliberation by PACST.
Organization (other than the financial authority) that coordinates the science and technology budget (government bill)	The Cabinet and CSTI (plans, drafts, and comprehensibly coordinates measures to distribute the science and technology budget)	Office of Science, Technology and Innovation Coordination
R&D evaluations	A system for systematic and comprehensive evaluations has been created under the Basic Act on Science and Technology/the Basic Plan. Measures, including the activities of corporations, are evaluated mainly as part of the project evaluations of each ministry. Policy evaluations involve reviews of existing policies when new policies are being made.	R&D project evaluations are carried out mainly based on the Basic Plan for R&D Performance Evaluations. There is currently no policy evaluation in the field of science and technology.
Characteristics of overall science and technology administration	1. CSTI is the command center to promote science, technology and innovation policy. 2. The Science, Technology and Innovation Basic Plan, the long-term comprehensive plan to promote science and technology, is drafted (reported) by CSTI and determined by the Cabinet. 3. Relevant ministries such as MEXT systematically plan, draft, implement, evaluate, and improve their policies, in accordance with the Basic Plan, the Cabinet, and the policies of each ministry, under the CSTI's command center function.	1. The Office of Science, Technology and Innovation Coordination places a unifying role in promoting the government's science and technology policy. However, its leader is a vice minister, and it is a different organization to PACST, which has the command-center function. 2. Decision-making organizations are operated in a decentralized manner, and system improvements are being made.

Source: KISTEP "Administration Systems for Science, Technology, and Innovation in America and Japan and their Implications"

As is clear in the table above, Japan's command center was created in its Cabinet organization. In South Korea, the Vice Minister's Office of Science, Technology and Innovation Coordination has the unifying function, but its authority and the work it actually carries out are not compatible, so from this perspective there is a need to raise the prestige of the organization that brings together science and technology policy. Moreover, PACST's functions are limited to advice and deliberation (it does not have the function of holding deliberations on original issues and stating opinions like Japan's CSTI does), and on top of this deliberations on topics that are relevant to science and technology also take place in other councils. There is therefore a tendency for advisory and deliberative functions to be scattered across multiple organizations, and a need to unify these functions for science and technology. One possible measure could be to grant policy-creation and budget-planning functions to PACST or to strengthen these functions and increase its position and prestige as the highest-level legislative organization for science and technology.

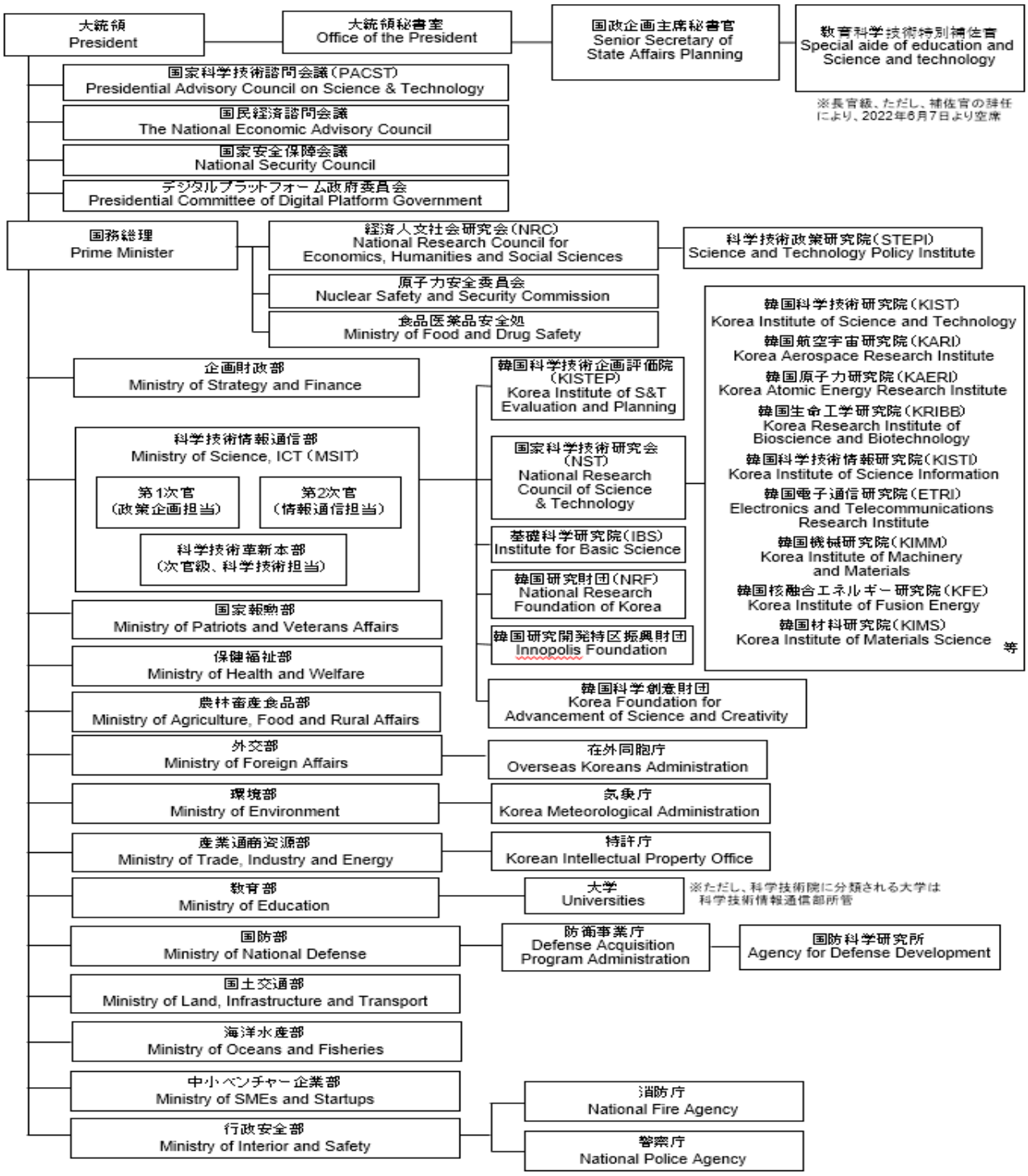


Figure 2-5: Organizational chart of South Korean government institutions (Yoon administration)

Source: Some APRC revisions and additions with reference to MEXT's *Indicators of Science and Technology*

As the reader has at this stage, gained a certain understanding of the administrative system for science and technology in South Korea, this section will now commence its main topic, Strategies for Winning the Fourth Industrial Revolution. The Moon Jae-in administration decided to start with the policies and legal systems that were causing a bottleneck in the development of new technologies and new industries through the People-Centered Plan for the Fourth Industrial Revolution.

2.2 Developing polices and the legal system

To ensure an awareness of the importance of the Fourth Industrial Revolution and take appropriate measures, the government first created a provision (presidential decree) for the establishment and operation of the Presidential Committee on the Fourth Industrial Revolution (PC4iR) in August 2017, setting up the **Presidential Committee on the Fourth Industrial Revolution** under the direct control of the president in October that same year.[46] The reason given for establishing the PC4iR by the President was: "To enable the government to respond appropriately to the various changes that will occur in South Korean society as the era of the Fourth Industrial Revolution arrives, to discuss the strategies and policies needed for these responses, and to carry out the coordination required for work between ministries." The PC4iR consisted of at least 20 civilian experts, and the leaders of MSIT, the Ministry of Trade, Industry and Energy (MOTIE), the Ministry of SMEs and Start-ups (MSS), and the Ministry of Employment and Labor.

The Committee was discontinued with the change of administration on August 15, 2022, and its work and functions were absorbed into the newly created **Digital Platform Government** committee. However, for five years starting in 2017, the Committee created many policies connected to the Fourth Industrial Revolution, including the People-Centered Plan for the Fourth Industrial Revolution, the AI R&D Strategy, and the Strategy for the Promotion of Smart Cities. In 2019, it gave the government appropriate advice about how it should handle the overall changes in the economy and society with the publication of the "Recommendations for the Government on the Fourth Industrial Revolution," which reflected private-sector opinions. The Committee was under the direct authority of the president but was able to coordinate and discuss policy across departments, and included civilian members, making it an organization that realized public-private coordination.

To implement the policies and systems needed to promote the Fourth Industrial Revolution in South Korean society and ensure its fruits were reflected in society, the PC4iR's first focus after its establishment was revising existing policies and systems and creating and introducing new ones as necessary.

2.2.1 Introduction of the regulatory sandbox system[47]

One issue arose: the Fourth Industrial Revolution sees rapid technological development and fusion, and South Korea's current systems could not reflect the changes in new technologies and new industries in a timely manner. The government therefore introduced the regulatory sandbox system, which involves priority permission–post-regulation for new technologies and industries.

Although the regulatory sandbox system has been established with certain conditions (limited period/location/scale), it allows business owners priority market testing of new goods or services that are provided using new

[46] In January 2021, the presidential decree was amended, and the role of public-private joint data governance was added, generalizing the national data policy. However, after the change of administration, the focus was on securing technological capabilities in the core fields of the Fourth Industrial Revolution, so there was a shift to private sector-centered R&D systems, and during this process 11 committees connected to MSIT were abolished. The PC4iR was one of these.

[47] For information about the regulatory sandbox system, see the Office for Government Policy Coordination "Dedicated page for the Regulatory Sandbox"; https://www.sandbox.go.kr/sandbox/info/sandbox_intro.jsp
See policy briefing: Regulatory Sandbox https://www.korea.kr/special/policyCurationView.do?newsId=148857563#L5

technology without being subject to all or some existing regulations. The data obtained during the process leads to improved regulations. In short, it is a system that offers a "place to experiment with innovation" and opportunities for business owners with ideas to freely challenge themselves.

This system was first introduced by the UK government in 2016, and since then has been implemented in more than 60 countries around the world. **The South Korean system is unique in that it runs in the real economy (ICT and industry) rather than just the financial field.** Moreover, while it runs a "special case system for verification," as in other countries, the system also handles on "temporary permissions" that enable immediate release to the market, and "rapid confirmation," where ministries confirm whether there are any regulations and communicate this quickly to the company. These increase convenience for companies.

- **Special case system for verification**: In cases where projects using new technology wish for permission but there is no basis for this in law, or there is a possibility that the application of an existing law will come into conflict with another law, this system allows test operations for a limited time period. If outcomes of the trial and/or a need for regulatory improvement is acknowledged, an applicable law will be created. The maximum grace period with this system is four years.
- **Temporary permission system**: In the case that it is difficult to launch a product or service onto the market due to ambiguity in the relevant laws, even though the safety and innovation of the product or service in question has been proven, this system means that the regulations do not apply for a certain period of time (giving temporary permission). The grace period here is also four years.
- **Rapid confirmation**: In the case that companies wanting to develop their business using new technology wish to confirm whether there are any regulations, they can make a confirmation application and the relevant authority must reply within 30 days. If there is no reply, the company may assume there are no regulations.

In September 2017, the Moon Jae-in government announced the regulatory sandbox system via the "new administration's direction of regulatory reform promotion," and after a preparatory period of less than a year, the system was launched in January 2019. This system started only in the field of ICT and industrial fusion, expanding to regulation-free special zones (April 2019), smart cities (February 2020), and R&D special zones (December 2020), and reaching a level of completion as a system while actively reflecting feedback from companies.

The Office for Government Policy Coordination is responsible for overall system planning and integration for the regulatory sandbox system, and manages the system through its own system of mutual cooperation with the ministries in charge of different areas. Coordination and exchange of opinions between ministries is carried out through the TF for ministries connected to the regulatory sandbox. As of March 29, 2023, this system had promoted a total of 861 projects.

In May 2020, there was an addition to the system that had been run only by government organizations: a private-sector organization was established to reduce obstacles to usage and enable more companies to make use of the system. This was the Korean Chamber of Commerce and Industry Regulatory Sandbox Support Center. The reasoning for this was that a private sector organization was judged to be more convenient and accessible from the corporate perspective.

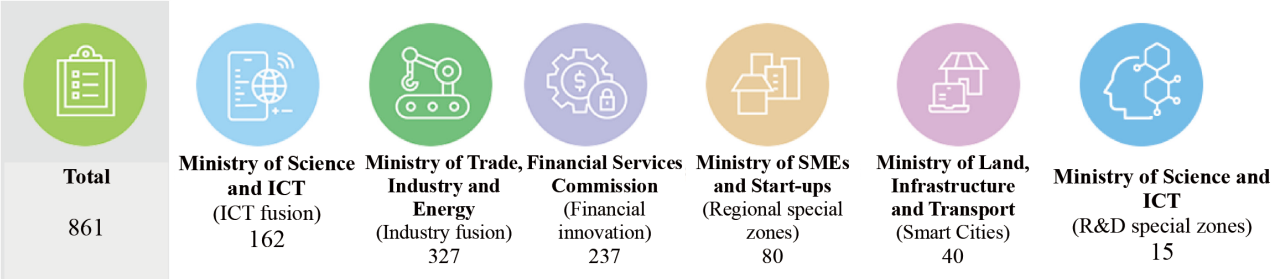


Figure 2-6: Ministries responsible for the regulatory sandbox and their current projects

Source: Office for Government Policy Coordination Regulatory Sandbox webpage

Furthermore, as was stated in Chapter 1, South Korea emphasized the mission of creating a strong foundation for science and technology, in particular D.N.A. (data, networks, and AI), and so the government also **modified laws and policies focused on data, networks, and artificial intelligence** to emphasize its Fourth Industrial Revolution Mission.

2.2.2 Revising the three data laws[48]

First, in terms of data, the most important task was to revise the so-called "three data laws" of South Korea: the Act on the Use and Protection of Credit Information ("Credit Information Act"), the Personal Information Protection Act (PIPA), and the Act on the Promotion of Information and Communications Network Utilization and Information Protection ("Network Act").

In short, the reasons for revising the three data laws were to ameliorate the issue of duplicated regulations caused by the division of the ministries responsible for the three data laws, and to broaden the scope of the data that companies could use.

The importance of data and the IT industry grows daily with the information revolution and the technology fusion revolution; data can cause a paradigm shift in global industry—regardless of what that industry is. Thus, the development of new industry through the promotion of data use became a vital task for the advancement of the Fourth Industrial Revolution. In particular, the use of data that utilizes new technologies such as AI, cloud, and the IoT is vital for the development of new industries, but societal regulations that enable the safe use of data are needed for this. Draft revisions for the three data laws were submitted in November 2018, with the main aims of revising regulations concerning data use and developing a system for the protection of personal information, and these revisions were approved in January 2020.

The main changes resulting from the revision of the three data laws are given in the four points below.

1. Introduction of the new pseudonymized information concept, enabling companies to use data without the individual's consent if certain conditions are satisfied.

[48] See the following for information on the three data laws. Government of the Republic of Korea policy briefing: "Policy DB-Three Data Laws," https://www.korea.kr/special/policyCurationView.do?newsId=148867915;
Ministry of the Interior and Safety, "Revisions to the Personal Information Protection Act, green light for data economy," https://www.mois.go.kr/frt/bbs/type010/commonSelectBoardArticle.do?bbsId=BBSMSTR_000000000008&nttId=75225

2. Similar and overlapping laws concerning personal data were unified into the Personal Information Protection Act (PIPA), and regulatory/supervisory organizations were integrated into the Personal Information Protection Commission.

3. Introduction of MyData, which allows consumers to check personal information scattered in entities such as banks, insurance companies, and credit card companies on one app.

4. Increased responsibility of personal information processors with the use of data (a fine of up to 3% of sales can be imposed).

(1) Credit Information Act

The Credit Information Act was revised with the following goals: (1) To develop financial products by making effective use of the Big Data accumulated by financial organizations such as banks, insurance companies, and card companies, and to create added value through the fusion of these with other industries. (2) To introduce MyData, which lets people manage information as they wish, and strengthen the right of self-determination for personal information.

The largest point of change was the introduction of the new definition of pseudonymized information. According to Article 2, **pseudonymized information is information that has been subject to measures to ensure an individual cannot be specified or identified**. In other words, this falls between personal information that can identify a specific individual and anonymized information that has been subject to measures to make it completely unidentifiable. Pseudonymized information has a reduced chance of identification because information that can identify an individual, such as a name or phone number, has been removed or replaced with a pseudonym, etc. Financial organizations **can use pseudonymized information without consent if it is to be utilized for the creation of statistics, including for purposes of commercial viability; for research, including for industrial purposes; and to maintain records for the public**.

These revisions provided a legal basis for the analysis and use of Big Data from financial organizations. Pseudonymized information held by different companies can be collated by specialist organizations with security arrangements in place designated by the government. If someone wishes to obtain information, they must submit an application to a designated specialist organization. These measures work to ensure the safe handling of pseudonymized information, and a rapid response should any issues arise.

Table 2-7: Classification of personal information, pseudonymized information, and anonymized information

<table>
<tr><th></th><th>Definition</th><th>Possible scope of use</th></tr>
<tr><td>Personal information</td><td>Information associated with a specific individual, information that can identify an individual. E.g., name, address registration number (equivalent of the Japanese My Number), and images in which these can be read are categorized as personal information. In addition, information that can identify an individual if combined with other information, even if a name, etc. is not directly written, is also personal information.</td><td>Information can be used to a limited degree with advance and specific permission.</td></tr>
<tr><td>Pseudonymized information</td><td>Information that has been subject to protection processes that ensure the individual cannot be identified without additional information.
Inappropriate example:
<table>
<tr><td>Name</td><td>Date of birth</td><td>Phone no.</td><td>Address</td><td>Occupation</td><td>Household</td><td>Account balance</td><td>Loan</td></tr>
<tr><td>Delete</td><td>Delete</td><td>Encode</td><td>Cheongdam-dong, Seoul</td><td>National Assembly member</td><td>Spouse, 2 daughters</td><td>4,567,900</td><td>45,686,700</td></tr>
<tr><td colspan="8">As this data includes National Assembly member in the occupation category, if the area of residence and family structure is known, it is highly likely the person can be identified. In this case, it would be appropriate to delete the occupation category.</td></tr>
</table></td><td>Can be used without needing consent for the following purposes:
1. The creation of statistics (also possible for commercial purposes)
2. Research (including industrial research)
3. Purpose of maintaining records for public use</td></tr>
<tr><td>Anonymized information</td><td>Information that has been subject to processing on a level that makes restoration impossible (measures to make unidentifiable), so an individual cannot be identified.</td><td>Can be used freely without limits, as this is not personal information</td></tr>
</table>

Source: Created by the author based on the Ministry of the Interior and Safety's Draft Revision of the Personal Information Protection Act, Green Light for Data Economy

Additionally, strengthening the right of self-determination for personal information meant the establishment of a new right in Article 33: a person whose personal information is in use can request the transfer of their information from their credit information provider or user (**right to request the transfer of personal credit information**). This is known as **MyData**, and **made it possible for consumers to consolidate their information scattered across multiple organizations (communications companies, banks, credit card companies, etc.) in a single app for management and use**. The system works as follows: if consumer A exercises their right to request a personal credit information transfer through the MyData app, the financial company transfers A's information to the MyData operator via API, and A can reference and manage their own information through the MyData operator. Consumers can check and manage their own information, which is scattered across various companies and organizations, in a single app, as well as checking which financial products and services suit them. Consumers reference and integrate information of their own will, and are able to manage their credit and assets; from this perspective, it can be said this app maximizes the use of personal data. The MyData operator's role is to support the movement of information gathered by financial organizations and communications companies to other companies and organizations. This project was implemented on January 5, 2022.

The available services on MyData are organized by field and listed in the table below.

Table 2-8: What can be done with MyData? (partial excerpt)

Field	Information that users can check and manage
Banking	Savings balance, transaction history, loan balance and interest rates, repayment information
Insurance	Details of contract, special contracts, insurance premium payment history, balance and interest, etc.
Investment	Status of stock purchases, holdings, valuations, principal invested in funds and balance, etc.
Credit card	Payment history, amount invoiced, points, taking out small loans and the use of card loans
BNPL (BUY NOW PAY LATER)	Details of order, amount to be charged, etc.
Communications	Communication fees, details of carrier payment use
Public services	Status of tax payments, insurance premiums, history of pension payments

Source: KDB Future Strategy Research Institute "MyData Service Domestic Status"[49]

(2) Personal Information Protection Act (PIPA)[50]

The revisions to PIPA had the following objectives:

1. To contribute to the development of new industries and the creation of quality jobs based on data
2. To prevent confusion between corporate and citizens' data by ensuring the uniform management of personal information, and to systematically facilitate policy.
3. To guarantee the independence of regulatory authorities, as required by the adequacy evaluation in the EU's General Data Protection Regulation (GDPR).

First, the revised PIPA **clarified the definition of personal information**, and established new methods and standards for the safe use of data.

According to Article 2 of the PIPA, personal information is (1)information relating to a (2)living (3)individual, (4) information that identifies a particular individual, or (5)information that can identify an individual if combined with other information, even if the information alone does not enable identification. Therefore, information relating to a deceased person, a corporation, or an organization is not personal information.

It is also possible to make use of pseudonymized information for the development of new technologies, products and services based on data; scientific research, including industrial purposes; market research; statistical surveys for commercial purposes; and maintaining records for the public. Individual consent is not needed, depending on the usage. Therefore, in addition to the financial organizations set out in the Credit Information Act, medical institutions and companies are also able to make use of pseudonymized information if it is for the purposes listed above.

Finally, various matters were made obligatory to strengthen the responsibilities of personal information processors, and security was provided on an institutional basis to protect personal information—e.g., imposing fines if the law is

[49] https://eiec.kdi.re.kr/policy/domesticView.do?ac=0000165256

[50] Full text of Personal Information Protection Act: https://www.law.go.kr/LSW/lsInfoP.do?efYd=20171019&lsiSeq=195062#0000

violated. If a company or other organization processes pseudonymized information to identify individual information, **it may be ordered to pay a fine of up to 3% of its annual sales, and up to five years imprisonment or a fine of up to 50 million won may be imposed.** Moreover, the **supervisory organizations for personal information** scattered among security departments, the Financial Services Commission, and the Korea Communications Commission were **integrated into a single personal information commission.** This commission has been designated a central administrative authority directly under the Prime Minister.

(3) Network Act

The Network Act was also revised with the revisions to the PIPA, with the main objectives of enabling safe network use and removing confusion caused by regulations that overlapped with other laws.

Before this, content relating to personal information was divided between PIPA and the Network Act, and there was an issue of overlapping regulations, so **the content concerning personal information was all transferred to the PIPA.** On top of this, the online personal information protection supervisory organization changed from the Korea Communications Commission to the Personal Information Protection Commission.

Various industries associated with the Fourth Industrial Revolution, which relies greatly on data, became able to make use of pseudonymized information and push forward through R&D. It also became possible to share data between companies, leading to increased expectations of technological and economic development. From the consumer perspective, companies, public organizations, and financial organizations process and use data to provide innovative services, and in so doing enable expectations of higher quality, more convenient lifestyles.

Feature: Data-based administration[51]

As the importance of data increases, the government aims for scientific administration that is evidence-based, data-based, and statistics-based, and in June 2020 it established the Act on the Promotion of Data-Based Administration ("Data-Based Administration Act").

However, in contrast to the three data laws, the key phrase "suspicion of the government" is embedded in the background to this establishment of this act. The draft for the act was submitted to the National Assembly in December 2017, directly after the impeachment of President Park Geun-hye. In short, this was a time in which many people experienced disappointment at the incompetence of the bureaucracy and the government, and suspicion of the government was at its peak. This act was inspired by the public desire for the government to use scientific data as a basis when formulating policy and making decisions for administrative work, rather than individual subjective opinions and experiences. It is thought that this was merely a proactive effort by the Moon Jae-in administration to regain the trust of the people.

Regardless of its background, the Data-Based Administration Act was an important initiative expected to improve the quality and efficiency of administration. South Korea has demonstrated its strengths in digital government infrastructure, ranking first in the OECD Digital Government Index (2019),[52] but it has been pointed out that its analysis and use of data is lacking when compared to the enormous amount of data that it has accumulated.[53] It is conceivable that the creation of this Act improved this to a certain extent.

Furthermore, in a compartmentalized bureaucracy, data is managed by each ministry individually, and it has been noted that a lack of information sharing and cooperation between ministries is an issue. With the creation of a data platform that encompasses different ministries, one can imagine that there was an opening for improvement.

The definition of data-based administration in South Korea is: administration that is conducted objectively and scientifically by utilizing data created by the government, local municipalities, and public institutions or acquired from and managed by another public institution, corporation, or organization for policy formulation and decision-making in a manner that collects, stores, processes, analyzes, etc. it (Article 2). For example, analyzing report data from calls to 110, criminal statistic data, migrant population, and credit card sales data to predict the potential of crime, then distributing limited resources for public order (patrol personnel, patrol cars) in an appropriate manner to contribute to crime reduction is data-based administration.

51 See Ministry of the Interior and Safety, "Leading Innovation growth with the creation of a data platform that crosses ministries," https://www.mois.go.kr/frt/bbs/type010/commonSelectBoardArticle.do?bbsId=BBSMSTR_000000000008&nttId=65014.

52 OECD Digital Government Index (DGI): 2019 https://www.oecd.org/gov/digital-government-index-4de9f5bb-en.htm

53 Korean Finance Information Institute, "Data-Based Administration Act" Q&A https://blog.naver.com/kpfisnet/222231419905

The main content of the Data-Based Administration Act covers (1) the establishment of a Data-Based Administration Promotion Committee, (2) procedures for the shared use of data, and (3) the creation of an integrated data management platform.

This was the first trial of data-based administration in South Korea, and the Data-Based Administration Promotion Committee was formed to encourage the establishment of this administration. Participants in the Committee include employees involved in ministries, public institutions, and research organizations, as well people who work with the law and academics, and they discuss and coordinate data-based administrative policy. They also formulate a Master Plan for Promoting Data-Based Administration every three years. The First Master Plan for Promoting Data-Based Administration (2021 to 2023) was published in February 2021.

The Act set out specific processes for investigating, registering, and utilizing joint-use data, increasing its safety and utility. First, the government, local municipalities, and public organizations must decide upon a data-based administration officer. This officer takes charge of not only the registration of data on the platform, but also the promotion of data-based administration policies, work involving shared data use and collaboration, and the construction of data management systems. The Minister of the Interior and Safety can request that the officers of ministries and local municipal governments provide data to enable smooth implementation, if that data is determined to be necessary for shared use, and the officers of ministries and local municipal governments are also able to exercise their own judgement and register data that would be useful for shared use to the integrated data management platform, the government's Integrated Data Analysis Center. Data registration requested by the Minister of the Interior and Safety must be registered within 60 days by the officer.

In terms of international trends, the US had already taken concrete measures toward evidence-based policymaking in around 2010,[54] and in 2013 it published its Next Steps in the Evidence and Innovation Agenda.[55] The UK, Singapore, Japan, and New Zealand have promoted data-based policies through government, and it is thought that South Korea, which is highly ranked for its digital government, should have addressed such a policy at an earlier stage.

54 Brian W. Head, "Reconsidering evidence-based policy: Key issues and challenges", *Policy and Society* 29(2), 2010, pp. 78-80.

55 OMB, "Next Steps in the Evidence and Innovation Agenda", 2013.

2.2.3 Preparing for 5G commercialization[56]

To continue, when it came to networks, South Korea's policy and legal preparations focused on 5G (5th generation). 5G is a core infrastructure of the Fourth Industrial Revolution that transmits and connects vast amounts of data at super high speeds. 5G makes it possible to realize a connected society beyond audio and data communications and to create new industries such as fusion services and advanced terminals and devices.

The South Korean government believed that using 5G technology for diverse industries and encouraging upstream and downstream industries would enable the creation of economic value of 1.161 quadrillion won by 2026.

Why does the South Korean government have so much faith in 5G technology? This is because of its experience commercializing world's first CDMA in 1996, and the world's first super high-speed network in 1998. The commercialization of CDMA and the super high-speed network started to raise South Korea up as a nation with strong ICT capabilities.

In December 2017, the government presented a 5G commercialization roadmap, and steadily advanced preparations to commercialize 5G.

- PyeongChang Olympic Games pre-management (February 2018)
- Spectrum auction (June 2018)
- Establishment of technical standards for wireless equipment (August 2018)
- Base station/terminal wave authentication (October to November 2018)
- Report on service use agreement (November 2018)
- 5G waves emitted (December 2018)

Thus, **on April 3, 2019, the world's first smartphone infrastructure 5G commercialization was achieved**.

After the commercialization of 5G, the 5G+ Strategy Committee was created with ministry and civilian experts as members, and in April 2019, the **5G+ Strategy to Realize Innovation and Growth** was formed.

The 5G+ Strategy project includes 10 major core industries and five major core services.

- 10 major core industries: Intelligent CCTV, VR and AR devices, next-generation smartphones, network facilities, edge computing, information security, 5G V2X, connected robots, futuristic drones, and wearable devices.
- Five major services: Digital healthcare, smart farms, autonomous driving, smart cities, and interactive content.

In the abovementioned strategic fields, by 2026 the goals of this strategy are: (1) reach a total production value of 180 trillion won, (2) create 600,000 new jobs, (3) increase the global share to 15%, and (4) reach an export value of 105 trillion won.

The 5G+ Spectrum Plan was added to this in December 2019, expediting the increased quality of 5G and the surety/provision of the world's widest spectrum for 5G. In 2019, the bandwidth was 2,680 MHz, and this is expected to approximately double, expanding to 5,320 MHz in 2026.

[56] For policies on the commercialization of 5G, see Policy briefing: 5G Commercialization https://www.korea.kr/special/policyCurationView.do?newsId=148863556

From 2022, more and more facility and terminal companies based on 5G commercialization are expanding overseas. Moreover, the government is supporting technological development to stimulate the private sector-led market. The development of 5G modules for B2B was completed in October 2021, and the government is currently supporting the development of technology for 5G performance experimental infrastructure and key facilities and products (small cells, antennae, etc.).

To improve the quality of the 5G communication service, the government offers incentives such as tax credits to mobile communications providers and encourages fair and free competition through public quality assessments (twice a year). Each mobile communications provider presents reasonable and diverse payment plans to encourage more users to make use of 5G. At the end of May, 2022, the number of 5G users had exceeded 24.04 million people,[57] surpassing the momentum when 4G was introduced.

2.2.4 Artificial intelligence development strategy[58]

The country's most important policy for AI is the National Strategy for Artificial Intelligence. It goes without saying that AI is the force that will lead the Fourth Industrial Revolution, and will bring about major changes to the structure of industry and society, rather than just being a new technology. Countries are making unceasing efforts to take the lead in AI.

For example,

・The US: Creation of AI Initiative executive order (February 2019)

This introduces private-sector vitality and competition via long-term, systematic government investment in R&D and human resources and gives priority to AI investment. The government is focused on next-generation R&D and use in the fields of military and security, which are limited with only private-sector development.

・China: Creation of Next Generation Artificial Intelligence Development Plan (July 2017)

Led by the government, this plan promotes large-scale investment and HR development in the fields of data and AI, identifies advanced companies and creates platforms tailored to different industries (BAIDU = autonomous driving, Alibaba = smart cities, TENCENT = medicine and healthcare). Government leadership + the creation of huge amounts of data on platforms that make use of Chinese companies secures competitiveness in AI.

・Japan: Creation of AI Strategy 2019 (March 2019)

This strategy accelerates technological innovation in AI as a means of leading industrial revitalization and solving social issues such as low growth and aging, fostering 250,000 applied personnel, 2,000 high-level personnel, and 100 people at the highest level each year. Japan is conscious of the challenges of maintaining its industrial competitiveness as well as solving social issues.

The South Korean government published its **National Strategy for Artificial Intelligence in December 2019**. A major characteristic of this is that every ministry participated in the formation of this strategy, not just MSIT. This is surely

[57] NEWSIS "5G users exceeds 24 million people in May," https://www.newsis.com/view/?id=NISX20220704_0001930763

[58] For details about AI, see Policy briefing: AI
https://www.korea.kr/special/policyCurationView.do?newsId=148868542

proof that AI is a key field that will lead to innovation in both the economy and society. South Korea is strengthening its AI technology and industrial competitiveness through **select and focused strategies**, and using the slogan "**human-centered AI**" as it narrows its investments to fields in which it can lever its strengths.

The first goal of this strategy is to be the world's most competitive country in AI semiconductors by making use of South Korea's strengths in memory semiconductors. Thus, the Strategy has reinforced investment in the development of PIM (processing-in-memory) semiconductors.[59] It has also set out an education system in which everyone, from children to seniors, can enjoy experiencing software and AI. In addition to this, the strategy determined that the next step after electronic government is a switch to intelligent government that uses AI based on cutting-edge ICT, to provide high quality public services. Finally, it aims to realize an age of human-centered AI with the creation of employment and an AI code of ethics, so that all citizens can reap the benefits of AI.

The South Korean government decided to make full use of AI in all industries and is gradually expanding its large-scale AI fusion project.

Table 2-9: Examples of the introduction and use of AI by field in South Korea

Field	Examples of the introduction and use of AI
Manufacturing	Popularization of AI-based smartphones (2,000 by 2023), creation of industrial data platforms by industry
SMEs	Creation of platform for data analysis and use for micro enterprises (e.g. people operating a small business, such as self-employed persons)[60] (2021)
Bioscience, medicine	Creation of a platform for new drug development (2021), support for hospitals focused on medical data (five in 2020), creation of AI medical device clinical trial sample data/investigation system (2021)
Cities, logistics	Creation of smart city data hub (2020), development of autonomous driving technology by public transportation organization (2021)
Agricultural and marine products	Establishment of smart agriculture farms (2022), smart aquaculture testbeds (2022)
Culture, content	Development of engine for intelligent character creation (2021)
National defense	Development of intelligent platforms that use national defense data and support functions for command systems (2020)

Source: Policy briefing: AI

[59] Semiconductors that change CPU-centered computing into computing centered on memory semiconductors that can imitate a brain. This is expected to solve the issue of decreasing memory processor speeds and efficiency and increased electricity consumption.

[60] In South Korea, SMEs is a concept that includes people operating micro enterprises. The Act on the Protection of and Support for Micro Enterprises states that these are small businesses as set out in the Framework Act on Micro Enterprises (sales of 1 billion to 12 billion won, depending on the type of business) with less than a certain number of people (from five to less than ten depending on the type of business). Generally, the common perception of micro enterprises in South Korea is someone who is self-employed or a very small company. Estimation--Jointly by relevant departments (December 20, 2018) "'Comprehensive measures for the growth of self-employment and innovation' created with self-employed people" p28.

The South Korean government will invest 1.0096 trillion won (2020 to 2029) in the development of core AI semiconductor technologies to maintain its technological competitiveness in AI; in 2020 it established a fund for the development of future technologies (300 billion won), and provides low-interest loans for SMEs and venture companies in the field of innovation growth (up to 10 billion won per company, to be paid back over 10 years). Its Tech Incubator Program for Startup (TIPS) welcomed research teams in the field of AI.

In addition to substantially increasing its investment in basic research, applied research, and technological development focused on AI, the government decided to work on reforms that will gradually change positive regulation into negative regulation for AI through bold regulatory reform.

Positive regulation refers to regulations that forbid everything that is not specified by law or policy. Negative regulations permit everything other than actions that are forbidden by law or policy.[61] One can say that positive regulations are stricter than negative regulations.

Efforts were made to foster AI talents, with university departments establishing and expanding their AI-related courses, and graduate schools increasing and diversifying their AI programs. Since 2020, education in AI has been compulsory for civil servants, teaching staff, and military personnel, including people who expect to be hired in these fields, and the government will be promoting education that designates AI knowledge as a compulsory subject in elementary and middle schools.

In December 2020, the government **published the AI Ethical Standards** to handle the ethical issues arising with the development and use of AI. The OECD and the EU, among other places, had published ethics regulations for AI earlier than South Korea, and it is clear that MSIT started planning its regulations from the perspective of keeping pace with the state of global development. The AI Ethical Standards hold the realization of humanity as the highest value in all processes, from the development to the use of AI, and have three major principles: (1) respect for the dignity of humans, (2) prioritizing common good for society, and (3) emphasizing the rationality of the aims of technological development. At the same time as issuing these ethical provisions, the government also published a Roadmap for Artificial Intelligence Laws, Systems, and Regulations, which determined that it would take around four or five years to develop the necessary laws and regulations for the era of AI.

While the use of AI is progressing in various industries, scandals relating to AI also occur frequently, and the South Korean government issued the Strategy to Realize Trustworthy Artificial Intelligence in May 2021 to make the use of AI safer; in October 2021, it published the Direction to Promote the Diffusion of AI in Regional Areas to ensure that AI is used to develop regional economies as well as metropolitan areas—this suggested making use of the characteristics and strengths of each region to develop areas in which AI can be used.

In summary, to win in the era of the Fourth Industrial Revolution, the South Korean government has developed policies and laws focused on data, networks, and AI, and introduced a regulatory sandbox system to support new industries and new technologies. The formulation of policies and laws does not guarantee the development of technology and industry, but there can surely be no objection to the fact that they are aspects vital for favorable development. One of the characteristics of the era of the Fourth Industrial Revolution is the rapid changes in

61 See Yonhap INFOMAX, "Commentary on financial vocabulary: positive regulations and negative regulations" http://news.einfomax.co.kr/news/articleView.html?idxno=4037293

new technologies and new industries, and without the appropriate regulations to support this, it is possible that development could be impeded, and issues could arise in old and new industries, so the government's timely responses and formation of appropriate policies is extremely important.

2.3 Measures to strengthen basic research

With the revisions of policies and systems and the establishment and introduction of new regulations to advance the Fourth Industrial Revolution and ensure its fruits are reflected in South Korean society, as detailed in 2.2, the next step for South Korea was to actively focus on strengthening basic research.

As was mentioned above, the Fourth Industrial Revolution is the product of a fusion of the development of foundational sciences and technologies, including math, physics, and biology, and the development of ICTs such as AI and the IoT. It cannot do without the development of basic research. To ensure cutting-edge technology, stronger basic research is an absolute requirement.

Strengthening basic research is one of the initiatives continued on from the time of the Roh Moo-hyun administration, but since the dawn of the era of the Fourth Industrial Revolution, it has been emphasized even further.

2.3.1 Increasing the basic research budget

The strengthening of basic research is suggested firstly from the sudden increase in investment in basic research. As is evident in the figures below, investment in basic research soared from around 2017.

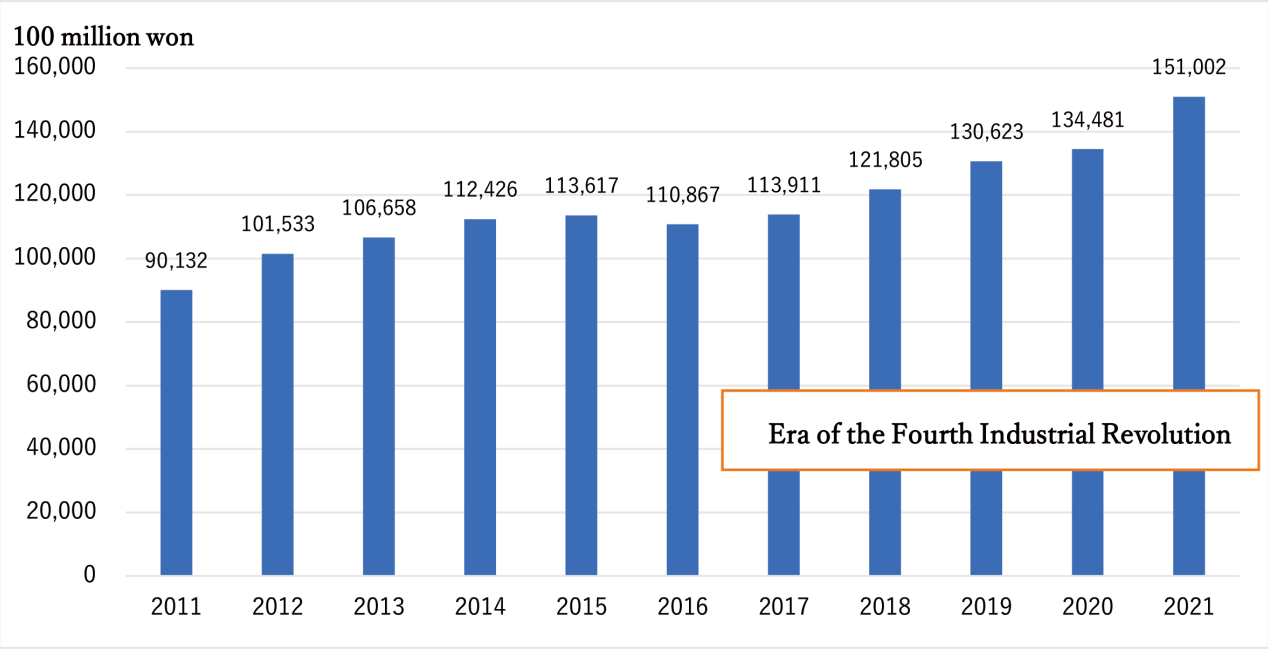


Figure 2-10: Changes in South Korea's basic research expenses

Source: South Korean National Science & Technology Information Service (NTIS)

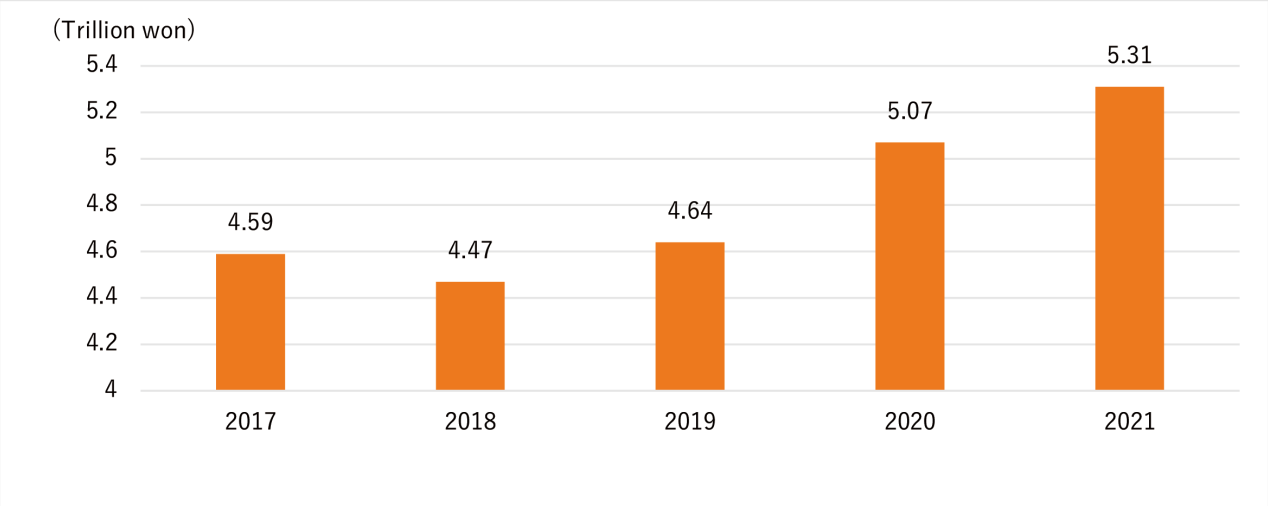


Figure 2-11: Changes in funding support for basic research in South Korea

Source: KISTEP "FY2021 National Research and Development Project Survey and Analysis Report"

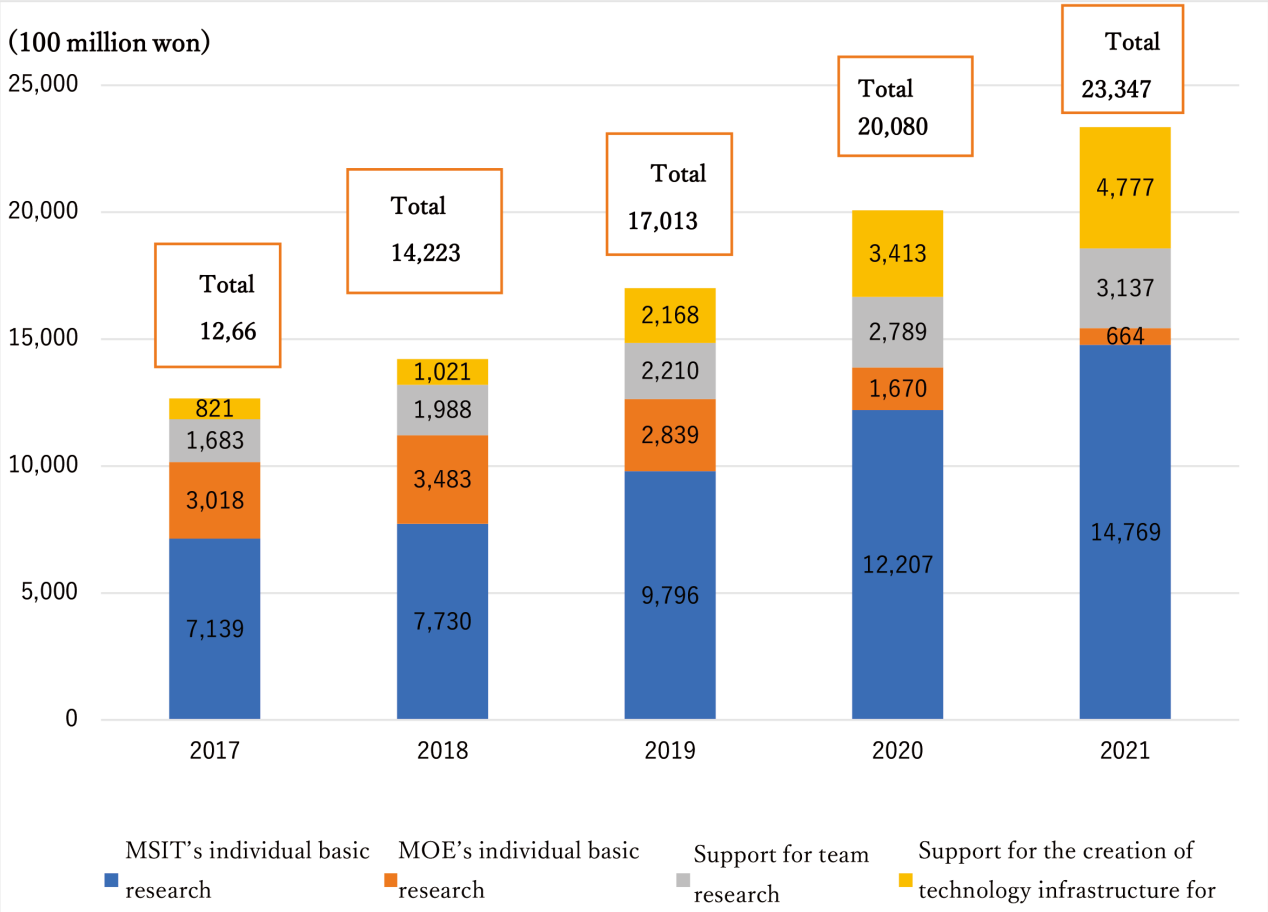


Figure 2-12: Breakdown of researcher-led basic research funding projects

Source: KISTEP "FY2021 National Research and Development Project Survey and Analysis Report"

A comment on the figures:
The bottom-up and top-down projects in Table 2-13 are included in the funding projects in Figure 2-12.

Table 2-13: Types of funding program for basic research

Type		Details
Bottom-up	Free application	Researchers (industry, academia, public sector) freely propose research themes and receive support for research expenses. E.g., MSIT's Basic Research Program (Individual Research), MSIT's team research support program
	Field-specific	The field (products, technology) alone is specified, and researchers submit R&D methods and proposals, which are assessed and support provided. E.g., New renewable energy technology development program, program for the discovery of future materials
Top-down		· These programs could also be referred to as mission or goal-orientated, and call for projects with research topics set by different ministries, which then receive support for research expenses. E.g., MSIT's South Korean robot development program, food safety management program · Projects that move forward with management costs or project costs paid to government-funded institutions or national institutions, or money paid to support these costs, to meet the targets in the government's science and technology policy. E.g., Government-funded research institution project expenses and organization management expenses, policy R&D projects

Source: KISTEP "FY2021 National Research and Development Project Survey and Analysis Report"

The researcher-led basic research funding projects from Figure 2-12 are included in the free application (bottom-up) section of Table 2-9 above.

As is shown in Figure 2-10, investment in basic research increased from 2017, when South Korea started making serious efforts toward the Fourth Industrial Revolution. The **basic research expenses for 2021 came to 15.1002 trillion won (14.8% of the total), an increase of 12.3% compared to the previous year**. The policy document issued by the Moon Jae-in administration, "The Fourth Industrial Revolution led by science and technology development" included the intention to greatly increase investment in basic research and to improve the treatment of researchers working on basic research.[62]

In South Korea, a comprehensive plan to promote basic research is formulated every five years with changes in the administration, and in 2018 the government issued the Fourth Comprehensive Basic Research Promotion Plan (2018-2022). This plan set out **increased support for funding projects for researcher-led basic research, going from 1.26 trillion won in 2017 to 2.5 trillion won in 2022, roughly double the original amount.** It also aimed to raise the number of university faculty members working on basic research and receiving funding support from 22.6% of the total in 2017 to around 50% by 2022. The expectation was to ensure the number of university faculty members support for

62 Donga Science, "The Moon government's 100 major national policies: Full-scale promotion of basic research, fostering young researchers," https://www.dongascience.com/news.php?idx=19020

research expenses (16,184 in 2017) exceeded 20,000 in 2022.[63]

While strengthening support for young people, the government also focused on supporting mainstay researchers in basic research areas who were producing the most results. More specifically, in 2019 it diversified the types of funding project, matching the research capabilities and research content of researchers, and increased the amount of support for excellent researchers (equivalent to project leaders). Previously, mainstay researcher funding projects had been standardized at more than 50 million won but less than 300 million won; this changed to a more flexible support system, in which projects were divided by scale, etc. into 50 million to 200 million won projects and 200 million to 400 million won projects. Support for excellent researchers also expanded in scope, going from a uniform 800 million won to 800 million or 1.5 billion won.[64]

In May 2022, **with the change of administration, the Yoon Suk Yeol government clarified that it planned to invest 7.8 trillion won in the development of talents and basic research using the 2023 R&D budget**, and expects to continue strengthening basic research.[65] MSIT also made it clear that it would invest 2.05 trillion won in funding projects for researcher-led basic research in 2023 (up 48.7 billion won from 2022).[66]

2.3.2 Strengthening support for young researchers

Support for graduate students and postdoctoral researchers also improved. The government introduced and expanded a basic academic incentive stipend to secure basic everyday living for graduate students so that no-one gives up research due to financial difficulties.

The basic academic incentive stipend system started to come into use in around 2019 in science and technology universities, with differing amounts depending on the university; around 800,000 won per month is paid for master's students, and around 1 million won per month for doctoral students.

Examples of monthly payments with the basic academic incentive stipend system[67]:

- KAIST: Master's: 700,000 won; doctorate: 1 million won
- Gwangju Institute of Science and Technology (GIST): Master's: 610,000 won; doctorate: 1.37 million won
- Ulsan National Institute of Science and Technology (UNIST): Master's: 80,000 won; doctorate: 1.1 million won

The basic academic incentive stipend system is still limited to science and technology universities but is gradually

63 See National Research Foundation of Korea, "What is the reborn basic research support policy?", (June 2018) https://blog.naver.com/basic_science/221303543432

64 See full text MSIT "2019 plan for researcher-led basic research support projects" https://search.naver.com/search.naver?sm=tab_hty.top&where=nexearch&query=%EB%A6%AC%EB%8D%94%EC%97%B0%EA%B5%AC%EC%9E%90+4%EC%96%B5%EC%A7%80%EC%9B%90&oquery=%EA%B8%B0%EC%B4%88%EC%97%B0%EA%B5%AC+4%EC%96%B5%EC%A7%80%EC%9B%90&tqi=h24i4wprvTossvO6jFosssstuN-081598#

65 Chosun Ilbo, "MSIT budget proposal for next fiscal year 18.8 trillion won, 41% for support for fostering talent and basic research," (August 2022) https://biz.chosun.com/it-science/ict/2022/08/31/VHBXRUQJGNHEDEDPK6U534AFRI/

66 See MONEYTODAY, "Next year's basic research budget is 2.05 trillion won, up to 10 years' support for young researchers," https://news.mt.co.kr/mtview.php?no=2022111011511360519

67 See the websites for each university and graduate school application guides.

expected to expand to universities across the country. In contrast to Japan, this system is characterized by also acting as scholarships handed out to students at master's level as well as students at doctorate level.

Moreover, to strengthen support for postdoctoral researchers, South Korea has added the National Research Foundation of Korea's KIURI Project and MSIT's Sejong Science Fellowship Project, in addition to the existing MOE Postdoctoral Domestic and Overseas Training Project, the National Research Council of Science and Technology's Project to Nurture R&D-Fit Talent, and the National Research Foundation of Korea's Innovation and Challenge Research Basic Support Project. As of October 2022, the following five postdoctoral support programs[68] are being run in South Korea.

・**MOE Postdoctoral Domestic and Overseas Training Project (from 1996):** This is for people involved in science and technology who have obtained their doctorate within the last seven years. It also supports regional universities to relieve disparity. The payment for a single person per year is around 60 million won (from one to three years). The budget for FY2022 was 53 billion won, with around 900 people to receive support.

・**National Research Council of Science and Technology's[69] Project to Nurture Research Institute-Fit Talent (from 2009):** This project provides support to people who have obtained their doctorate in science and technology within the last five years (with priority for people who did so at a foreign university) so they can carry out research for up to two years at a government-funded research institute. Only core research fields selected by the National Research Council of Science and Technology are eligible, and details are determined by each research organization.[70] People who are selected receive up to 60 million won a year, and the four main insurances[71] and leaving fees are also paid (for up to two years). This project has called for 112 people for 2022, with an average annual payment of around 50 million won.

・**National Research Foundation of Korea's Innovation and Challenge Research Basic Support (from 2012):** This project was developed with the goal of ensuring that young researchers can take on the challenge of innovative research without fear of failure; all science and technology fields are eligible (includes non-tenured teaching staff). People who are selected receive up to 70 million won a year (for one to three years).The budget for 2022 is 155.5 billion won, with around 2,800 people to receive support.

・**(New) National Research Foundation of Korea's KIURI[72] (from 2020):** This program was launched with the goal of encouraging postdoctoral researchers to move into industry, and requires them to be involved in joint research with a company or research to solve corporate issues. Therefore, the fields that are eligible for support are limited to science and technology fields thought to be promising for companies in the future or in which companies anticipate

68 See STEPI, "The scale and characteristics of Korean postdoctoral researchers II: The current state of Korean postdoctoral researchers and analysis of support programs," (May 2022)

69 A organization under MSIT that supports government-funded research institutes in the field of science and technology. Established in 2014.

70 For each research organization's application guidelines, see https://www.hibrain.net/recruitment/recruits/3313292

71 Refers to state pensions, health insurance, employment insurance, and disaster insurance.

72 KIURI means "to raise."

collaboration. People under 39 years old who have obtained their doctorate in the last five years are eligible,[73] and can receive support of 50 million won to 100 million won a year (for up to three years). The budget for 2022 is 12 billion won, and 92 people are supported. Of the 92 people with KIURI support in 2021, 16 have successfully been employed in the company with which they were collaborating.

*The following are currently eligible for support: Seoul National University (bio-health), Sungkyunkwan University (energy and environment), Yonsei University (future automobile components), and POSTECH (bio-treatments).

・**(New) MSIT's Sejong Science Fellowship (from 2021):** This program provides support so that young researchers can push forward with their research while receiving stable support, and is not limited to any particular field. People less than 39 years of age who have obtained their doctorate in the past seven years and non-tenured teaching staff (fixed term employment) in science and technology can apply. This program pays more than others, being able to give up to 100 million won a year, and also provides child benefits, etc. Support is given for up to five years, and the budget for 2022 is 310 billion won, with around 300 number of people receiving support.

2.3.3 Reforming the research system

The abovementioned Fourth Comprehensive Basic Research Promotion Plan and the Fourth Basic Plan for Nurturing and Supporting Scientific Talents (published in 2021) often mention improving the treatment of researchers and reforming the research system to create an environment that enables researchers continue their research with peace of mind and to change assessment methods to ensure fairness and improved motivation.

(1) Supporting long-term research over more than five or ten years

First, in 2020 R&D Programs for the Fusion of Science and Difficult Challenges[74] were developed in science and technology universities (research-focused universities) such as KAIST. These are all projects involving long-term, challenging research of five years or more. In terms of budget, the government is expected to invest 46 billion won over five years. Most funding projects in South Korea last for one to three years, leading to a tendency for short-term support, but to strengthen basic research, the country has expanded its support for long-term support projects.

The Yoon administration established the Dedicated Support Project for Research[75] in 2023, which provides **support for 10 years** so that young researchers can focus their efforts on a single basic research field for a long period of time and produce excellent research outcomes. This project is limited to 15 challenging and highly innovative basic research topics; research teams led by young PMs who obtained their doctorate within the last 15 years are selected and supported for 10 years with 200 million won every year. The costs of research equipment and the use of facilities are also paid in the first year. In the first year of this project, 2023, 15 research teams have been selected.

73 Originally there was no age limit, but the support recipients were narrowed down in 2021. This was an improvement based on feedback from the world of industry.

74 Donga Science, "Investment of 46 billion won over five years for challenging scientific research," (December 2019) https://www.dongascience.com/news.php?idx=32786

75 For details, see MSIT, "New Dedicated Support Project for Research, 10 years' support for excellent young research talents," https://www.msit.go.kr/bbs/view.do?sCode=user&mId=113&mPid=238&pageIndex=&bbsSeqNo=94&nttSeqNo=3182783&searchOpt=ALL&searchTxt="

(2) Creation of free research environments[76]

Various reforms have been launched to enable researchers to push on with their research in more free environments, based on the keywords of "autonomy, responsibility, fairness, and expertise." First, there were fixed research expenses that could be used each year, but this has been adjusted so the expenses can be used freely within the research period. In other words, only the total amount of research expenses and the research period are fixed, and their specific use is left to the researcher. Moreover, it is also possible to extend the research period to a certain extent depending on the necessity of the research project (however there will be no additional research expenses).

On top of this, universities have increased research support staff and are providing support for the payment of research expenses, adjustments, and the creation of different application documents to reduce the burden on researchers created by administrative work. Application documents for funding projects have been simplified. Various application forms, research plan documents, and reports, which had detailed rules concerning style, have been improved by each ministry, and the rules have been minimized as much as possible. Items for which funds may not be used have also been minimized.

Furthermore, support to enable continuous research has been strengthened for researchers producing results, with consideration for the continuity of basic research. To ensure fairness and expertise in evaluations, specialist evaluation teams have been created and an expert with experience leading a basic research project must be involved in evaluations of basic research; evaluations are also carried out by field. Diverse evaluation methods are in use, making use of not only peer review but also ample discussion with researchers and the characteristics of the project.

(3) Initiatives for safe research environments

The Employee Insurance Act was revised in 2019 to ensure that students can carry out research and experiments in safer environments: if a student is involved in an accident in a university laboratory, they are handled as an employee and compensated. It also became compulsory to establish and operate laboratory safety management committees in universities, and to ensure that protectors are present in laboratories. On top of this, the available budget for laboratory safety management expenses was limited to 1–2% of the university's research expenses, but this was abolished with revisions to the Act on the Establishment of Safe Laboratory Environment in 2020. With this, the available budget for maintaining research environments for students increased, and students are now able to focus on research and experiments in safer environments with better peace of mind.

When it came to science and technology, the country's shift from a fast follower to a first mover was a target continually referred to over multiple years, and the same content was referenced in policy issues in the new administration.

To become a country that prioritizes science and technology, strengthening basic research is a must; the Yoon administration also emphasizes strengthening basic research, and the fact that the country is now able to welcome qualitative change is noteworthy.

[76] For the details of this part, see NRF Newsletter, "Reborn basic research support policy," https://blog.naver.com/basic_science/221303543432 (June 2018)

Feature: The path to strengthening basic research in South Korea

This feature offers a simple introduction to the path involved in strengthening basic research in South Korea. The history of basic research in South Korea is relatively short when comparted to other countries.

Going into the 1980s, the effects of technological protections in advanced nations such as the US and the oil shocks caused South Korea to begin developing its own technologies; it started acknowledging the importance of basic research, and in 1989 it established the Promotion of Basic Science Research Law.

Then, in 2005 the Roh Moo-hyun administration published the first Comprehensive Basic Research Promotion Plan 2006–2010. The Roh Moo-hyun administration aimed to build a society centered on science and technology,[77] and set out multiple policies that emphasized this, including the introduction of a deputy prime minister of science and technology system and the establishment of the Office of Science, Technology and Innovation Coordination. It was this administration that started the Science and Technology Basic Plan, formulated every five years. It could be said that the Roh Moo-hyun administration laid the foundation to strengthen basic research. The Comprehensive Basic Research Promotion Plan 2006–2010 increased the percentage of the government's R&D budget assigned to basic research from 19.4% in 2003 to 25.4% in 2007.

Following this, the Lee Myung-bak administration[78] published an upgraded version of the previous administration's Comprehensive Basic Research Promotion Plan, the Comprehensive Basic Research Promotion Plan 2008–2012; although the government's investment in basic research reached 25.4% in 2007, it was noted that the quality of the basic research was still low, and very few people felt that basic research had strengthened on the ground, so in 2012 the percentage of investment was increased to 35%. The government also declared that R&D expenses would rise to 5% of the country's GDP until the change in administration. Looking at the actual data, R&D expenses reached 4.36% in 2011, so it fell slightly short of the target, but this was still a big increase when compared to 3.2% in 2007. In addition to this, the support (funding) for basic research expenses for individuals with originality rose from 364 billion won in 2008 to 1.5 trillion won in 2012, making this a period in which basic research really started strengthening. This was also the period in which the Institute for Basic Science (IBS), which now produces many research outcomes and is growing as an excellent research organization, was created (2011).

77 For the part concerning the Roh Moo-hyun administration, see Roh Moo-hyun archives "Basic research investment analysis and policy direction"
http://archives.knowhow.or.kr/policy/all/view/20555; "Comprehensive Basic Research Promotion Plan 2006–2010"
https://academic.naver.com/article.naver?doc_id=18250283

78 For the part concerning the Lee Myung-bak administration, see the Comprehensive Basic Research Promotion Plan 2008–2012.
https://www.bioin.or.kr/board.do?num=179863&cmd=view&bid=policy

One can say that the full-fledged strengthening of basic research began with the Lee Myung-bak administration.

Subsequent administrations continued to strengthen basic research, and the Park Geun-hye administration issued the Comprehensive Basic Research Promotion Plan 2013-2017, publishing the goal of increasing the percentage of the government's R&D budget for basic research to 40%. This goal was reached in 2016 at 39%. It should be noted that in the past, the South Korean government divided research into fields and supported basic research based on this, but the Park Geun-hye administration decided to focus on people rather than fields, leading to a reborn system that provides support in accordance with researchers' careers, including young people, mainstays, and seniors. This enabled young researchers, who had not been the subject of much attention, to receive support; the idea of the Moon Jae-in administration's human-centered innovation system also agreed with this, and so it continued during this administration. As the importance of fostering young researchers grows day by day, it is conceivable that ways of providing support based on the research level of the researcher will increase researchers' motivation and lead to equitable evaluations.

2.4 Policies to develop new industries

In Chapter 1, the Fourth Industrial Revolution was defined as a great change moving toward an age in which everything is connected to the Internet and the data accumulated there is analyzed by artificial intelligence, leading to the development of new products and services. Chapter 2 has so far introduced, in turn, the development of policies and systems and the strengthening of basic research as measures carried out by the South Korean government to promote this industrial revolution. This section will explore the development policies that were enacted for new industries at the core of this industrial revolution, and in which the government hoped to bring about revolutionary development. Evaluations of the success of these development policies are included in Chapter 3, together with those of other parts of this chapter.

In the first Innovative Growth Big 3 Promotion Conference, held in 2020, the South Korean government focused on the future automotive industry, system semiconductor industry, and bio-health industry as new core industries that would drive future economic growth in South Korea, and clarified measures to strengthen concentrated investment. These industries are known as the "Big 3" industries that will lead the Fourth Industrial Revolution in South Korea.

2.4.1 Developing new industries centered on the Big 3 industries

At a Blue House conference in April 2019, Moon Jae-in stated, "To realize our goal of growing innovation, the government has continuously invested in eight major leading industries: smart farming, bio-health, smart cities, energy, drones, future automobiles, smart factories, and fintech. However, as the scale of each industry has become larger, we also sense the issues and limitations. In light of widening markets and increasing export values, as a government our policy will be to focus on the three industries with the greatest potential for growth—the future automotive industry, the system semiconductor industry, and the bio-health industry—and strengthen concentrated

investment in the future."[79]

To develop the Big 3 industries, the South Korean government held Innovative Growth Big 3 Promotion Conferences more than 20 times between 2020 and 2022, and enacted strategies for support.

First, this section will look at the future automotive industry.

(1) Future automotive industry[80]

The future automotive industry comprehensively refers to environmentally friendly electric vehicles, hydrogen vehicles, and autonomous driving based on ICT and AI. Automobile manufacturers such as Toyota, Volkswagen, and GM are also proactively working on the production of electric vehicles and hydrogen vehicles. In Japan, revisions were made to the Road Traffic Act to prepare for autonomous driving, and the US, Germany, and China are also making preparations for autonomous driving.

Automobile production quantities in South Korea started falling in 2015 (2015: 4.56 million ⇒ 2016: 4.23 million ⇒ 2017: 4.11 million ⇒ 2018: 4.03 million), with continuing financial difficulties in the parts industry. According to an announcement made by the government,[81] only seven South Korean companies were in the top 100 major global parts companies, 46% of parts companies only had one supplier, and parts companies also faced financial difficulties with the drop in automobile production. Although parts manufacturers hoped for investment in the future automotive industry, they suffered from insufficient investment capital and needs. Thus, in December 2018, the government published its program to increase vitality in the automobile parts industry, offering **3.5 trillion won of support to parts manufacturers who had potential for growth but were struggling due to fundraising.** Looking at the details, the government was to provide low-interest loans of up to 15 billion won for SMEs and 25 million won for mid-tier companies, and the repayment period for existing loans would be extended by one year.

Furthermore, to increase domestic demand, the government issued extraordinary measures: **it reduced consumption tax by 30% when purchasing a new vehicle, and reduced consumption tax by 70% if someone cancelled the registration of an aging diesel vehicle (10 years or more) and purchased a new vehicle.** On top of this, to realize the switch to electric vehicles and hydrogen vehicles, it decided to increase the number of electric vehicles, which was just 56,000 in 2018, to 430,000 in 2022, and the number of hydrogen vehicles from 923 to 65,000; it also aimed to install 310 charging spots for hydrogen vehicles across the country by 2022 (around twenty times the number in FY2019), and over 10,000 charging spots for electric vehicles.

After this program was implemented, in 2019 the amount of production increased by 1.1% compared to the previous year, and the amount of exports also rose by 1.9%. The number of electric vehicles grew sevenfold by August 2019, while the number of hydrogen vehicles was multiplied by thirty nine (when compared to data from 2016).

79 See Ministry of the Interior and Safety Presidential Archives, "Leading the future through the leading economic Big 3 industries," (April 2019)
http://19report.president.pa.go.kr/story/view/13.

80 See Policy briefing: Future automotives https://www.korea.kr/special/policyCurationView.do?newsId=148867273.

81 See Ministry of Trade, Industry and Energy, "Program to increase the dynamism of automobile parts" (December 2018) https://www.korea.kr/news/pressReleaseView.do?newsId=156309326

Meanwhile, test operations of autonomous driving on expressways started in February 2018, and K-city,[82] the test base for this, was completed in December 2018.

The South Korean government's assessment of the country's strengths and weaknesses concerning the future automotive industry were as follows:

"It excels in terms of its communication infrastructure and eco performance (environmentally friendly); with regard to communications, we have a world-class infrastructure that can support services connected to autonomous driving. Moreover, electric and hydrogen vehicles are the foundation of domestic production and are also at the top of the world in terms of efficiency and distance travelled. We possess some of the world's best fuel consumption technology for electric vehicles (Hyundai IONIQ 6.4 km/kWh) and have realized the longest distance in the world (609 km) for hydrogen vehicles. However, it must be said that the parts that form the basis of AI and our technological capabilities, the so-called core of software, are still at a low level, equivalent of 77% of those of advanced countries. Various profit-based relationships are intertwined in the automotive service field, so the system is as yet incomplete, and the provision of some services is delayed."

To overcome these issues, in October 2019 the government established the "**Future Car Industry Development Strategy 2030**," setting out a strategy to jump to the top of the world in future cars by 2030. In a nutshell, the goals are to get ahead in the global market through eco technology capabilities and popularization within South Korea, and to become a nation with a system and infrastructure for the world's first completely autonomous driving by 2024.

The strategy formulated to realize these goals can be summarized in the following four points.[83]

1. Increase the share of domestic new cars to 33% by 2030 and obtain a 10% share of the global market.

The country will produce electric vehicles and/or hydrogen vehicles for all car models by 2030 and achieve world-class performance in all. Companies that are actively working to improve fuel consumption and distance travelled will be supported with a subsidiary fund of 385.6 billion won from 2020 to 2026. Moreover by 2030, 600 hydrogen vehicle charging spots and 15,000 electric vehicle charging spots will be installed, so in 2030 drivers will be able to reach a hydrogen vehicle charging spot within 20 minutes of a major city, and within 75 km of an expressway. The government will continue to provide support for subsidiary aid until electric and hydrogen vehicles are popularized across the country, as well as support to gradually broaden and establish autonomous driving in buses, taxis, and trucks.

2. Achieve the world's first commercialization of completely autonomous driving in 2027.

The original goal was to commercialize completely autonomous driving by 2030, but the target was brought forward to 2027. To realize the commercialization of completely autonomous driving, the country has set out to introduce a

82 A 320,0000 m^2 experimental city for autonomous driving built in Hwaseong in Gyeonggi Province by Ministry of Land, Infrastructure and Transport. 12.5 billion won was invested.

83 See full text, Ministry of Trade, Industry and Energy, "Future Car Industry Development Strategy 2030," https://www.korea.kr/news/pressReleaseView.do?newsId=156355724

legal system to support completely autonomous driving by 2024 (determining performance verification, insurance, and the duties of drivers, etc.). Then, it will develop four major types of infrastructure (infrastructure for communication facilities, precise maps, traffic control, and roads) to complete a system and infrastructure faster than anyone else in the world, and, on the technology side, concentrate investment in core components such as systems, parts, and communication so as to become a country with strong autonomous driving technology by 2027.

3. Spread autonomous driving services and implement flying cars in 2023.

In this context, "services" includes private sector-led services and services based on public needs; private sector-led services include autonomous driving shuttles and taxis, and truck platooning, whereas services based on public needs refers to autonomous driving portals, support for operating emergency vehicles, day and night monitoring, emergency responses to vehicle failures, emergency restoration work for roads, shared car services, the optimization of public transport, and the diffusion of public administration services through autonomous driving. Through these services, the country aims not only to improve convenience for users, it hopes to ensure the safety of citizens and the optimization of urban functions.

4. Among parts manufacturers, increase the percentage of electronic device manufacturers to 20% by 2030.

In the past, the main type of support was short-term, concentrated support, with attention on the flow of funds, but the focus has changed to the shift to future automobiles, and at present the level of independence of core parts and materials for future automobiles has risen from 50% to 80%. In addition, the aim is for cooperation between large companies and SMEs to increase, and for further support for investment in equipment and securing talents for parts manufacturers aiming to become electronic device manufacturers (expected to be around 2 trillion won). The strategy also includes fostering at least 2,000 personnel who will be useful in the field or in research and promoting joint technology development with complete vehicle companies overseas.

The future automotive industry is very significant in South Korean society. The country's automotive industry is ranked seventh in the world (4.3 million vehicles in 2018) and contributes a lot to the domestic economy. According to data from 2018, sales from the automotive industry were 193 trillion won (13% of the manufacturing industry), it employed 400,000 people (11% of the manufacturing industry), and its export value was 91.872 trillion won (11% of the total). If the switch to future automobiles does not succeed, the damage to the South Korean economy may be beyond imagining.

The future automotive industry does not yet have an absolute leader, unlike the current automotive industry, and so can be seen as a chance for South Korea to dash ahead.

(2) System semiconductor industry (general non-memory business)[84]

After the future automotive industry, a second Big 3 industry is the system semiconductor industry.

"System semiconductor" is an expression specific to South Korea, and refers to the general non-memory business,

[84] For more details about system semiconductors, see Policy briefing: System semiconductors, https://www.korea.kr/special/policyCurationView.do?newsId=148868225.

such as the independent development, design, and production of system LSI (integrated circuits in which multiple functions are concentrated) and foundry (contracted production) services. System semiconductors, as semiconductors that play a role in data calculation and information processing such as control, are made up of more than 8,000 diverse components.

It is common knowledge that South Korea is a leader in memory semiconductors; the system semiconductor industry makes up 50–60% of the global semiconductor industry, and its market (though this does fluctuate depending on the year) is said to be equal to that of memory semiconductors (2018) or even approximately half as large again (2011). It is also famous as an industry that is not greatly affected by economic fluctuations. Looking at the changes in the percentage of the global market held by system semiconductors, the numbers are stable: 62% in 2011 ⇒ 59.8% in 2013 ⇒ 59.1% in 2015 ⇒ 53.4% in 2017 ⇒ 52.1% in 2018. Memory semiconductors are generally produced before orders, so there can be sudden price fluctuations if the demand and supply are inconsistent. On the other hand, system semiconductors are made-to-order to meet customer needs—they are produced after an order is received, meaning there are few price fluctuations due to inconsistencies in supply and demand.

Integrated device manufacturers (IDM) such as Samsung Electronics also produce system semiconductors, but the top 10 global companies such as the American Intel and Qualcomm hold over 60% of the system semiconductor market, and the structure of the industry is such that the design (fabless) and production (foundry) sectors are split. When it comes to memory semiconductors, IDM are responsible for all processes, from design to creation.

In 2018, the fabless market share (companies specializing in designing system semiconductors) was 61.7% in the US, 19% in Taiwan, 12.6% in China, 3% in the EU, 2.5% in Japan, and 1.6% in South Korea. In the US, six companies (Intel, Qualcomm, TI, Broadcom, NVIDIA, and AMD) were selected as top 10 global companies for system semiconductors thanks to generous support for private-sector companies through technology protection and other measures and the country's strength in basic research; these held 70% of the global market. Strategies to develop the semiconductor industry, both memory and system, were progressing in China, and increased domestic demand and robust support from the government had raised the fabless (technology/design sector) market share to third place. Taiwan was trying to develop global fabless companies such as MediaTek, Novatek, and Realtek through collaboration between the fabless (technology/design) and foundry (production) sectors.

In light of the situation described above, it cannot be said that South Korea was necessarily in an advantageous position for system semiconductors, so why did the South Korean government specify system semiconductors as a target industry?

The first reason was that this field had expectations for rapid growth. South Korea's experience with memory semiconductors meant that it had already secured technological and process know-how and high-level talent, which could both be utilized for system semiconductors. In 2001, the country's market share for memory semiconductors was only 25.6%, but in 2018 it demonstrated its potential and raised its share of the global market to 62%. This growth process took advantage of (20 years') accumulated knowhow in the foundry field (production sector) and aimed to develop system semiconductors along the same lines as memory semiconductors.

The other reason was that the country wanted to make use of the strengths of its network. South Korea was the nation that had realized the world's first commercialization of 5G; it was possible for it to create markets not only for smartphones and communication equipment, but also future industries such as smart factories, smart cities, and autonomous driving. System semiconductors are core components of future industries such as AI, the IoT, and autonomous driving, and are a field in which people anticipate major growth through fusions with other industries

(especially automobiles and energy).

Above all, the main reason for focusing on system semiconductors was a great need. There were many automobile and electronic industries (smartphones, TVs, etc.) with high demand for system semiconductors in South Korea, and in many cases, these were developing as global companies. In 2017, Samsung Electronics held a 21.1% share in the global smartphone market, overtaking Apple's 14.3% to stand at the top.

So, what strategies did South Korea employ to develop the system semiconductor industry with its super-high potential?

In 2019, the South Korean government created the **System Semiconductor Vision and Strategy**[85] and published the following targets: for the fabless (technology/development sector) market share, which was 1.6% in 2018, to reach 3% in 2022 and 10% in 2030, for the foundry (production sector) market share to grow from 16% in 2018 to 20% in 2022 and 35% in 2030. Work in the system semiconductor field should increase, with the number of people employed rising from 33,000 people in 2018 to 40,000 in 2022 and 60,000 in 2030.

To meet these targets, the country enacted the five strategies below.

1. **Fabless:** This strategy focuses on fields with much demand, such as automobiles, biotechnology, energy, IoT home appliances, robotics and machines, and fields in which competitiveness can be secured in a short period of time, creating a **platform (Alliance 2.0) for cooperation between companies with demand and companies with supply** and promoting joint "need identification ⇒ technology design ⇒ R&D." There were 25 ministries, companies and research organizations that participated in Alliance 2.0 and signed an MOU. Here, the **government is to carry out priority R&D investment of 30 billion won a year** for technology thought to require development. The strategy also sets out to establish **funding specifically for the private sector-led fabless sector (100 billion won),** to support fabless scale-ups with a basis for growth, designate excellent companies and research institutes, and provide **four years' of R&D support of up to 700 million won a year** so that these can freely develop products to meet market needs. It also calls for the creation of a system of cooperation between organizations with demand and the fabless sector in fields in which public need is expected, such as national defense, traffic infrastructure, safety and energy; the promotion of 26 million projects by 2030 through "identifying demand ⇒ planning projects ⇒ developing technology ⇒ supply," and the creation of over 240 billion won in market value.

[85] For the details below, see the full text of the System Semiconductor Vision and Strategy: https://www.korea.kr/news/pressReleaseView.do?newsId=156329321.

Table 2-14: Main companies participating in Alliance 2.0

Field	Companies with demand	Companies providing system semiconductors
Automobiles	Hyundai Mobis	Nextchip, Telechips
Bio/health	Onetech	OPTOLANE
IoT home appliances	LG Electronics, Dayouwinia, Cuchen	LX Semicon, MCSLOGIC
Energy	Korea Electric Power Corporation, Korea Gas Corporation	Silicon Mitus
Advanced robots/ machines	Hyundai Robotics, HIGENmotor	Dongwoon Anatech

2. **Foundry:** This strategy's goal is to simultaneously capture the leading market and the niche market; it sets out to offer tax system deductions and financial support to companies so that representative foundry companies can focus on high-tech processing technologies, and mid-tier companies can develop and invest in middle-tech processing technologies. One example is the KDB's support program for adjustments to industrial structures, which loans up to 250 billion won to companies investing in the facilities of major industries and their technology.

3. **Technology:** This strategy calls for **investment of more than 1 trillion won over 10 years in the development of next-generation intelligent semiconductor technology** such as AI semiconductors, and the establishment of related systems so that national core technologies are not leaked overseas. The breakdown of this 1 trillion won consists of investments of 520 billion won between 2020 and 2026 by the Ministry of Trade, Industry and Energy (MOTIE), and investments of 480 billion won between 2020 and 2029 by MSIT. **Among R&D projects from the last five years (2017 to 2022), system semiconductors were the first to have a preliminary feasibility study budget[86] of over 1 trillion won**.

Table 2-15: Typical examples of next-generation intelligent semiconductors

AI semiconductors	AI semiconductors to be used in smart cities, VR/AR, and Big Data
Automobiles	Semiconductors that will improve the battery performance of electric vehicles tenfold
Biotechnology	Semiconductors for in-vitro diagnosis, which diagnoses diseases using body fluids
IoT	Semiconductors for extremely small equipment that makes autonomous collection, evaluation, and processing of data possible
Energy	Semiconductors that convert natural energy to electrical energy
Robots/ machines	Semiconductors for robots that can communicate emotionally with humans

[86] A preliminary feasibility study is a preliminary investigation of the feasibility of a project that is to receive money from the national budget. The system was introduced in 1999 to reduce wasted budget and project risks. These surveys are carried out for 100 billion won or more (in the case of financial support, 50 billion won or more.)

4. **Talent:** This strategy fosters the semiconductor talents that companies need by establishing **new courses of study for semiconductor contracts** and gradually increasing the intake number. These courses aim to agree contracts in advance so that students can gain employment at relevant companies after graduation, rather than companies providing support by paying course fees. The aim is to **foster 17,000 semiconductor talents by 2030**.

   First, at the undergraduate level, Yonsei University and Korea University both established semiconductor contract courses in 2021, starting with 80 applicants. The policy is to gradually increase this number so as to foster 3,400 people by 2030. They have also introduced a new specialist track for system semiconductors. This specialist track system is a degree program without set numbers, and can be freely chosen by students without limiting their major; if they complete the specified credits, they can obtain a nanodegree. These are new programs to foster integrated talents who can respond to changing societal demand, and the expectation is that they will develop integrated talents with the innovation needed for the era of the Fourth Industrial Revolution. One strength of these programs is that students specializing in AI can also join the specialized semiconductor track and become knowledgeable about both AI and semiconductors, making it very likely they will be in a good position for employment.

   On the post-graduate level, R&D programs are being developed with 140 billion won to meet corporate needs, and the policy is to foster 4,700 people by 2030 by promoting master's and doctoral development programs with collaboration between universities and industry.

   In addition, to foster practical talents, a polytechnic university in Anseong City (specialist university) is expected to change into a university dedicated to semiconductors, and additional investment of 2 billion won is to be given to support the IC Design Education Center (IDEC).[87] The IDEC has nine hubs across the country, including KAIST, and contributes to the development of talents by providing lectures and seminars online and in person (mainly 2–6 week programs). It is mostly used by students and working adults to increase their skills. High-quality lectures are given directly by university faculty members, and can be attended for free, making it appealing.

5. **Win-win system:** The aim is to create a win-win system, in which the growth of the fabless industry leads to increased demand for foundry, and the growth of foundry contributes to increased competitiveness in fabless products. This strategy calls for the government to support the development of infrastructure, etc., to enable the provision of design house services that act as bridges between the fabless and foundry sectors. It also sets out to develop systems to strengthen the protection of information, including that of national core technologies, and to develop systems to add new national core technologies such as 5G communication modem chips.

The market share and growth rate of system semiconductors is low when compared to memory semiconductors, and this has been a concern of South Korea for many years; to become a country that leads in both types of semiconductors, which is South Korea's aim, it must overcome this issue.

87 https://www.idec.or.kr/

(3) Bio-health industry[88]

The last of the Big 3 industries is the bio-health industry. The bio-health industry produces products to be used for the human body based on biotechnology, medicine, and pharmaceutical knowledge, and provides relevant services. This also includes manufacturing industries such as pharmaceuticals and medical devices, and digital healthcare services. The bio-health industry is one in which technology and funding is concentrated, so although significant time and costs are needed for R&D, if a company, etc. obtains excellent outcomes they can take up an advantageous position in the market in a short period of time.

Complex interests are more and more intertwined in the bio-health industry, including those of doctors, patients, and hospitals, so cooperation between companies, governments, and research organizations has become more important. If there are side effects, it is highly likely that a situation in which a person's life is at stake will occur, so it is vital that R&D complies with social ethics, and all processes, from market creation, production and sales, to distribution, must be thoroughly managed.

This industry is designated one of the Big 3 in part because of the direct bearing it has on the health of citizens, but above all because it has a high growth potential and there are expectations of it making great contributions to increased employment. As the global population ages, the demand for healthcare increases day by day, and in this context South Korea moved from an aging society to an aged society in 2017,[89] and is expected to become a super-aged society in 2025.[90] Focusing on South Korea's bio-health industry could be said to be an inevitable choice based on its social structure.

South Korea has demonstrated its high level of competitiveness in the bio-health industry, ranking second on a global scale for its biopharmaceutical production capacity in 2018, with exports of new drugs and new technologies recorded as 5.3 trillion won (up four times from the previous year).[91] The export value of pharmaceuticals and medical devices was marked as 20.4019 trillion won, an increase of 19% from the previous year. The technological capabilities of the industry as a whole still do not reach those of the US, but its ultrasound imaging diagnostic equipment ranked first for global exports, with dental implant exports ranking fifth.

The **Bio-health Industry Innovation Strategy** created in May 2019 noted three goals: **increase the global market share of new drugs and medical devices threefold by 2030, create jobs for 300,000 people, and develop five major export-orientated industries in the bio-health industry**.

To accomplish these, the government set out specific strategies[92] for everything from the R&D stage to the release (market launch) stage.

1. R&D stage: To build five major Big Data platforms (national bio-Big Data, data-centered hospitals, Big Data

88 For details relating to the bio-health industry, see Policy briefing: Bio-health industry, https://www.korea.kr/special/policyCurationView.do?newsId=148862220#L2.

89 According to the UN, an aging society occurs when the number of older people aged 65 and over exceeds 7% of the total population; if they exceed 14%, it is an aged society, and if they exceed 21%, it is a super-aging society.

90 Donga Ilbo, "South Korea, three years on, a super-aging society, in 2040 one in three people will be elderly," (April 2022), https://www.donga.com/news/article/all/20220415/112889981/1.

91 Ministry of Trade, Industry and Energy, "Bio-Big Data: 4 trillion won of R&D investment, developing a global level of bio-health," (May 2019), https://www.motie.go.kr/motie/ne/presse/press2/bbs/bbsView.do?bbs_seq_n=161704&bbs_cd_n=81.

92 See policy briefing: "4 trillion won a year for bio-health R&D, taking on the challenge of becoming a global power," https://www.korea.kr/news/policyNewsView.do?newsId=148861034.

concerning candidates for new drugs, bio patent Big Data, Big Data from public organizations) to be used for R&D in new drugs/new medical technology, to create national bio-data for 1 million people by 2029, and to gather genome information for interested parties. The R&D budget for new drugs and medical devices is to be gradually enlarged from 2.6 trillion won in 2018 to at least 4 trillion won in 2025. In addition, **15 trillion won of dedicated funding**[93] **is to be used** to strengthen finance and tax support in the bio-health field, with more than 2 trillion won of government investment over five years **driving private-sector investment**. There should also be proactive development, such as tax deductions for R&D expenses and increased eligibility for these in accordance with the characteristics of bio-health companies (the new addition of expenses for clinical trials of biobetters).

2. **Approval/permission stage:** At this stage, the aim is to strengthen the expertise of the Ministry of Food and Drug Safety and achieve rapid processing for approval and permission. Increasing the number of personnel responsible for reviews will ensure priority reviews for new drugs from innovative manufacturing companies. This strategy also calls for stronger safety management in all processes for biopharmaceuticals, especially advanced biopharmaceuticals, and the creation of a system for clinical research on regenerative medicine. The strategy requires the improvement of regulations concerning drug creation and medical devices in line with the US and the EU, and the removal of bottlenecks to global competition, etc.
3. **Production stage:** The government is to support information sessions about joint investment in advanced companies, business creation, and innovation companies, aimed at overseas investors, to create a system of cooperation between advanced companies, business creation, and innovation companies. In addition, referencing the example of Ireland establishing the National Institute for Bioprocessing Research and Training (NIBRT) in 2011 and successfully training experts in all areas of bio-drug creation, the strategy sets out the creation of an education system similar to NIBRT, the development of data specialists, and the expansion of AI graduate schools (see 2.5.2 for details). It also calls for the establishment of a center to foster talents involved in bio processes, developing production facilities to an international standard (facilities that meet Good Manufacturing Practice (GMP) (a standard of production and quality management for pharmaceuticals)) so they can receive training on biopharmaceutical production processes, and for a significant increase in the number of specialist personnel involved in production processes. As a country, South Korea's aim is to ensure the domestic production of the raw materials and equipment needed to operate biopharmaceutical production facilities at as early a stage as possible, to cut production costs, and for the combined growth of upstream and downstream industries. Although South Korea is said to have a high production capacity for biopharmaceuticals, the more it relies on imports for everything from consumable goods to production equipment, the more domestic production becomes an urgent issue.
4. **Release (market launch) stage:** The government aims to actively use new technologies such as digital healthcare in actual medical services to create a market for bio-health, and to improve the quality of in-person diagnosis and services. First, this strategy expects the government to encourage the popularization of new technologies by **designating large hospitals as centers for the assessment of domestically produced devices, improving performance while these centers increase trust through their device assessments, and strengthening R&D support for the development of domestically produced medical devices**.

[93] Scaling up funding is funding created to support the domestic development of new medicines. Up to 2022, the budget was 15 trillion won.

In 2020, the Act on the Development of Medical Devices and Act on In Vitro Diagnostic Medical Devices were established, and a certification system for medical devices used to treat intractable illnesses was introduced. This enabled accompanying diagnostic medical devices developed at the same time as pharmaceuticals to gain medical device/pharmaceutical approval at the same time, saving the time used for a second review.

Moreover, in 2020, the regulations in the four following major fields were reviewed through a program to improve core bio-health regulations, aiming to relax the regulations of the bio-health industry.

Table 2-16 Program to improve core bio-health regulations

Four major fields	Issues for improvement
Improving research environments for new industries	· Utilization of medical data, widening of private-sector openings · Permission for the development of medical technologies and pharmaceuticals that reuse medical waste (e.g. fats disposed of after liposuction) · Provision of guidelines for the use of derived research resources such as microbiomes · Improvement of award system in the bio-health field (system that awards people who have worked in the industry for at least 15 years and made major contributions to the development of the industry and technology)
Innovation in medical devices	· More types of VR/AR (virtual reality/augmented reality) medical devices · Priority review system for highly innovative medical devices · Realization of early market penetration of medical devices through the improvement of systems to assess technology
Services relating to health management	· Introduction of health management service certification and health incentive system · Wider scope for approval for genetic testing requested by consumers themselves · Simplification of certification for genetic testing institutions
Abolishment of overlapping regulations	· Relaxation of scale limitations concerning the production facilities of companies in cutting-edge medical complexes · Increased scope of exemptions for safety certification of electronic parts for medical devices · Increased scope of exemptions for the environmental burden fee for medical device waste · Development of regulations for PR surrounding medical devices · Clarification and transparency of price information for medical devices, period of payment, etc.

Source: Program to improve bio-health core regulations[94]

The above section introduced strategies for the development and support of new industries, especially the Big 3 industries.

In recent years, the focus has been on stronger support for SMEs, venture companies and startups as one part of the strategy to develop new industries; the support measures for this are detailed below.

94 Program to improve core bio-health regulations, https://www.korea.kr/news/pressReleaseView.do?newsId=156371082

2.4.2 Stronger support for SMEs, venture companies, and startups

As was mentioned in Chapter 1, a social structure centered on large companies works as a weakness in the era of the Fourth Industrial Revolution, so the South Korean government aimed to resolve the bottlenecks in industrial development and strengthen competitiveness by greatly strengthening support for SMEs.

In South Korea, "9981" is a figure used to refer to SMEs, signifying that 99% of companies are SMEs and these provide 81% of employment. From this, one could assume that SMEs have a notable position in the South Korean economy, but according to a 2016 survey carried out by the Korea Institute for Industrial Economics and Trade, only 52.4% of the policies to support SMEs implemented by historical administrations yielded results, and it has been pointed out that it is necessary to improve the quality rather than consistently expand the scale of support.[95]

The Moon Jae-in administration revised the Government Organization Act in July 2017, with the aim of ensuring full-fledged support for SMEs, venture companies, and startups, and elevated the **Small and Medium Business Administration to the Ministry of SMEs and Start-ups (MSS)**[96] Projects relating to smart factories, which had been run by MSIT and MOTIE, were all transferred to MSS. In 2019, the SME Policy Committee, consisting of Minister of SMEs and Start-ups, corporate representatives, experts, and other members, was established; this deliberates and coordinates policy for the protection and growth of SMEs.

(1) R&D support for SMEs, venture companies, and startups

Moon Jae-in stated in his presidential election pledge that he would "Double R&D support for SMEs"; in 2017, R&D support for SMEs was 3.1686 trillion won, exceeding 2.8973 trillion won from the previous year. After this, the amount of R&D support for SMEs was kept at a level of over 3 trillion won each year, and was increased to 4.9721 trillion won in 2021, nearly 5 trillion won. According to government announcements, a total of 34,781 funding projects were developed to encourage SME growth between 2017 and 2020, averaging 8,695 a year. Funding used to support technological development in SMEs was 4.7718 trillion won, averaging 1.1930 trillion won a year. Over three years, 19,799 smart factory facilities were established, and this greatly contributed to increased SME productivity and a decrease in defective products.[97] As is evident in the figure below, companies that worked towards technological development with government support clearly had higher sales and exports that those that did not receive support.

95 Participation and innovation, "What is included in Moon Jae-in administration's SME policy?" (November 2017), http://www.laborplus.co.kr/news/articleView.html?idxno=11892.

96 It has been around 20 years since the Kim Dae-jung administration elevated the Small and Medium Business Administration to the Ministry of SMEs and Start-ups in 1996.

97 For the data above, see Office for Government Policy Coordination, "The Moon government's achievements promoting 100 major national policies" (2021)

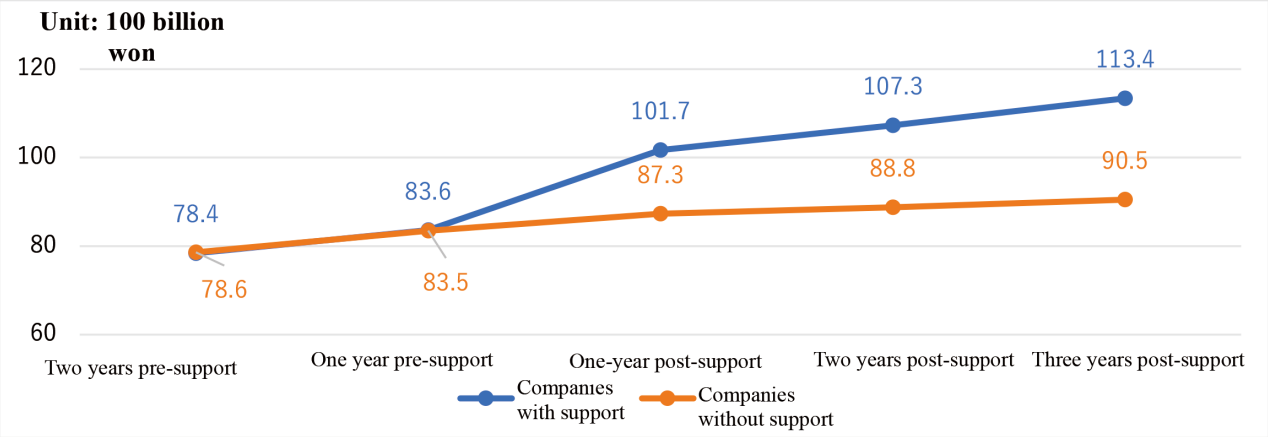


Figure 2-17: Comparison of sales of SMEs that received governmental R&D support and those that did not

Source: Office for Government Policy Coordination "The Moon government's achievements promoting 100 major national policies"

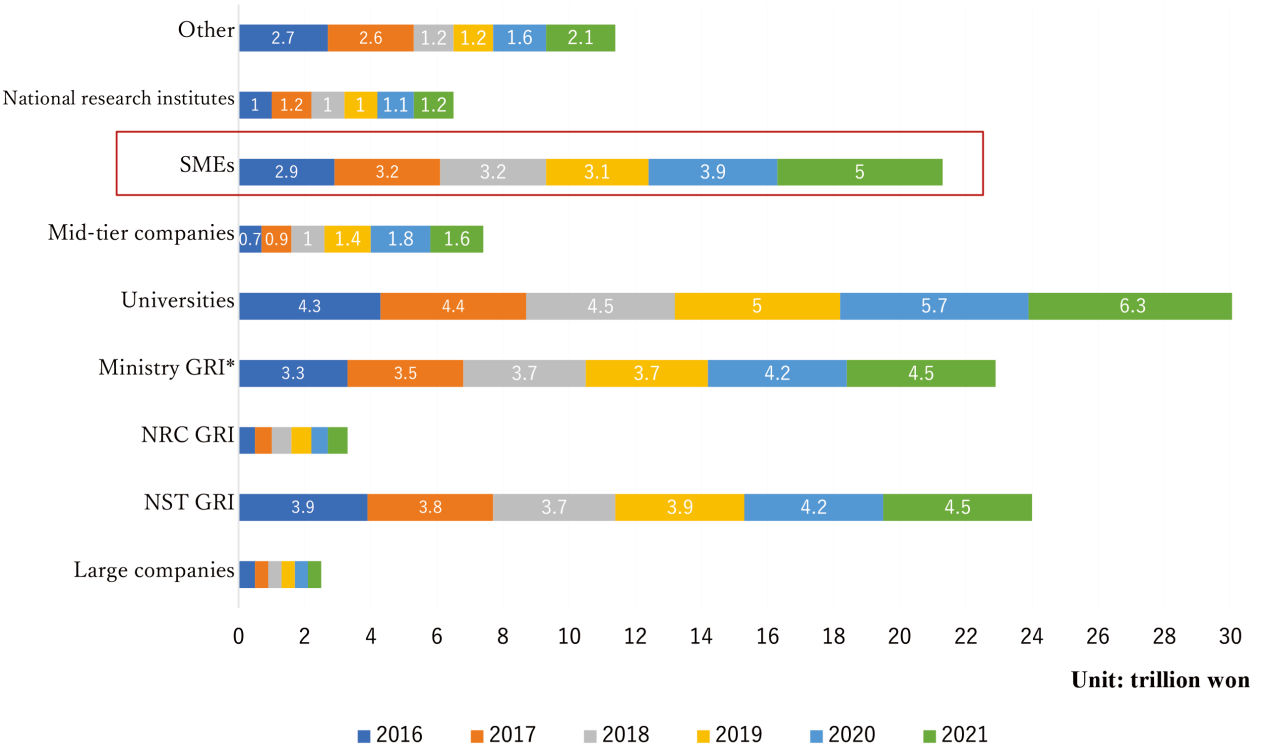


Figure 2-18: Changes in R&D expenses by research leaders*

Source: STEPI R&D activity report from each fiscal year

*Comment on Figure 2-18: Changes in R&D expenses by research leaders: In South Korea, there are government-funded research institutes that operate with full or partial financial support from the government. Government-funded research institutes established on the legal basis of the Act on the Establishment, Operation, and Fostering of Government-funded Research Institutes fall under the jurisdiction of the National Research Council for Economics, Humanities and Social Sciences (NRC), and government-funded research institutes established through the Act on

the Establishment, Operation, and Fostering of Government-funded Science and Technology Research Institutes fall under the authority of the National Research Council of Science and Technology (NST). Simply put, government-funded research institutes are split according to whether they are concerned with the natural sciences or not.

Government-funded research institutes are here referred to as GRI, and are split into the following three categories in South Korea.

• GRI under the umbrella of the National Research Council of Science and Technology (NST GRI): This refers to 26 organizations, such as the Korea Institute of Science and Technology (KIST) (including the National Research Council of Science and Technology) and the Korea Institute of Machinery and Materials (KIMM). The NST was established in 2014 as an organization under MSIT and helps the development of national research programs and industries by supporting, fostering, and systematically managing GRI in natural science fields (excluding GRI under the direct control of ministries).

• GRI under the direct control of ministries: This covers 47 organizations, including specified research organizations (KAIST) that fall under various ministries, the Agency for Defense Development, and the Korea Institute of Ocean Science and Technology.

• GRI under the National Research Council for Economics, Humanities and Social Sciences (NRC GRI): This refers to 27 organizations, such as the Korean Development Institute (KDI) (including the NRC), and the Korean Research Institute for Human Settlements (KRIHS). The NRC is an organization established in 2005 that falls under the authority of the Prime Minister and supports government-funded research institutes in the fields of the humanities and social sciences.

The **government set extraordinary tax benefits to support R&D in SMEs**.[98] First, to be eligible for the tax benefits, the company must have established an **affiliated research institute** that only carries out in-house company research; companies with affiliated research institutes can enjoy various tax benefits. This section introduces some of these.

- **Financial support equivalent to 80% of the tariffs for goods imported for the purpose of R&D.**
- **Capital investment for the purpose of R&D can mean reductions of 10% of corporation tax or comprehensive income tax reductions.**
- **Local tax exemptions for real estate purchased to establish an affiliated research institute.**
- **SMEs can enjoy 25% tax reductions for R&D expenses. R&D expenses for promising technologies (technologies that could have new growth power) and innovative technologies can have reductions of up to 40%, and those for national strategic technologies can have reductions of up to 50%.**
- **Businesses can receive support for 50% of the HR costs for staff hired for the purpose of employment support programs (one year only). If those staff members are research talents, tax reductions of 25% of the expenditure minus the amount of HR cost support are also available.**
- **Companies that enjoy tax reductions and exemptions must pay a minimum set tax and a special tax for farming and fishing villages (an amount equivalent to 20% of the reduction), but companies focused on R&D are also**

98 Golden Taxation Platform, "Why SMEs should actively take on R&D," (October 2022), https://blog.naver.com/lala5303/222903248800.

exempt from this.

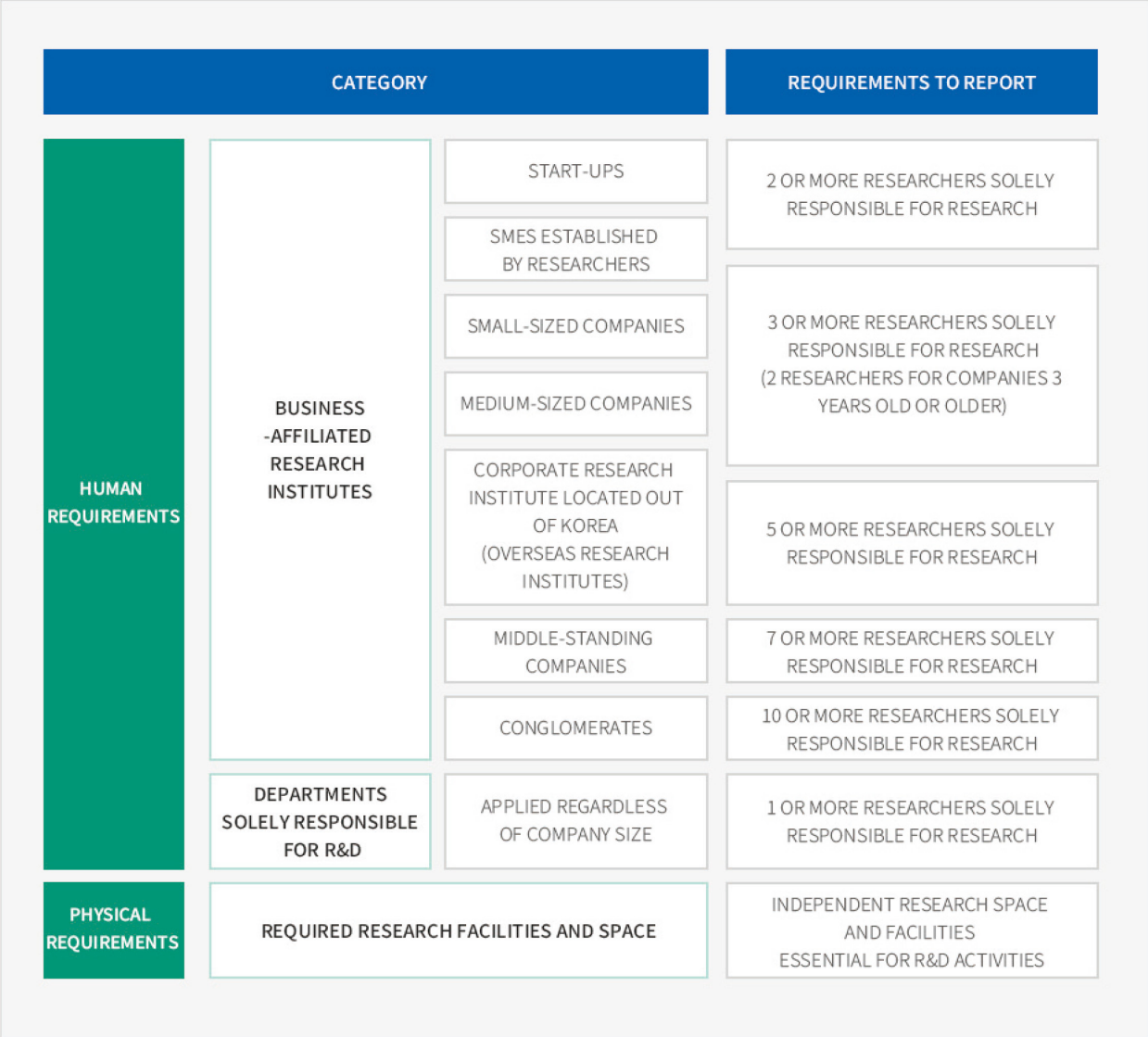


Figure 2-19: Conditions for the establishment of business-affiliated research institutes

Source: Ministry of Trade, Industry and Energy invest korea[99]

[99] https://www.investkorea.org/ik-jp/cntnts/i-750/web.do

Support		Related Law
Tax deductions for research and HR development expenses	General research	Article 10 of the Restriction of Special Taxation Act (Attached Table No. 6)
	New growth engines	Article 10 of the Restriction of Special Taxation Act (Attached Table No. 7)
Tax deductions for R&D and HR development and facility investment		Article 25 of the Restriction of Special Taxation Act
Local tax deductions for real estate to be used as business-affiliated research institutes		Article 46.1 of the Restriction of Special Local Taxation Act
Special taxation for technology transfer and leasing, etc.		Article 12 of the Restriction of Special Taxation Act
Income tax reductions or exemptions for foreign engineers		Article 18 of the Restriction of Special Taxation Act
Special taxation for R&D-related contributions, etc.		Article 10.2 of the Restriction of Special Taxation Act
Corporate tax reductions or exemptions for high-tech companies in special R&D zones		Article 12.2 of the Restriction of Special Taxation Act
No income tax for research activities of researchers		Article 12.12.3 of the Enforcement Decree of the Income Tax Act
Customs reductions or exemptions for industrial technology R&D goods		Article 90.1.4 of the Customs Act

Figure 2-20: Tax benefits for businesses with affiliated research institutes

Source: Ministry of Trade, Industry and Energy invest Korea

(2) Support for venture companies

To support venture companies, the government proactively makes use of a fund of funds.

In South Korea, this refers to a mother investment fund (a pooled fund that invests in smaller funds). Rather than directly investing in venture companies or venture capital, the South Korean government first sinks capital into a fund of funds, then the fund of funds contributes to venture funds (venture capital), and the venture funds support venture companies; this means the government provides indirect support to venture companies.[100] Sinking government capital into venture funds (venture capital) via a fund of funds enables additional capital to be collected from the private sector. The Government **invested 4.8 trillion won in the fund of funds over five years from 2017**. The cumulative contribution from when the fund of funds was established in 2005 until June 2017 was 2.6 trillion won, but in July the Moon administration announced an investment of 800 billion won in the fund of funds in 2017, leading to a ninefold increase from the previous year. In 2020, the amount newly invested in the venture funds (venture capital) from the fund of funds and the private sector, and the amount of venture investment, reached a historic high.

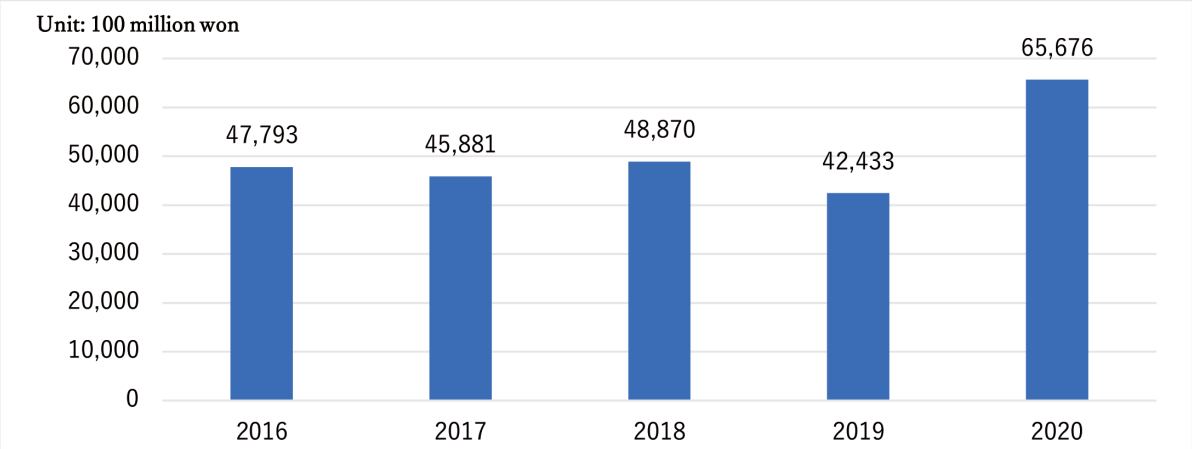


Figure 2-21: Amount invested in venture funds by the government and private sector

Source: Office for Government Policy Coordination
"The Moon government's achievements promoting 100 major national policies"

[100] Maeil Business Newspaper, "What is a fund of funds?" (December 2004), https://www.mk.co.kr/news/home/view/2004/12/443843/.

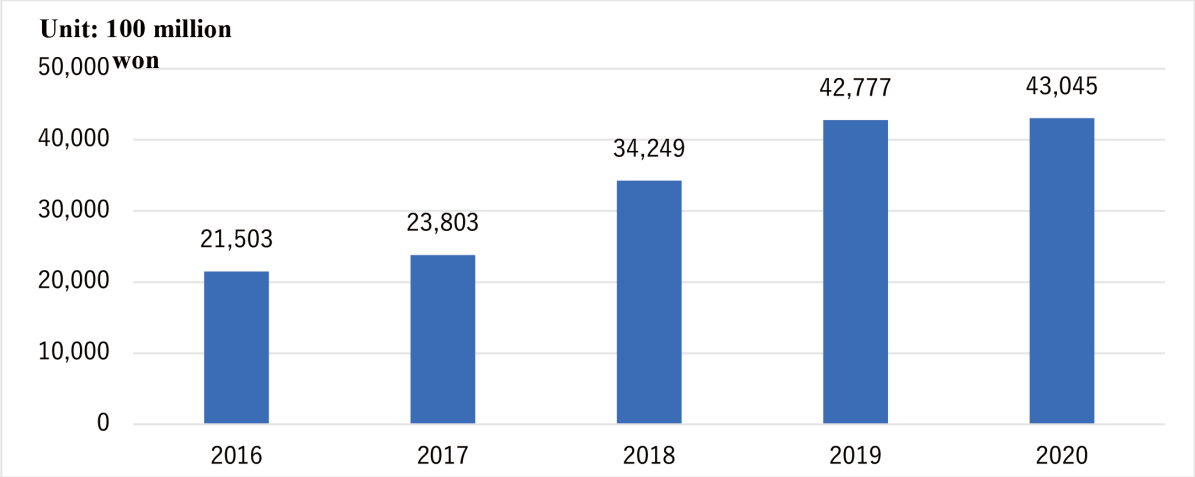


Figure 2-22: Past venture investments

Source: Office for Government Policy Coordination
"The Moon government's achievements promoting 100 major national policies"

This section will explore the **main targets of support from the fund of funds**.[101]

The first is **support for young companies.** The fund of funds provides capital (from 2021 onwards) for a young people's business creation fund that concentrates its investment in companies created by young people. This refers to companies founded less than seven years ago whose representative is 39 years old or less, or at least 50% of all staff are 39 years old or less. The young people's business creation fund has invested 102.5 billion won in companies created by young people as of 2021, and of this, 60 billion won is from the fund of funds.

The second is support for the development of innovation companies in their growth phase into unicorn companies. As of 2021, the fund of funds has invested 295 billion won into a **scaling-up fund** that develops innovation companies.

To encourage the growth and establishment of venture companies, the government formulated the Venture Investment Promotion Act (August 2020), and **from 2021, any public organization purchasing goods necessary for business must purchase goods equivalent to 8% of the total purchase amount from newly established companies**. Moreover, **to facilitate the creation of businesses in the manufacturing industry, 16 types of contribution paid when establishing factories (contribution to use groundwater, contribution to transportation, etc.) were exempted**. On top of this, **until 2022, the joint liability system for corporate representatives was completely abolished** to reduce the burden in times when things go wrong. A system improvement from 2018 saw the government make it unnecessary to set up a person or body for the collective responsibility of loans if a legal corporate representative passed assessments of morality and liability (accountable management review), regardless of their history, and removed restrictions that made it difficult to take on challenges again or re-establish a business due to an inability to repay a loan in the case of temporary management deterioration or cessation of business.

[101] For information about the Young People's Business Creation Fund and Scaling-up Fund, see Policy briefing "Ministry of SMEs and Startups, 400 billion won fund set up to invest in innovation companies and young business founders," https://www.korea.kr/news/policyNewsView.do?newsId=148893794 (September 2021); money today, "Additional 400 billion won added to venture fund, concentrated on scaling-up fund, young people's business creation fund," (September 2021), https://news.mt.co.kr/mtview.php?no=2021093010394272185.

(3) Support for unicorn companies[102]

Support for promising startup companies was provided through the K-Unicorn Project.

The K-unicorn Project started in 2020, with the aim of fostering unicorn companies. A unicorn company is an unlisted venture company with a corporate value assessment of 1 trillion won or more. Support for unicorn companies is rolled out in two stages; the first stage is discovering promising startups (baby unicorn companies) and fostering them as pre-unicorn companies; the second stage is supporting them so the pre-unicorn companies can be valued by and receive investment from South Korea and other countries.

Around 40 companies have been selected as **baby unicorn companies**, and support of up to 15.9 billion won is being given, including 300 million won for market development costs. In addition to this, **special guarantees (up to 5 billion won) and business funds (up to 10 billion won)** are also available. The beneficiaries are companies founded less than seven years ago and companies with cumulative investment of 2 billion won up to 10 billion won. Screening is split into three stages, with the first stage consisting of a assessment of the company's technology and business feasibility, the second stage involving an expert examination of the business plan, and the third stage being a public review, meaning a presentation is given in front a team made up of experts and members of the general public. Outside of the above support, there is also **high-pass financing**, in which case companies selected as baby unicorn companies can **quickly receive funding of up to 10 billion won** if they clear just the minimum requirements.

Around 15 companies have been selected and supported as **pre-unicorn companies**; eligible companies are those with a corporate value of 100 billion won or sufficient market validation,[103] growth potential,[104] and innovation potential.[105] The screening process is very similar to the process for baby unicorn companies, but also includes a written evaluation (confirming whether the company has the qualifications to apply). The companies selected can receive special guarantees of up to 10 billion won. Selected companies can **receive special guarantees of up to 10 billion won**. Special guarantees are for companies with the potential to grow into unicorns, and refer to support via funding for scaling-up of up to 10 billion won.

The level of commitment to strengthening support for SMEs, venture companies, and startups is evident from the elevation of the Small and Medium Business Administration to ministry level, and can be said to have occurred on an unprecedentedly large level, both in terms of the amount of support and the scale of it.

2.5 Measures to foster digital talents

Now, in the global competition in science and technology, it is no exaggeration to say that securing and fostering talents is the key to victory. While South Korea is making efforts to foster practical talents to secure the core technologies of the Fourth Industrial Revolution, it is also developing programs to strengthen the innovation potential

[102] For information about unicorn companies, see Policy briefing: Launch of the K-Unicorn Project, (April 2020), https://www.korea.kr/news/pressReleaseView.do?newsId=156385238; Policy briefing: Establishment of special guarantee system for pre-unicorn companies, (April 2019), https://www.korea.kr/news/pressReleaseView.do?newsId=156327924.

[103] Has successfully attracted investment with a cumulative total of 5 billion won.

[104] Companies with a compound annual growth rate of at least 20% in sales over the last three years. If the company was founded less than three years ago, companies with at least 10 billion won of annual sales are eligible.

[105] Evaluated according to technological assessment grade standards; the outcome must be at least a BB grade for technology and business model.

and digital capabilities of young talents, especially university students. In addition, it is improving digital education for all citizens, so that everyone, regardless of age, can respond as quickly as possible to the rapid changes occurring in the era of the Fourth Industrial Revolution.

2.5.1 Fostering practical talents for companies

As was stated above, 99% South Korean companies are SMEs, and unlike the large companies in which job seekers gather, SMEs are chronically concerned with a lack of human resources. On the other hand, according to data from 2015 to 2020, the employment rate of graduates from higher education institutions stagnated around 65%,[106]with employment mismatches between companies and talents. The Fourth Basic Plan for Nurturing and Supporting Scientific Talents[107] issued by the government included analysis suggesting that there were insufficient talents needed for target industries and new industries in the Fourth Industrial Revolution, but many people were graduating from specialist fields in industries with a lack of demand. Looking at the percentages of R&D investment in different fields, taken from the total R&D investments by companies, the fields that were the focus of businesses in 2016 were information communications (51.7%), machinery (20.6%), construction and transportation (10.6%), biotechnology (5.2%), and materials (5.8%). On the other hand, in that same year, the breakdown of university graduates with master's and doctoral degrees by major was a mere 16.3% for information communications, in which large corporate demand was expected, 5.6% for machinery, 7.6% for construction and transportation, and 26.1% for biotechnology, in which little corporate demand was expected. Moreover, MOTIE noted (in 2018) that there was a serious lack of high-level talents with master's or doctoral degrees in industry; the percentages of the numbers of talents lacking compared to the need for them were 13.8% in machinery, 3.1% in software, and 11.6% in digital healthcare.[108]

Aiming to resolve this mismatch, the government started programs to foster talents for employment in SMEs, including the following.

1. SME contract courses[109]

First, the government developed an SME contract course system, establishing degree programs required by SMEs (industry) through agreements between the Ministry of SMEs and Startups and universities, and fostering practical talents. This is limited to promising technology fields in the era of the Fourth Industrial Revolution (future automobiles, semiconductors, etc.)

The SME contract course system is said to be a system with advantages for students (employees), SMEs, and

106 Higher education institutions include specialist universities, universities, regular graduate schools, graduate schools of industry, schools of education, and vocational schools. From 2015 to 2020, the employment rate was as follows, without major fluctuations: 67.5%⇒67.7%⇒66.2%⇒67.7%⇒67.1%⇒65.1%.See the E-national indicators for the employment rates of graduates from higher education institutions: https://www.index.go.kr/potal/main/EachDtlPageDetail.do?idx_cd=1551.

107 Full text of the Fourth Basic Plan for Nurturing and Supporting Scientific Talents: https://www.bioin.or.kr/board.do?num=319643&cmd=view&bid=agenda

108 See p6 of the Fourth Basic Plan for Nurturing and Supporting Scientific Talents.

109 For information about this system, see Ministry of SMEs and Startups, introduction to SME contract course program, https://www.smes.go.kr/sanhakin/ and program details: https://www.mss.go.kr/site/smba/supportPolicy/supportPolicyDetailDiv.do?cmm_code=BB020400&searchSeq=ST_000000001065842; 2021 documents for new recruitment information: https://www.mss.go.kr/site/smba/ex/bbs/View.do?cbIdx=86&bcIdx=1030505.

universities. Employees can obtain a degree, find employment, and improve their ability to work; SMEs can secure excellent talents, and increase their business productivity. Universities can foster talents that can response to needs in the real world of industry, and develop and manage a curriculum, as well as receive government support of 35 million won per semester.

The system consists of the following three programs.

- **Employment requirements:** This program ensures that participants gain their degrees with employment contracts already signed, and graduates must work at the relevant company for at least two years. In return, students' tuition fees during their enrollment are completely paid by the government.
- **Re-education:** This program is aimed at staff working in SMEs (people who have been employed there for at least six months), and allows the staff to obtain a degree through programs at night and on weekends, aiming to improve their work capabilities. The government provides 65% of the money needed for the staff members to obtain their degree, and the company and the staff member in question pay the remaining 35% (the distribution of payment between the company and the staff member is decided by both parties). The staff member must work at the company in question for at least one year after obtaining their degree.
- **Re-education and employment:** This concurrent study-work program was developed for new working adults. Participants must obtain their degree through programs at night and on weekends while employed and working at a company. All tuition fees for the program are paid for by the government. Participants must remain at their company for at least two years after graduation.

This system was introduced in 2010, but the aim when it was first launched was for staff members at SMEs to improve their work capabilities through the re-education program described above, which enables further study after gaining employment. After this, the system expanded to have diverse programs from 2018, and was reborn as a system with the double benefits of securing talents for companies and resolving difficulties in finding employment among students. From 2018, around 2,000 students (employees) have received support each year (1,852 in 2018, 2,065 in 2021). As of 2021, this system is implemented in 48 universities across the country.

2. Supporting the employment of master's degree and doctorate holders in SMEs[110]

The system to encourage the employment of master's degree and doctorate holders in SMEs is a program that runs concurrently with the SME contract course system. Through this program, the government provides opportunities for science and technology master's degree and doctorate holders who have not yet determined their place of employment to gain the practical experience needed for corporate work and offers support so they are able to find employment in companies.

The program aims to support people (no previous employment) who gained their master's degree or doctorate within the last five years and graduated with a specialty in a science and technology field and enables them to participate in corporate training while receiving a salary for up to nine months. The main training centers are government-funded

[110] For information about this program, see the Korea Industrial Technology Association's introduction to the training program for science and technology specialist technology master's degree and doctorate holders: https://www.koita.or.kr/manpower/sb_edu.aspx.

research institutes and national or public research institutes; participants join company support projects as researchers, and become involved in corporate work by solving issues faced by the company. This program started in 2018. It only accepted master's degree holders in the first year,[111] and these were supported with a monthly payment of 1.8 million won a month; it accepted doctorate holders from the following year. In 2021, master's degree holders were paid 2.5 million won a month, and doctorate holders received 3.5 million won a month, with 250 people (90% were master's degree holders) reaping the benefits of this program. In 2018, only six research organizations were involved, but this had risen to 20 by 2022; participants are able to confirm the recruitment criteria of each organization on the portal site Science & Engineering JOB,[112] run jointly by MSIT and the Korea Industrial Technology Association (KOITA) and apply online.

Research organizations carrying out work concerning applications from master's degree and doctorate holders are given personnel expenses to handle the applications by the government—24.8 million won per master's degree holder and 34.7 million won for doctorate holders. [113]

The master's degree and doctorate holders who participate in this program engage in research to solve actual issues that companies face, thus playing active roles as the R&D talents that companies need. Dispatches and business trips to companies may be included in the training, so they are able to gain experience of the real environment of corporate work. According to a program report from MSIT, the employment rate for master's degree and doctorate holders who participated in this program is a favorable 91.4% (2021).

3. Newly established contract courses and fusion courses

The issue of a lack of talents in core technology fields in the era of the Fourth Industrial Revolution is referenced many times in this report; according to the Plan for the Concentrated Nurturing of Talents to Lead in the Era of the Fourth Industrial Revolution,[114] published by MSIT in 2019, South Kora's education system and the talents desired by industry are significantly divergent, so fields such as data, AI, cloud, and AR/VR, said to be the core technologies of the era of the Fourth Industrial Revolution, face serious talent shortages. Thus, the government's desire was to foster the talents needed in the era of the Fourth Industrial Revolution by establishing subjects in universities that consider industrial demand.

In 2020, many universities worked on creating subjects on advanced technology that can lead the Fourth Industrial Revolution, and began establishing fusion subjects to foster multidisciplinary talents. These subjects eliminated or consolidated an existing X subject, taking the form "AI +X."

These subjects can be broadly split into those related to semiconductors, AI, Big Data, future automobiles (mobility), and information security.[115]

111 For the 2018 application requirements, see https://www.nst.re.kr/www/selectBbsNttView.do?key=59&bbsNo=17&nttNo=5370.

112 https://snejob.koita.or.kr/track1/trk1SbList.do?menu=22

113 See https://www.koita.or.kr/manpower/sb_edu.aspx.

114 See full text of the Plan for the Concentrated Nurturing of Talents to Lead in the Era of the Fourth Industrial Revolution: https://www.korea.kr/news/pressReleaseView.do?newsId=156310687

115 e-University Journal, "Newly established subjects showing AI-related strengths," (August 2020), http://www.dhnews.co.kr/news/articleView.html?idxno=127301

Table 2-23: Examples of new subjects (partial excerpt)

School	New subject(s) in 2021	New subject(s) in 2022
Gachon University	—	Smart factories, smart security, next-generation semiconductors, smart city integration
Catholic University of Korea	AI	Data science
Kyonggi University	AI	—
Kyung Hee University	—	Using Big Data, AI
Korea University	Semiconductor engineering, data science, smart security, fusion energy engineering	—
Kookmin University	—	AI, future mobility, AI design, AI Big Data fusion management
Sangmyung University	Fintech, Big Data fusion, smart manufacturing	—
Seoul National University of Science and Technology	Using AI	Intelligent semiconductor engineering, future energy fusion
Sungkyunkwan University	Global fusion	—
Yonsei University	System semiconductor engineering	AI
Inha University	AI engineering, data science, smart mobility engineering, design technology	—

Source: Edudonga "Attention to advanced science and technology"[116]

The number of people accepted depends on the subject, but the larger subjects take 40-50 people, and the smaller ones take 20-30 people.[117]

4. Contract subjects with big companies and prestigious universities

Big companies enter into exclusive agreements with prestigious universities to secure high-level talents as soon as possible. In South Korea, this is also known as an employment requirements contract course. It is an exceptional system in which people's employment in a large company is decided at the same time as they enter university–students who graduate from courses with contracts can receive support for tuition fees and scholarships from these companies during their time in university, as well as guaranteed employment in that company after graduation. Although they are both referred to as contract courses, these contract courses have different goals to the SME contract courses, aiming to foster the so-called super-elite and so-called excellent talents. Recruitment is predominantly in the semiconductor

116 https://edudonga.com/?p=article&at_no=20210802100834362934&ckattempt=1 (August 2021)

117 See Electronic Times, "Newly established cutting-edge subjects include AI, intelligent semiconductors, smart farms," (July 2021), https://www.etnews.com/20210715000220.

and mobility fields, but organizations are expected to start accepting participants in the communications field in 2023. In July 2022, South Korea published the Program to Foster Semiconductor Talent, and is putting so much effort into developing the semiconductor industry it declared it would foster 150,000 semiconductor talents by 2030.[118] Major companies such as Samsung Electronics offer entry into Samsung Electronics after graduation and scholarships during study, as well as favorable conditions such as training in other countries and an enriched internship system.

Table 2-24: Examples of contract subjects with big companies and prestigious universities (partial excerpt)[119]

Contracting organizations	Number of people accepted	Treatment
Sungkyunkwan University semiconductors x Samsung Electronics	36 people	Full support for tuition fees, internship (for third year students)
Yonsei University semiconductors x Samsung Electronics	40 people	Full support for tuition fees, internship
Kyungpook National University mobility x Samsung Electronics	20 people	Full support for tuition fees, internship (for fourth year students), support for training in other countries for excellent students
Hanyang University semiconductors x SK hynix	40 people	Full support for tuition fees, internship in SK hynix laboratory
Korea University semiconductors x SK hynix	25 people	Full support for tuition fees, support for research in South Korea or another country
Korea University mobility x Hyundai Motor Company	50 people (undergraduate/ master's degree holder integration process of 5 years)	Full support for tuition fees, guarantee of joining Hyundai Motor Company with an R&D position, possibility of participating in industry-academia collaborative project
Korea University next-generation communications x Samsung Electronics	30 people	Full support for tuition fees, support for training in South Korea or another country, internship
Yonsei University display fusion x LG Display	30 people	Tuition fees, support for boarding expenses, internship

Thus, big companies, SMEs, and the government are all working to foster practical talents via their own methods, and are focusing on strengthening the innovative power of university (graduate) students for the future of the country.

[118] See SPAP, "South Korea, fighting with semiconductors, declaration of nurturing 150,000 semiconductor talents in 10 years," (October 2022), https://spap.jst.go.jp/korea/experience/2022/topic_ek_13.html.

[119] EZ University entrance examination, "New employment requirement courses, including semiconductor subjects," (June 2022), https://blog.naver.com/dldbstjd282/222793401221; EDU BOBY, "The employment requirements contract courses with no concerns over finding employment," (October 2022), https://blog.naver.com/eduboby_ep/222902656173; Great Education (위대한 교육), "The attention is on employment requirement contract courses, confirming employment at the same time as entering university!" (January 2021), https://blog.naver.com/wcareer/222225929517.

2.5.2 Innovation programs to foster talent in universities

With the rapid development of the Fourth Industrial Revolution, South Korea has seen a rise in discussions of universities in crisis. These discissions concern the worry that in 2030 many universities will cease to exist if the country persists with the current focus on curriculums (restrictions due to fixed curriculums), campuses (restrictions due to physical classroom attendance on a fixed campus), and subjects and majors (restrictions due to fixed classes by faculty members). This does not only apply to South Korea; universities around the world are experiencing a shift from a focus on classroom attendance to obtain a degree to a focus on different types of experience, and it is predicted that a system that is campus-less, with bookless libraries, professorless classrooms, and learning platforms will become established.[120]

In South Korea, several reform programs that focus on universities are being rolled out, to reform the university education system and to foster next-generation digital talents with high levels of innovation.

1. SW-centered university program

SW (Software)-centered university programs involve the selection of several universities from among the nation's four-year universities to reform them into SW-centered universities. In other words, these programs aim to reform university education, so it is centered on software, thus fostering expert talents in software and strengthening the software competitiveness of students, companies, and society. The goal is for students that major in software to progress as talents with strong practical abilities who are ready for global competition, and for those who do not major in software to grow as multidisciplinary talents through basic training on software beyond their area of specialized knowledge. The programs are implemented in a university for four years, and the government provides financial support of around 2 billion won each year. If the university achieves an excellent evaluation in the fourth year assessment, the support period can be expended for a further two years, enabling them to receive support for up to six years. In 2015, programs were launched in eight universities,[121] and had expanded to 44 universities at the end of 2022.[122]

Reforms for SW-centered universities are progressing as follows. [123]

・Universities designated as SW-centered universities must ensure that all new students (regardless of their major) complete a course with a basic SW curriculum. Students who complete the basic curriculum and have an interest in SW are given the chance to take an SW integrated curriculum (deeper education), thus stimulating SW education.

・Those with practical experience are hired as full-time teaching staff (at least five people), and create an educational curriculum in collaboration with companies. No weight is placed on the evaluation of academic papers, which was previously stressed during staff assessments—the assessment of their actual SW abilities is prioritized. The aim is to

[120] See Dongguk University Press, "The Fourth Industrial Revolution and university education," (September 2019), http://www.dgupress.com/news/articleView.html?idxno=31672.

[121] The support programs in universities selected in 2015 and 2016 have already finished. A total of 14 universities have finished their program. https://www.swuniv.kr/condition

[122] The list is available on the SW university website, https://www.swuniv.kr/condition.

[123] See https://www.swuniv.kr/36 for the details of the SW-centered university program.

create a new education system that can achieve a fusion with other majors and classes for credits and other courses across subjects, without being constrained by subjects and majors. Practical English education for students is enhanced (e.g. at least six credit classes) and bilingual education is established at least 50% of the time.

・Collaboration with companies is valued, and industry-academia collaborative projects to solve issues, which resolve actual problems in companies, are proactively developed; collaboration with SW-centered universities becomes stronger, regular workshops and other meetings are held.

・Universities collaborate with local elementary, middle, and high schools, contributing to the spread of SW education in these schools. They actively cooperates in organizing special lectures and SW camps for young people.

Proactively developing SW-centered university programs and sending many software talents out into society increases the contribution of universities to society. The employment rate of students who graduated from a SW-centered university is 74.8%, which is considerably higher than the 63.5% rate in regular universities (2020). With this favorable reputation, the capacity has increased from 1,034 people in 2015 to 8,217 people in 2021.[124]

2. Digital innovation sharing university program[125]

In addition to the SW-centered university program, one new program that has been a focus with the arrival of the era of the Fourth Industrial Revolution is the digital innovation sharing university program. This program started in 2021 with the target of fostering 100,000 talents in new technology fields needed for the Fourth Industrial Revolution by 2026; its full name is the "university program to foster talents in new digital technology and share innovation." As its name suggests, this program removes the limitations of universities and majors, and offers support so any university student can receive an education in fields relating to new technologies.

Here, the phrase "fields relating to new technologies" refers to AI, Big Data, next-generation semiconductors, future automobiles, bio-health, VR/AR, and similar areas, and university projects are developed by field—e.g., Big Data innovation sharing universities, and energy and new industry innovation sharing universities. In the first fiscal year, this project received 83.2 billion won in investment, and 8.9 billion won in 2022.

The essential part of this program is that universities collaborate with each other through information, and build sharing platforms.

This section takes a look at examples of energy and new industry innovation sharing universities.

First on the list of energy and new industry innovation sharing universities is Korea University as the administrative institution, with Seoul National University, Hanyang University, Kangwon National University, Pusan National University, Jeonbuk National University, and Kyungnam College of Information and Technology as participating institutions. The curriculum was created based on feedback from research organizations and experts, and is split into four parts: energy production, energy conservation and transfer, energy transport and control, and energy management; each university is responsible for their own part.

[124] See https://www.swuniv.kr/44 for the outcomes of the SW-centered university program.

[125] For information on digital innovation sharing universities, see the website https://coss.nrf.re.kr/main.do; Ministry of Education, "You can do it too, innovation sharing universities," (August 2021), https://blog.naver.com/moeblog/222605871047.

<Universities and the parts for which they are responsible>

・Kangwon National University: Energy production

・Kyungnam College of Information and Technology: Energy conservation and transfer

・Korea University: Energy production and energy management

・Pusan National University: Energy conservation and transfer and energy production

・Seoul National University: Energy management and energy production

・Jeonbuk National University: Energy production

・Hanyang University: Energy transport and control

A four-year curriculum has been created for each part, split into elementary, intermediate, and advanced levels, and students who have completed at least 12 credits are issued a micro degree for the part in question; students who complete all credits are awarded an undergraduate degree. Of course, it is possible for students to participate to gain their own knowledge or out of curiosity, without aiming for a degree. Lectures are a hybrid of on and offline. The majority of the elementary level is theoretical study, so more than 70% of the lectures for this course are available online, but as the levels advance, the classes also include a large amount of content in collaboration with real worksites, so the majority of the advanced level classes are offline.

This program has only just started, so it is still developing and exploring, but it is thought that it will become popular and established in universities where anyone can easily take classes, in accordance with its initial aim.

3. AI graduate school support program[126]

A new AI graduate school support program has been launched to foster high-level talents in the AI fields, one of the key parts of the Fourth Industrial Revolution.

MSIT started the AI graduate school support program in 2019 to solve the issue of a lack of high-level talents in South Korea's AI field. The program is mainly going ahead in universities that demonstrate their strengths in science and technology fields such as KAIST and POSTECH. The four areas below have become the program's pillars.

・**Intensive development of high-level researchers in AI:** Strengthening the research capacity of core AI technologies by fostering high-level master's degree and doctorate holders.

・**Management of education curriculums specializing in AI:** Establishing new education courses specializing in AI and developing classes using education methods that focus on projects to solve issues so as to provide systematic education.

・**Strengthening industry-academia collaboration:** Strengthening industry-academia collaboration by securing excellent research talents and solving issues faced by companies.

・**Strengthening global cooperation:** Inviting professors who are renown in other countries and experts from companies with influence, and strengthening global competitiveness through international joint research and internships with global companies.

[126] For an introduction to AI graduate schools, see Hanyang University WIKI AI graduate school support program: https://hyu.wiki/%EC%9D%B8%EA%B3%B5%EC%A7%80%EB%8A%A5%EB%8C%80%ED%95%99%EC%9B%90_%EC%A7%80%EC%9B%90%EC%82%AC%EC%97%85#人工知能_.EB.8C.80.ED.95.99.EC.9B.90_.EC.84.A0.EC.A0.95.EB.8C.80.ED.95.99_.EC.9A.B4.EC.98.81.EB.B0.A9.ED.96.A5

In the first year, five universities (Korea University, Sungkyunkwan University, KAIST, Gwangju Institute of Science and Technology, and POSTECH) were chosen for this program, with several more universities added in turn from the following year. In 2021, AI graduate schools were operating in a total of 10 universities, with Yonsei University, Ulsan National Institute of Science and Technology, Hanyang University, Seoul National University, and Chung-Ang University also participating. The universities selected are given 2 billion won each year over five years,[127] and can extend the support period to up to 10 years through evaluations at different stages.

Here, this paper explores some of the details of how the program operates, using the Department of Artificial Intelligence, Sungkyunkwan University as an example.[128] In addition to government support, Sungkyunkwan University operates this program with a total of 12.7 billion won of investment—900 million won from Gyeonggi Province (local government), where it is located, and 1.8 billion won from the university itself. It has 15 full-time and 15 part-time members of staff for the AI graduate school, so a total of 30 staff members are involved in its education.

It started recruiting for its master's and doctoral course in 2019, and recently has maintained around 50-60 people a year.

Table 2-25: Capacity of the Department of Artificial Intelligence, Sungkyunkwan University

Capacity (people)	2019	2020	2021	2022	2023
Master's course	20	40	45	45	45
Doctoral course	5	10	15	15	15
Total	25	50	60	60	60

Source: Department of Artificial Intelligence, Sungkyunkwan University website[129]

The L.E.A.R.N. education model was selected as the method for education.

127 1 billion won was paid in 2019, the first year, only, with 2 billion won provided each year from 2020 onwards.

128 For the example of the Department of Artificial Intelligence, Sungkyunkwan University, see the website of the Department of Artificial Intelligence, Sungkyunkwan University, https://ai.skku.edu/ai/corp_intro.do#a.

129 https://ai.skku.edu/ai/project_intro.do#a

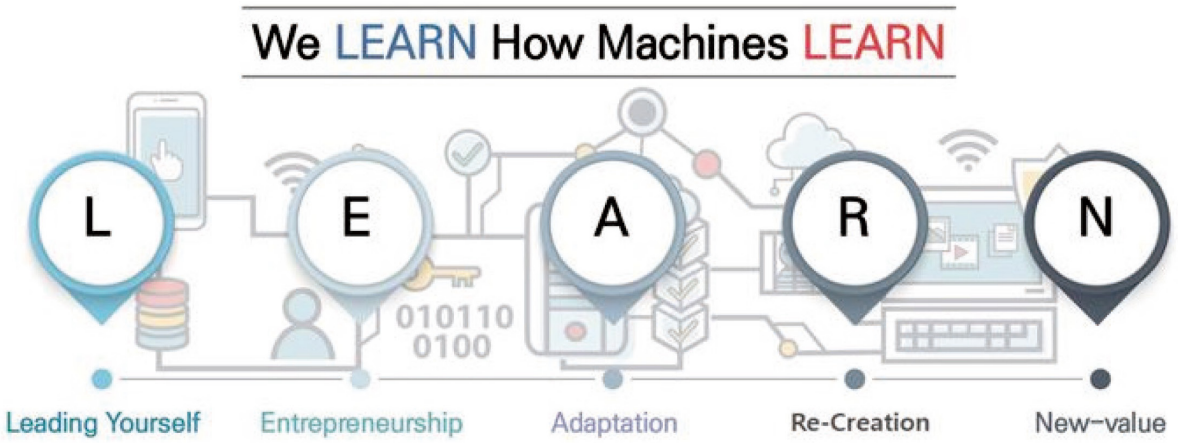


Figure 2-26: Department of Artificial Intelligence, Sungkyunkwan University education model

Source: Department of Artificial Intelligence, Sungkyunkwan University website

L (Leading yourself) refers to talents who can take the initiative for themselves, and aims for classes in which both students and professors participate and interact based on projects (PBL).

E (Entrepreneurship) means having a close relationship with real-world industry. The more the university carries out projects to solve company issues, the more a mentoring system through which learners can receive pertinent guidance from company experts develops, supporting learners so they can obtain internships in companies or research organizations lasting at least two months (master's level) or six months (doctoral level).

A (Adaptation) refers to fostering talents who can react quickly to new technologies and change and are resilient against environmental change. The program introduces a system to inform students as quickly as possible of the latest technologies and research outcomes from around the world as the new technology field of AI becomes more important.

R (Re-creation) refers to using global network environments to foster world-class innovation talents. To do this, the university invites famous researchers and professors of AI from Korea and from other countries, who teach the students about the latest research.

N (New Value) refers to the creation and expansion of integrated education and applied subjects, and trying to develop projects and classes in new ways.

In terms of collaboration with industry, the method chosen was for students to visit companies themselves and find out about issues with AI that the company hopes to solve. Then, based on the "needs identification project" for collaboration with companies, they enhance exchange with companies with whom there is already a good relationship, and gain an understanding of the needs of a company in real life. They create an advisory council with companies with good relationships, and a forum where they can regularly hear opinions from actual companies. The university also runs programs[130] to support regional companies based on cooperation with local governments.

[130] Gyeonggi Province (local government) provides 90%, and private companies provide 10% of the cost to run projects to solve corporate issues.

The university works to create a system with a virtuous cycle between collaboration with companies and employment promotion, ensuring that company collaboration produces results, and these results help improve the employment rate of master's level/doctoral level researchers participating in the project.

The universities participating in the AI graduate school program are taking in more people each year. The program is run in collaboration with large companies such as Samsung Electronics, Google, MIT, Hyundai Heavy Industries, KT, and NAVER, and it is expected to contribute to R&D outcomes in AI and to industries.

In this way, South Korea is continuing to take on the challenge of new programs to foster both practical talents who can respond to corporate needs and hybrid research talents in the core technology fields of the Fourth Industrial Revolution, and is coming up with ways to strengthen the digital capabilities of all citizens. For example, there are over 1,000 **Digital Schools (Study Locations)**[131] across the country. These prevent increasing digital disparity, help people to gain digital knowledge, and alleviate doubts. Through these, participants can learn about basic ways to make use of digital operations, such as how to make online purchases with various tickets, mobile finances (Internet banking, etc.) and how to use social media. They also cover Excel, Photoshop, and video editing. Digital schools have the advantage of allowing people to casually study at any time if their inexperience with digital technology is causing inconvenience in everyday life, as well as offering different seminars and classes to allow people to study in more depth and advance their digital capabilities.

On top of this, **K-MOOC,**[132] **free online courses** based on the slogan "Anyone can experience growth at any time," were introduced to improve citizens' digital capabilities. These courses are offered in a variety of fields, not only science and technology fields but also the humanities and social sciences, history, and psychology, and current university professors, research staff at research organizations, company management, and influencers in various businesses work as lecturers; their high-level lectures have earned a favorable reputation. In addition to courses in Korean, courses in English and French are also available.

In conclusion, Chapter 2 introduced the various strategies in place for South Korea to win in global competition in the era of the Fourth Industrial Revolution. So what is the state of South Korea's science and technology capabilities after this series of strategies? This is explored in Chapter Three below.

131 https://www.xn--2z1bw8k1pjz5ccumkb.kr/main.do

132 http://www.kmooc.kr/courses

3 The Current State of Science and Technology in South Korea and Evaluation of Strategies

Chapter 2 introduced the various policies and programs on which South Korea is proactively working for the era of the Fourth Industrial Revolution.

This next part will explore the current state of South Korea's science and technology capabilities resulting from the various policies from before the era of the Fourth Industrial Revolution, and the various policies and programs introduced in this paper. It will also look at specific outcomes obtained from these policies and programs, and describe any remaining issues.

It should be noted that although this paper focuses on the science and technology policies from the Moon to the Yoon administrations, the science and technology outcomes and issues introduced here are not solely due to the activities of these administrations. Science and technology develop through the successive efforts of those involved in its long history, and science and technological capabilities, outcomes obtained through science and technology, and even issues that require solutions reflect all the progress until now.

Now, there are no fixed means when it comes to methods to demonstrate a country's science and technology capacity, so this paper has used typical science and technology indicators accepted by organizations like the OECD, and evaluations of international organizations such as WEF and IMD for analysis.

3.1 The current state of science and technology in South Korea

First, this section will look at the global position of South Korea's science and technology using typical science and technology indicators.

3.1.1 South Korea's science and technology capabilities from the perspective of indicators[133]

(1) R&D expenses

As of 2021, South Korea's **combined public and private R&D expenses** grew 9.7% from the previous year, **finally exceeding 100 trillion won at 102.1352 won** (*in this paper, the exchange rate is 1 won = 0.1 yen). South Korea's R&D expenses ranked **fifth in the world**. Taking into account the size of the country and its population, this figure and ranking is by no means low. South Korea started from 1.2 billion won in 1963, exceeded 1 trillion won for the first time in 1985, and this has repeatedly grown significantly since 1990. The steady growth continued with 3.2150 trillion won in 1990, 10.8781 trillion won in 1996, 13.8485 trillion won in 2000, 27.3457 trillion won in 2006, and 55.4501

[133] Unless otherwise noted, the data for this section references NTIS science and technology statistics and KISTEP's annual R&D activity research reports.

trillion won in 2012.

By 2021, R&D expenses as a percentage of GDP had grown to 4.96%, the second largest in the world. The **government's R&D budget** has tended to increase each year, and **exceeded 30 trillion won in 2023**. It is more than evident from this that South Korea is proactively focusing on R&D.

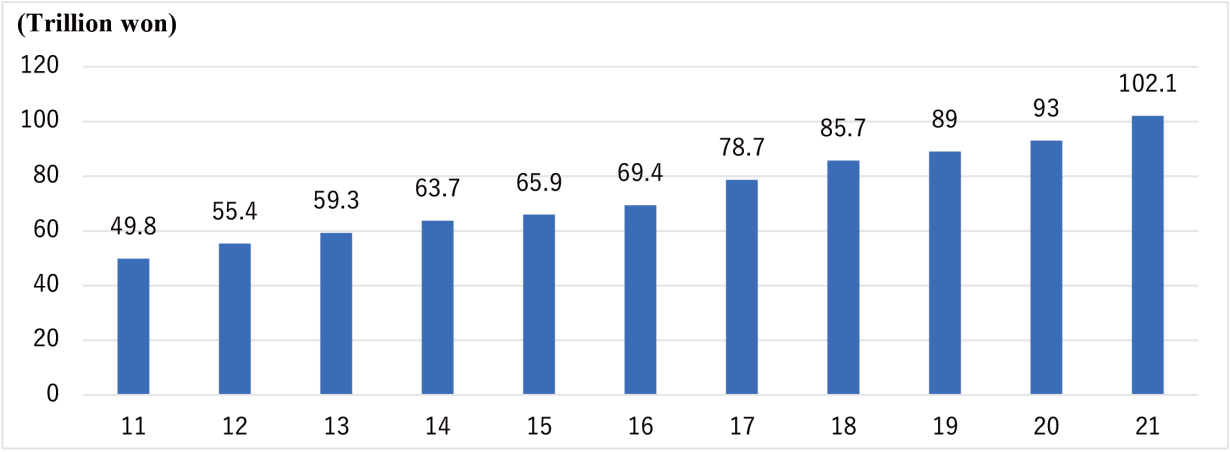


Figure 3-1: Changes in South Korea's R&D expenses

Source: NTIS science and technology statistics

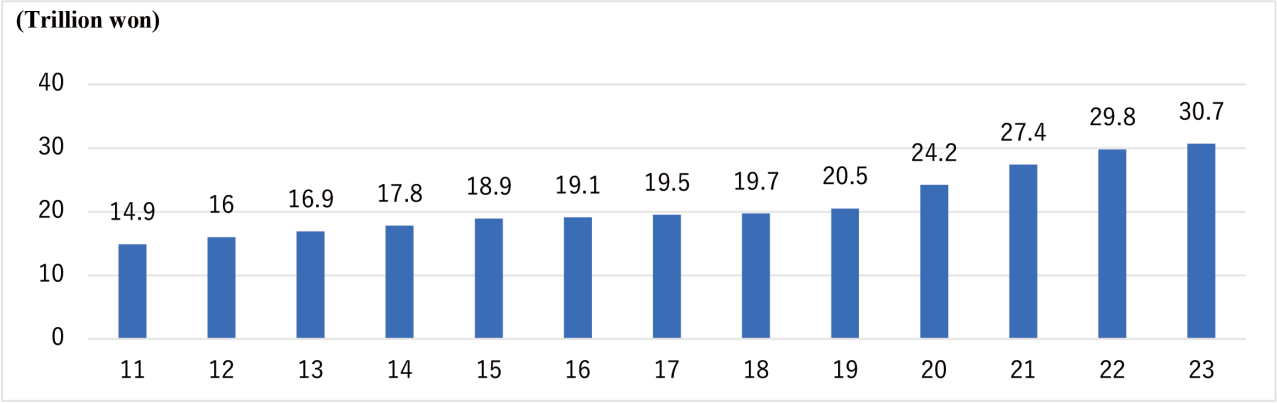


Figure 3-2: The South Korean government's R&D budget

Source: KISTEP "Analysis of the current state of the government R&D budget"

Looking at R&D expenses by research entity in South Korea, in 2021, companies accounted for 79.1%, research organizations for 11.7%, and universities for 9.1%. The percentages of each entity change each year, but companies remain at over 70%.

Moreover, if one looks at this by the stage of the R&D, basic research accounted for 14.8%, or 15.1002 trillion won, applied research for 21%, or 21.4704 trillion won, and R&D for 64.2%, or 65.5647 trillion won (2021).

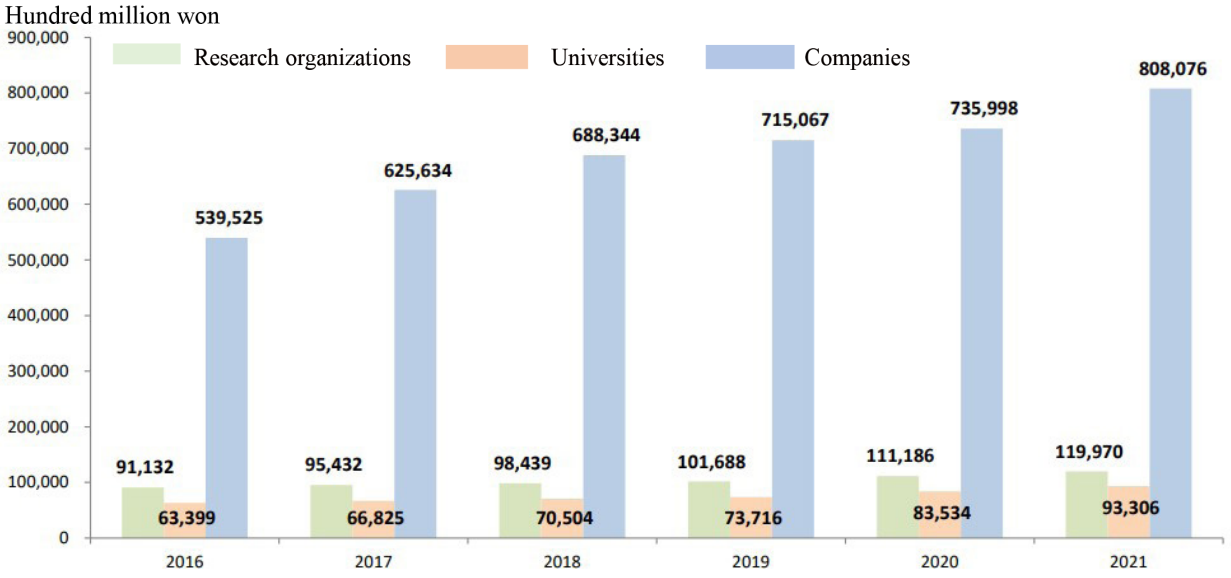


Figure 3-3: R&D expenses by research entity in South Korea

Source: NTIS South Korean technology statistics

(2) Researchers

The number of researchers in South Korea is proportionate to the increases in R&D expenses, and continues to rise by around 20,000 people each year. The number of researchers in 2021 was 586,666, an increase of 5.1% from the previous year. There were 470,728 FTE researchers, an increase of 5.4% from the previous year. South Korea is ranked fifth in the world for its total number of researchers, the same as for R&D expenses. The number of FTE researchers was also fifth until 2020; South Korea overtook Germany in 2021, ranking fourth after China, the US, and Japan.

There are 16.7 FTE researchers per 1,000 people involved in economic activity, and 9.1 per 1,000 people—South Korea is ranked first in the world in both cases. In other words, **it is the nation with the most researchers relative to its population**. Of these researchers, 82.9% are affiliated with companies, 9.3% with universities, and 7.8% with research organizations. It can be said that there is a high number of researchers affiliated with companies compared to major countries.[134]

[134] According to OECD data, the percentage of researchers affiliated with companies was 74.7% in Japan (2020), 62.9% in France (2020), 58.5% in China (2020), and 41.8% in the UK (2019).

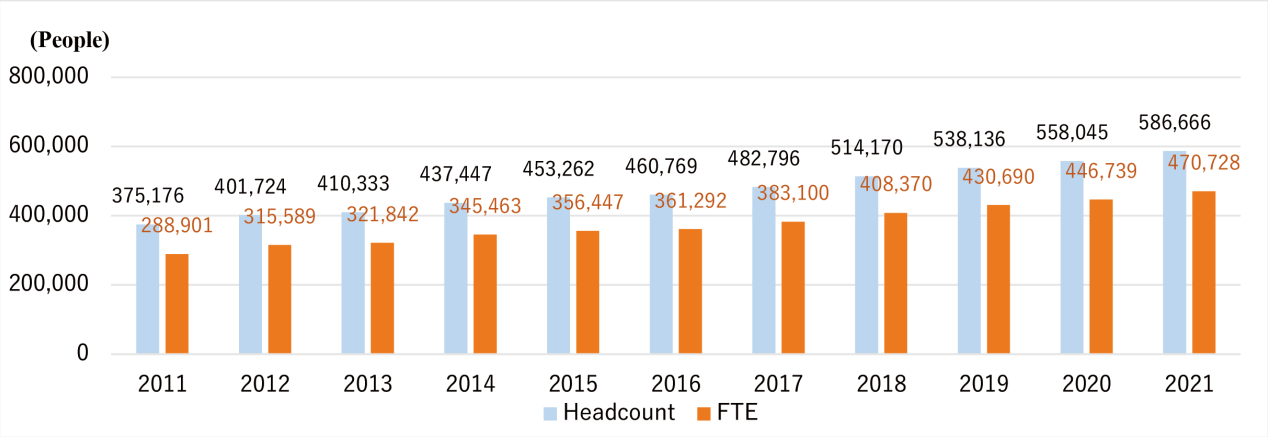


Figure 3-4: Changes in the number of researchers in South Korea

Source: NTIS South Korean technology statistics

(3) Papers and patents, etc.

The number of academic papers in South Korea is also tending to increase with R&D expenses and the number of researchers. As is evident in Figures 3–5 below, in 2011 the number of research papers was only around half that of Japan, but in 2020 the gap had closed less than 20%. By number of research papers, the country's global ranking has remained at 12th since 2007.

Moreover, according to NISTEP's Science and Technology Indicators 2022, **South Korea has surpassed Japan to be ranked 11th** for the **number of adjusted top 10% papers** (2018–2020 average, fractional count). This is the first time South Korea has ranked higher than Japan, and its progress in terms of the quality of its papers is remarkable.

On the other hand, while it can be said that in recent years the number of academic papers and the number of adjusted top 10% papers has increased significantly, South Korea's R&D expenses are ranked fifth in the world, and the number of researchers is ranked fourth; in light of this, it has been pointed out that that South Korea's international ranking for papers, etc. is not necessarily in line with its investment. The following are assumptions as to the cause.

1. From the Second World War, through the outbreak of the Korean War until the ceasefire in 1953, and then the military tensions between the North and South, R&D, especially initiatives to promote basic research, was delayed; as was noted above, the country first became conscious of the importance of basic research in the 1980s, and full-fledged strengthening of science and technology and basic research started with the creation of the first Comprehensive Basic Research Promotion Plan 2006-2010 by the Roh Moo-hyun administration in 2005. Consequently, the country started full-fledged investment in basic research late compared to countries with high international rankings in numbers of papers, and South Korea fell behind in research capabilities, in which accumulation is important.
2. The number of researchers is ranked fourth on a global level, and many researchers are affiliated with companies, so the percentage of researchers affiliated with universities and research organizations, which are chiefly responsible for producing papers, is one of the lowest for a major country. (From OECD data, the following are the numbers excluding the researchers affiliated with companies: South Korea: 17.1%, Japan; 25.3%, France: 37.1%, China: 41.5%, and the UK: 58.2%.)

The above are merely assumed factors, but if these are true, it cannot be said that the current number of research papers, etc. is not in line with the country's investment when considering the perspective of the investment in R&D expenses accumulated to date. In recent years, South Korea has continually increased its R&D expenses and continually strengthened its research universities, with institutes of science and technology at their core. It can be assumed that the trend will be for the number of papers and the number of adjusted top 10% papers to continue to increase.

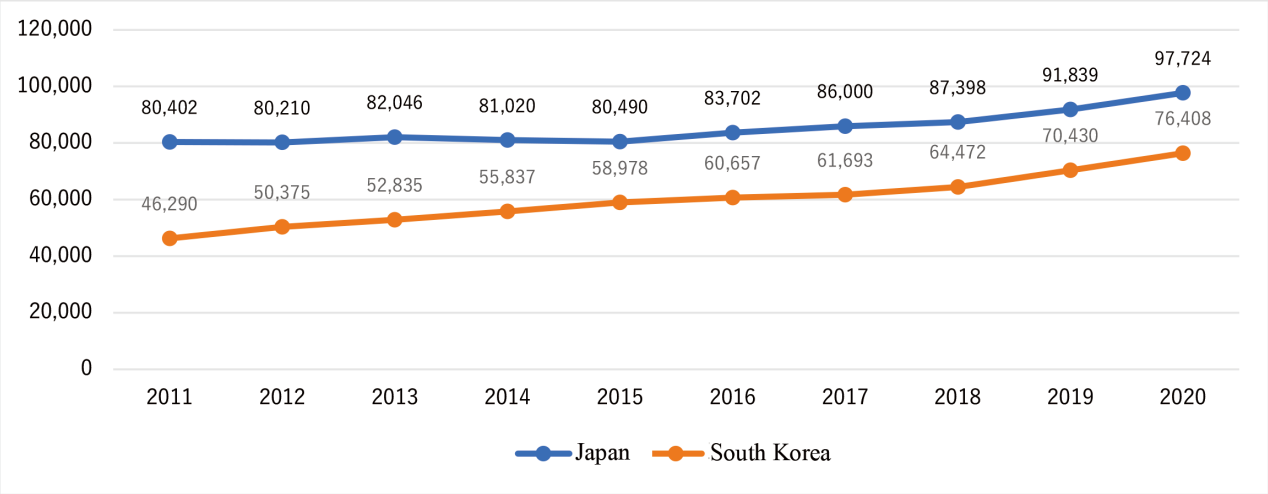


Figure 3-5: Changes in the number of papers in Japan and South Korea

Source: NTIS South Korean technology statistics

All fields	2018 - 2020 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
China	46,352	26.6	1
United States	36,680	21.1	2
UK	8,772	5.0	3
Germany	7,246	4.2	4
Italy	6,073	3.5	5
Australia	5,099	2.9	6
India	4,926	2.8	7
Canada	4,509	2.6	8
France	4,231	2.4	9
Spain	3,845	2.2	10
South Korea	3,798	2.2	11
Japan	3,780	2.2	12
Iran	3,504	2.0	13
Netherlands	2,859	1.6	14
Switzerland	2,143	1.2	15
Brazil	2,095	1.2	16
Sweden	1,546	0.9	17
Singapore	1,442	0.8	18
Turkey	1,386	0.8	19
Belgium	1,326	0.8	20
Denmark	1,292	0.7	21
Taiwan	1,249	0.7	22
Saudi Arabia	1,247	0.7	23
Poland	1,225	0.7	24
Egypt	1,059	0.6	25

Figure 3-6: Number of adjusted top 10% papers

Source: NISTEP Science and Technology Indicators 2022

Feature: What is the key to the rapid progress of South Korea's academic papers?[135]

The factors behind the number and quality of academic papers in South Korea, as well as their rapid progress, can be summarized in the following five points.

- **Continually growing investment in R&D expenses and basic research**
- **An increased number of researchers thanks to strategies to foster talent in science and technology**
- **Competition in performance resulting from a strict job-seeking environment**
- **Rapid progress in some universities, including science and technology universities**
- **A university culture that emphasizes the number of papers**

Science and technology papers are a key indicator of science and technology outcomes, but the greatest factor leading to results is continually growing investment in science and technology.

As can be seen from the figures above, South Korea's R&D expenses have increased year on year. In light of the population and size of the country, R&D expenses as a percentage of GDP and the number of researchers per 1,000 people are at the top of the world. In fact, these policies have continued to progress with changes in administration from the time of the Roh Moo-hyun administration, when the Science and Technology Basic Plan and Basic Plan for Nurturing and Supporting Scientific Talents were first formulated. One can say that a country that focuses on science and technology alone and even formulates basic plans and plans to nurture talent once every five years is unusual. The Roh administration created the foundation for science and technology development, and the Lee Myung-bak administration really started to get it on track. The Institute for Basic Science (IBS), which has now grown into a wonderful thinktank, was established (in 2011) after being proposed by the Lee administration, and research-centered university development was also conceived based on the "Program for the development of science and technology universities." The predecessor to the Brain Pool program, which invites famous, excellent researchers from other countries to South Korea, was the Lee administration's World Class University program.

During the Park Geun-hye administration, attention and support turned from research fields to researchers, and the government started its policies for human-centered support in accordance with the research levels and ages of researchers. The Moon Jae-in administration also emphasized human-centered R&D innovation, doubling the support for researcher-led free application research topics, and both administrations continued the generous support for basic research.

[135] For details about this feature, see MEXT Science and Technology Policy Bureau, Research and Development Strategy Division, "Understanding Evidence to Strengthen Japan's Research Capabilities (3)".

In addition, strengthening university research capabilities also greatly contributed to increased number of papers. The BRAIN KOREA program should be mentioned with regard to strengthening university research capabilities. This project began in 1999 to develop research talents, especially graduate students, and world-class universities and graduate schools, and has continued until today, barring a break of seven years. In South Korea, this is a rare large-scale R&D program that has continued regardless of the changes in administration. When selecting universities to support, the government uses papers, especially SCI papers, as indicators to evaluate that university's research capabilities. One of the catalysts for the start of this program was the fact that the number of SCI papers was very low in South Korea when compared to other counties. In 1998, the number of South Korean SCI papers was just 15.2% of the number in Japan, and 3.9% of that in the US, and the Korean government, starting to become aware of globalization, was shocked at these numbers, and so started proposing programs to increase paper numbers and strengthen university research capabilities. Since then, the number of papers (especially the number of SCI papers) has become an important indicator when hiring and promoting university faculty members. Thanks to BRAIN KOREA, both faculty and graduate students in universities started devoting themselves to writing papers, and the number of papers increased at an alarming speed.

In South Korea, the science and technology universities (also called institutes of science and technology) are the Korea Advanced Institute of Science and Technology (KAIST), Gwangju Institute of Science and Technology (GIST), Pohang University of Science and Technology (POSTECH), Ulsan National Institute of Science and Technology (UNIST), and Daegu Gyeongbuk Institute of Science and Technology (DGIST). All of these are research-centered universities. They have small capacities, but a wealth of scholarships, and the support for each student is robust, so they produce many research outcomes. The students affiliated with these universities have barely any financial burdens, whether they are undergraduate or graduate students, and engage in research in a favorable environment. As is shown in the tables below, the institutes of science and technology rank highly by the number of paper citations, and the quality of their papers is extremely high. The top universities in South Korea, including these, take the number of SCI papers as key indicators when hiring or promoting faculty members, and it is not uncommon for a number of papers in international publications to be a prerequisite for promotion (e.g., Sejong University). The situation is not notably different when obtaining master's degrees and doctorates, or for job-seeking post-doctoral researchers—a considerable number of papers is required. There are many people in South Korea who are unsatisfied with regard to the assessment methods that use papers as key indicators, and opinions calling for change (e.g. the joint declaration requesting improved methods for evaluating researchers) are also evident, but putting that aside, it is a definite fact that these systems and structures have contributed to the increased number of papers.

Table 3-7: Top 12 institutions by number of citations per paper in South Korea (2011-2020)

Rank	Name of research institution	No. of papers	No. of citations	No. of citations per paper
1	Ulsan National Institute of Science and Technology	8,584	240,726	28.04
2	Institute for Basic Science (IBS)	5,680	130,099	22.90
3	Pohang University of Science and Technology (POSTECH)	16,036	354,865	22.13
4	Korea Advanced Institute of Science and Technology (KAIST)	26,816	567,020	21.14
5	University of Seoul	5,048	99,064	19.73
6	Seoul National University Hospital	9,904	194,357	19.62
7	Korea Institute of Science and Technology (KIST)	12,842	248,750	19.37
8	Sungkyunkwan University	40,394	780,047	19.31
9	Gwangju Institute of Science and Technology	7,384	141,581	19.17
10	Ewha Womans University	13,126	245,151	18.68
11	Seoul National University	74,206	1,381,893	18.62
12	Samsung Electronics	4,569	82,477	18.05

Table 3-8: Top five research institutions by number of papers and top five research institutions by rate of increase in South Korea

Overall rank	Name of research institution	No. of papers 2011–2015	No. of papers 2016–2020	Rate of increase
1	Seoul National University	33,176	41,030	23.67%
2	Yonsei University	20,681	26,764	29.41%
3	Korea University	17,960	23,091	26.57%
4	Sungkyunkwan University	17,482	22,912	31.06%
5	Hanyang University	12,613	16,395	29.98%

Rank by rate of increase	Name of research institution	No. of papers 2011–2015	No. of papers 2016–2020	Rate of increase
1	Ulsan National Institute of Science and Technology	2,710	5,861	**116.27%**
2	Sejong University	2,939	6,246	**112.52%**
3	Seoul National University Hospital	3,588	6,138	**71.07%**
4	Chung-Ang University	5,547	8,175	47.38%
5	University of Ulsan	5,733	7,908	37.94%

Source: See KISTEP's "Analytical Research on the Outcomes of Science and Technology Papers 2011 to 2020" for the three tables above

In addition to the number of papers, since 2017 there has also been a tendency for an increased number of patent applications and registrations. In 2019, the **number of trilateral patents was 3,057, ranked fifth in the world**. Notably, **South Korea is ranked first in the world for patent applications in the clothing management device field**,[136] with LG Electronics, Samsung Electronics, and CONWAY leading the global market. The effects of COVID-19 led to an

[136] For information about patent applications for clothing management devices, see Statistics Korea, "Patent applications in the field of clothing management devices, we are the world no. 1" (April 2022), https://blog.naver.com/kipoworld2/222708422122.

increased interest in health and hygiene, so clothing management devices that keep cloth clean without hassle are now very popular, with the domestic market going from 29.4 billion won in 2015 to 393.7 billion won in 2020, an increase by a factor of thirteen; these devices were originally only sold in three countries, but as of 2020 this has increased to 20 countries. According to data from Statistics Korea, the number of patent applications to the IP5 for clothing management devices grew on average 27% a year between 2011 and 2019.

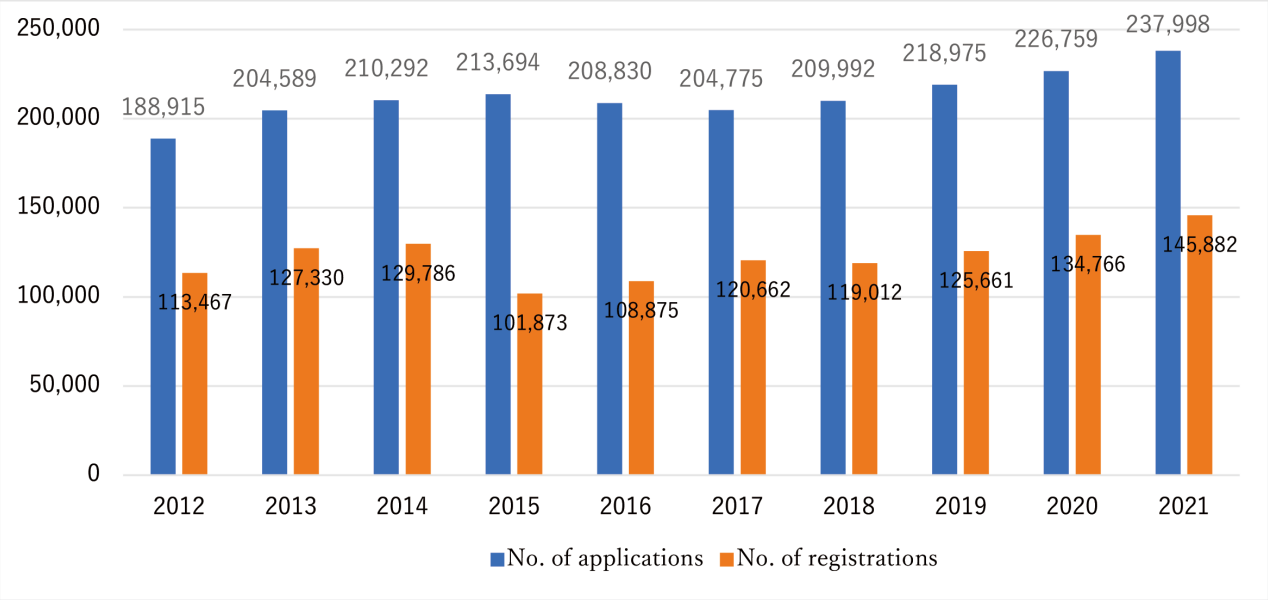


Figure 3-9: Changes in the number of patent applications and registrations in South Korea

Source: NTIS science and technology statistics

3.1.2 Science and technology fields that demonstrate South Korea's strengths

Which science and technology fields demonstrate South Korea's strengths or have shown remarkable growth in recent years?

(1) A power in mobile communications

First, the mobile communications field. When South Korean science and technology is mentioned, a lot of people likely think of mobile communications immediately. From CDMA to 5G, South Korea has demonstrated its strength in this field over a long period of time. Its world-first commercialization of 5G is the proof of this strength.

Wireless transmission is one of the key technologies for mobile communications, and R&D on wireless transmission such as WIFI6 and NEC solutions is going ahead in South Korea, especially in Samsung Electronics, showing real ability that is not inferior to America or Europe. Furthermore, Samsung Electronics has announced (mmWave RFIC, etc.) three types of next-generation core chips for base stations, and already reigns at the top of the world with 5GmmWave technology.

South Korea's mobile communications are highly regarded in terms of services and infrastructure, with the existing NSA-based 5G network being upgraded to SA, and in May 2021 a PS-LTE single disaster safety communication

network for the entire country was launched. This means that disaster response organizations, including the police, fire service, and coast guard, are connected on a single communication network. With the expansion of 5G, South Korea has also been actively working on developing wireless equipment specifically for 5G (indoor DAS equipment, 5G repeaters, 28 GHz repeaters), and is promoting the provision of 5G specialized networks to establish trustworthy services with little delay.

(2) World-class memory semiconductors

Next is the semiconductor field. South Korea shows its strength in semiconductors,[137] with Samsung Electronics ranked first in the 2021 ranking of companies by net income from semiconductors, and SK hynix ranked third.

When it comes to the global semiconductor market share, South Korea has one quarter, and the US has two thirds. By numbers alone, the US has the power, but in the field of memory semiconductors, South Korean companies have an oligopoly, with three quarters of the global market. South Korea demonstrates its strengths in memory semiconductors and the foundry field; it is not as strong as Taiwan and China in the fabless field, with a global market share of less than 1%. South Korea is aiming for rapid progress in the non-memory semiconductor field in addition to memory semiconductors—as various related strategies have been covered in the section on the Big 3 industries in Chapter 2, they will not be detailed here. Samsung Electronics has declared that it will stand at the top in fields other than memory semiconductors by 2030, and it will be interesting to keep an eye on its movements in the future.

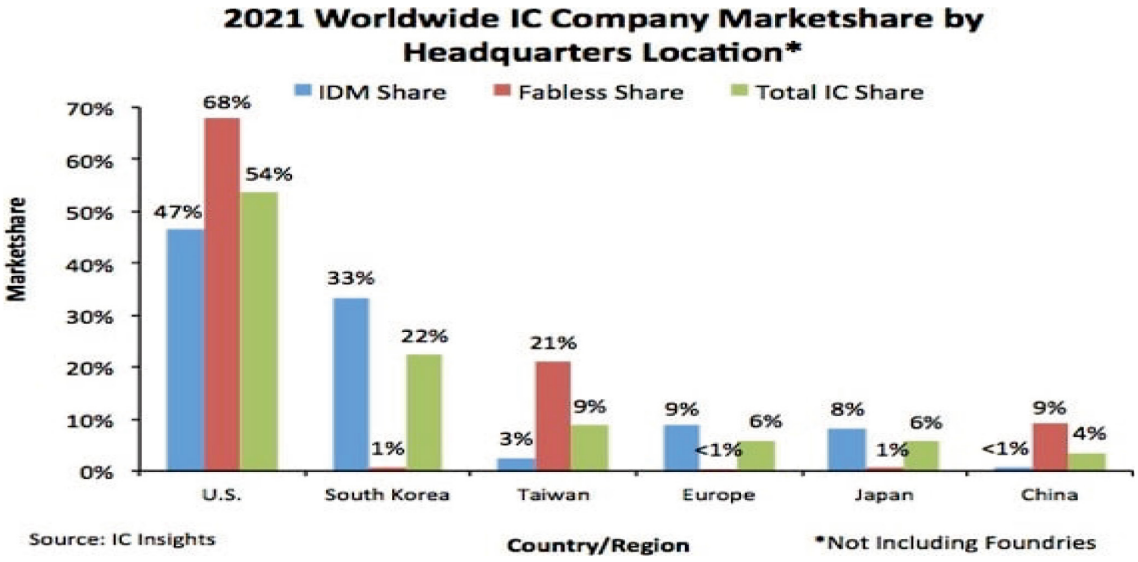


Figure 3-10: Semiconductor market shares

Source: IC INSIGHTS

[137] For more details about semiconductors, see "NAMUWIKI: Semiconductors," https://namu.wiki/w/%EB%B0%98%EB%8F%84%EC%B2%B4.

(3) A power in broadcasting media based on an outflow of South Korean content (Korean wave)

As the power of Korean wave content boasts popularity all over the world, including a Korean wave boom in Japan, the country has made use of that momentum to increase investment in the media market, and achieved rapid growth. Work to standardize MMT (MPEG Media Transport) has progressed, especially among companies such as Samsung Electronics and SK Telecom, and this technology is being actively used for smartphone media services. South Korea has considerably raised the level of the technology for commercialization with the introduction of the world's first MMT for terrestrial UHD business services.

Moreover, in 2020 SK Telecom launched CAST.ERA together with SINCLAIR, one of the largest terrestrial broadcasters in the US, leading the development and commercialization of applied technology for high resolution broadcasting services based on 5G and ATSC3.0.

In December 2020, the government announced a policy plan to stimulate terrestrial UHD, and is proactively supporting improvements to the UHD receiving environment and technology development. As a result of focused efforts based on public-private cooperation to improve the country's technological capacity for broadcasting media and better its services, the number of subscribers to OTT platforms such as Wavve and WATCHA is increasing daily.

In addition to these, space and science and technology for national defense have been suggested as fields that have demonstrated rapid growth in recent years.

(4) The world's seventh space power

On June 21, 2022, South Korea succeeded in launching a domestically made rocket known as "Nuri," rising up as one of the seven major space powers that have launched a satellite by themselves. On August 5, it also succeeded in launching its first lunar explorer, "Danuri," following the US, Russia, China, Europe, Japan, and India as the seventh country to send a lunar exploration vessel into space.[138] With regard to the national policy issues for science and technology, the Yoon administration stated that "We will ensure competitiveness in the space field, stimulating a space industry centered on the private sector and promoting space development that will drive social and economic development. We will also take on the challenge of becoming one of the seven major space powers through improving our space infrastructure and the systems and policies that will support this,"[139] demonstrating the country's policy of further increasing investment in R&D for space in the future.

(5) Ranked ninth in the world for science and technology for national defense

Science and technology for national defense has also experienced rapid growth in recent years. The "2021 Survey of National Defense Science and Technology Standards by Country"[140] by the Korea Research Institute for Defense Technology Planning and Advancement (KRIT) analyzed science and technology for national defense by eight main

138 See SPAP, "Success launching Nuri, independently developed by South Korea, and future plans for space," (July 2022), https://spap.jst.go.jp/korea/experience/2022/topic_ek_08.html; Yahoo News, "South Korea's first lunar explorer Danuri launches with successful communications, seventh in the world," (August 2022), https://news.yahoo.co.jp/articles/fb7851bd19ac724890d3c88401be39156a44adef.

139 See SPAP, "Yoon Suk Yeol administration's national policy issues for science and technology: Adding some commentary (part 2)," (September 2022), https://spap.jst.go.jp/korea/experience/2022/topic_ek_11.html.

140 The text is available at https://dtims.dtaq.re.kr/vps/OINF_selectBookInfo4.do?wiselog=BKC000120220110090206111.

fields and 26 main types of weapon system, and ranked South Korea ninth in the world.

According to this report, South Korea's science and technology for national defense ranked 11th in 2008, 10th in 2012, and joint 9th with Italy from 2015, with it taking the 9th spot alone in 2021, demonstrating the country's continuous growth. Its growth has also been remarkable in the fields of artillery, submarines, command and control, air defense weapons, cyber weapons, electron optics, underwater surveillance, CBRN, defense M&S and defense SW. Artillery and defense systems in particular have moved up four levels and six levels, respectively.

3.1.3 South Korea's science and technology capabilities based on evaluations of its technology level (ICT field)

So, how do South Korea's thinktanks evaluate the country's science and technology capabilities?

This section will analyze South Korea's science and technology capabilities in each ICT field with reference to KISTEP's "Report on the investigation of ICT levels and analysis of technology competitiveness." The evaluation method consisted of evaluations by experts, and awarding technology points in accordance with the Gordon Scoring Model.* With this model, the US, the country with the world's highest level of technology, has 100 points, and differences in technology are demonstrated by assigning other countries a percentage of this. In terms of overall ICT science and technology capabilities, South Korea has the equivalent of 88.6% of the US (*China has 91.5% and Japan, 88.4%), and the equivalent of a delay of around 1.2 years in terms of disparity.

The fields included in ICT consist of the 18 fields in the figure below, and the points are as follows.

90–99: The highest level in the world (or is reaching this level)

80–89: Approaching the countries with the highest levels of technology in the world

70–79: There is a certain gap between this country and the countries with the highest levels of technology in the world

60–69: The development of this country is slower than countries with the highest levels of technology in the world

59 or less: The development of this country is a lot slower than the countries with the highest levels of technology in the world

*The Gordon Scoring Model: a method of combining individual indicators and expressing them as one indicator. It calculates the overall technology level of high-level technologies and industry based on the following formula, using the technology level of low-level technologies as a base.

$$Mi = 100 \frac{C_1}{C^*} \left[K_1 \frac{X_{1i}}{X_{1^*}} + K_2 \frac{X_{2i}}{X_{2^*}} + \cdots + K_N \frac{X_{Ni}}{X_{N^*}} \right]$$

Mi: the comprehensive technology level of i; C: a constant (take as 1); Kn: The weight of n primary factor

N: number of factors included in the mode; Xn*: standard value of factor n; Xni: Value at time of comparison of factor n

Field	Score	World ranking/trend
ICT average	88.6	Approaching the countries with the highest levels of technology in the world
Mobile communications	97.8	The highest level in the world
Network	88	Demonstrating stable growth
Electromagnetic waves/satellites	85.4	Maintaining current level
IoT	92.5	The highest level in the world
Software (SW)	90.7	The highest level in the world
Cloud	87.8	Demonstrating stable growth
Computing systems	85.6	Demonstrating rapid growth
Autonomous driving for vehicles	86.8	Demonstrating stable growth
Artificial intelligence (AI)	87.8	Maintaining current level
Big Data	87.8	Maintaining current level
Broadcasting media	94.1	The highest level in the world
Digital content	86.8	Demonstrating stable growth
Smart devices	87.5	Demonstrating stable growth
Intelligent semiconductors	89.2	Demonstrating stable growth
Quantum information communications	85.2	Demonstrating rapid growth
Next-generation security	88.4	Maintaining current level
Blockchain	85.6	Demonstrating rapid growth
ICT fusion	88.3	Demonstrating stable growth

Figure 3-11: South Korea's ICT levels

Source: "Report on the investigation of ICT levels and analysis of technology competitiveness 2021"

According to KISTEP, South Korea has already reached the **highest levels in the world** in fields such as **mobile communications, IoT, software, and broadcasting media**.

In the case of mobile communications, INTEL, Broadcom, and Qualcomm control the global market, meaning American companies have an oligopoly. Since South Korea successfully commercialized 5G, it has maintained high-level technological capabilities, especially in wireless transmission and mobile communications service technology. Samsung Electronics, in particular, has made great contributions to mobile communications.

With regard to the IoT, cloud-centered global companies are leading the global IoT market through Amazon's AWS IoT, MS' Azure IoT, IBM's Watson IoT, and Google's Google Cloud IoT platforms. Three major South Korean players in communication are also developing their own platforms (SK Telecom, KT, LGU+) and providing diverse services, but are still struggling in the global competition. However, the country is showing its strength in ultra-small IoT device technology. In South Korea, Samsung Electronics, the Electronics and Telecommunications Research Institute, and SoluM are raising technology levels in basic and applied research fields through the development of chips for IoT devices. Active R&D on single services specific to domains is also going ahead.

When it comes to software, the US is top in both the technological development and commercialization of system software and software for development. Technological development and commercialization is going ahead in South Korea, mainly in companies. First, NAVER, the Kakao Group, and NHN are actively driving applied technology

commercialization for system software. There has been increased use of software for development in different industries, but this was almost all dependent on the introduction of foreign software. Therefore, the importance of the integration of systems and devices is increasing daily, and SW technology developed within South Korea, such as Samsung's SmartThings and LG's ThinQ has started to be put to use.

As for Internet distribution technologies and businesses for broadcasting media, companies such as NETFLIX, YOUTUBE, FACEBOOK, and DISNEY+ are famous around the world, but South Korea is also increasing its share in the Internet distribution business based on content such as Korean wave movies, dramas, and more. Services such as Wavve and WATCHA are original South Korean OTT platforms, and contribute to the diffusion of Korean wave content around the globe. In September 2020, the number of Wavve subscribers exceeded 10 million. Furthermore, COUPANG took over the Southeast Asia OTT provider HOOQ, and in December 2020 expanded into an OTT provider with COUPANG PLAY. COUPANG has also secured a large number of users as a large mail-order company.

Though they cannot be said to be at the highest global level, **computing systems, quantum information communications, and blockchain** are also **ICT fields showing rapid growth**.

Computing systems are systems configured to enable processors that analyze and execute programs, devices that save data and information, and I/O (input-output) devices to carry out information exchange and data processing operations. Computing system technology includes basic computing technology for the abovementioned processors and devices, and next-generation computing technology connected to the development of supercomputers.

Computing systems are one field with fierce global competition. In the US, global companies such as IBM, HPE, and NVIDIA possess high-level technological capabilities; China is working on technological innovation through its five-year plan for science and technology development. South Korea is promoting its own development of supercomputing technology, including CPU. Moreover, Samsung Electronics, KAIST, and the Electronics and Telecommunications Research Institute have demonstrated growth not only in basic research, but also in applied research and commercialization through industry-academia research collaborations. With regard to quantum information communications, APRC has published a research report, "Policy and R&D trends of quantum technology in the leading countries of the Asia and Pacific regions,"[141] which offers a detailed introduction to the quantum technology level in South Korea; it can be said that South Korea's strength lies in the quantum communications field. This can also be seen in the trends in papers and patent applications: according to the National Science & Technology Information Service (NTIS),[142] in the last few years (statistics from the five years from 2017), South Korea produced 6,059 papers related to quantum; in KISTI's R&I report,[143] between 2016 and 2020 there were 246 South Korean papers relating to quantum listed on Web of Science. Their relative quantities were quantum communications: 50.8%, quantum computing: 41.9%, and quantum sensing: 7.3%. Notable R&D investment in the private sector included movement in Samsung and three major communications companies, SK Telecom, KT, and LGU+. A quantum computing research team centered in the Samsung Advanced Institute of Technology is involved in the IBM Q Network, and is also working on joint research with the University of Chicago in the US. Furthermore, SK Telecom,

141 The full text of the investigative report: https://spap.jst.go.jp/investigation/report_2022.html#fy22_rr01

142 https://www.ntis.go.kr/ThSearchResultPaperList.do?sort=RANK%2FDESC&ntisYn=&searchWord=%EC%96%91%EC%9E%90&originalSearchWord=&originalSearchGubun=

143 KISTI R&I Report, "Analysis of quantum technology science, technology, and industry," P58–76.

KT (a communications company), WOORIRO, and WOORINET (equipment and parts development manufacturers) are focusing on the development of equipment and parts for quantum cryptosystems. When it comes to blockchain, tech giants and financial institutions around the world, as well as diverse startup companies, are participating in open source blockchain development projects, and advancing R&D. South Korea is improving its technological capabilities, especially in distributed ledger technology (DLT), and has prepared diverse demonstration services, but there is still inadequate system-based support, including legislation, for commercialization.

Next, this section will introduce the competitiveness of the papers and patents in each ICT field mentioned in the KISTEP report above.

First, the papers are scored based on the Web of Science papers from 2010 to 2020 in the 18 ICT fields above (Figure 3-11). Activity level is an indicator that expresses the quantity of papers—the countries with more papers have higher activity level scores. Influence refers to the quality of the papers, and is assessed based on the number of citations. Papers with a high number of citations have superior influence. Paper competitiveness equals the activity level score x 30% plus the influence score x 70%.

Patents are assessed in accordance with the WINTELIPS database from 2010 to 2020 in the 18 ICT fields. Activity level is the quantitative indicator, and countries with more patent applications are ranked higher. Influence is the qualitative indicator, and the number of citations per registered patent determine the rankings. Market power is an indicator showing the patent family percentage among patents for which applications have been made—the higher the market power, the more countries apply overseas, and the higher the ability to secure a market. Competitiveness is scored with the total of activity level x 15% + influence x 35% + market power x 50%.

When paper competitiveness in ICT fields is compared between the US, Europe, Japan, China, and South Korea, South Korea is at the very bottom, but the country does score slightly higher than Japan when it comes to the quantitative indicator of activity levels. Europe and China are ranked higher than the US in terms of application levels, but the US is superior when it comes to influence, which expresses quality. For overall paper competitiveness, Europe, with high scores in both qualitative and quantitative assessments, ranks top.

With regard to patent competitiveness in ICT fields, South Korea does not reach the US, Europe, or Japan, but does score higher than China, meaning it ranks fourth. South Korea surpasses Europe in the quantitative indicator of activity levels, also ranking fourth, and is ranked third in influence, the indicator of the number of patent citations, which is higher than Japan and China. It is fourth in market power, the indicator of the ability to obtain a market, higher than China. In the case of patents, while China is overwhelming in activity level due to a huge number of patents, the US and Europe are strong in influence and market power, and overall, it is the US with the highest patent competitiveness.

When viewed by field, South Korea's paper numbers in the ICT field are concentrated in networks, smart devices, the IoT, Big Data, computing systems, and clouds, and there are many patent applications in the fields of the IoT, quantum information communications, next-generation security, and broadcasting media.

Table 3-12: Competitiveness of papers and patents in the ICT field

	South Korea	United States	Japan	China	Europe
Paper competitiveness	**87.6**	99.4	90.0	91.9	100
Patent competitiveness	**84.7**	100	90.8	83.0	93.5

Table 3-13: ICT paper competitiveness: quality and quantity assessments

	South Korea	United States	Japan	China	Europe
Paper competitiveness	**87.6**	99.4	90.0	91.9	100
Activity level (quantity)	**87.2**	90.2	86.0	97.3	100
Influence (quality)	**86.1**	100	89.4	88.8	98.2

Table 3-14: ICT patent competitiveness

	South Korea	United States	Japan	China	Europe
Patent competitiveness	**84.7**	100	90.8	83.0	93.5
Activity level	**83.7**	95.4	89.3	100	74.7
Influence	**81.4**	100	78.0	77.0	82.5
Market power	**80.9**	93.7	93.7	76.1	100

Source for Tables 3-12 to 3-14: "2021 Report on the investigation of ICT levels and analysis of technology competitiveness"

Next, this section will introduce the current state of South Korea's science and technology capabilities based on evaluations by international organizations, IDM, WEF, and others.

3.1.4 South Korea's science and technology capabilities based on IMD rankings

(1) IMD's World Competitiveness ranking

This section will start with the IMD World Competitiveness ranking.

The IMD World Competitiveness ranking is a ranking given by the International Institute for Management Development, a business school located in Lausanne, Switzerland, based on the question "to what extent does the country have an environment in which companies can do business easily?" It has a 34-year history. In 2022, the school ranked the economic competitiveness of 63 major countries and regions around the world based on over 300 criteria under four indicators: Economic Performance, Government Efficiency, Business Efficiency, and Infrastructure.

According to the IMD World Competitiveness Ranking 2022,[144] South Korea's overall ranking was **27th** out of 63 countries (Japan was 34th). Of the Asian countries, Singapore was the highest ranked at 3rd (5th in the previous year), Hong Kong was 5th (7th in the previous year), and Taiwan was 7th (8th in the previous year), meaning that, similar to

[144] Full text: https://www.imd.org/centers/world-competitiveness-center/rankings/world-competitiveness/

the previous year, three countries/regions were in the top 10. South Korea fell four rankings compared to 2021, but has moved up and down around the 20th ranking since 2015.

South Korea's rankings in each field of the IMD World Competitiveness Ranking (the four indicators and the main criteria) are shown in the table below.

Table 3-15: South Korea's IMD World Competitiveness ranking by field

	Economic Performance					Government Efficiency					Business Efficiency					Infrastructure				
	Domestic economy	International trade	International investment	Employment	Prices	Public finance	Tax policy	Institutional framework	Business legislation	Societal framework	Productivity & efficiency	Labor market	Finance	Market practices	Attitudes & values	Basic infrastructure	Technological infrastructure	Scientific infrastructure	Health & environment	Education
2021	5	33	34	5	51	26	25	30	49	33	31	37	23	30	21	18	17	2	30	30
2022	**12**	**30**	**37**	**6**	**49**	**32**	**26**	**31**	**48**	**35**	**36**	**42**	**23**	**38**	**23**	**16**	**19**	**3**	**31**	**29**
Change	7 ↓	3 ↑	3 ↓	1 ↓	2 ↑	6 ↓	1 ↓	1 ↓	1 ↑	2 ↓	5 ↓	5 ↓	-	8 ↓	2 ↓	2 ↑	2 ↓	1 ↓	1 ↓	1 ↑

These elements all have some effect on R&D, and the ranking of the domestic economy under the "economic performance" indicator fell considerably. Analysis by the Ministry of Economy and Finance (MOEF) concluded that the increasing budget deficit relative to GDP and the decreasing financial condition of the government were the causes of the significant drop in the domestic economy ranking.[145]

It is thought that the country's ranking for public finance under the "government efficiency" indicator also fell substantially due to the abovementioned increasing budget deficit relative to GDP and the deceasing financial condition of the government.

With regard to the "business efficiency" indicator, the country's rank dropped 13th places for international standards of efficiency for large companies, but it is thought that this was a side effect of the corporate support policies centered on SMEs advanced by the Moon administration. Moreover, there were almost no policies to recall Korean talents from overseas, so it is conceivable that the country's fall in rank was affected by the response to the outflow of talent.

In terms of the "infrastructure" indicator, although the tendency was for the country's ranking to fall, there

[145] See https://www.yna.co.kr/view/AKR20220614153700002.

were some areas ranked higher than the overall evaluation, especially in science and technology and areas directly related to this. Following on from last year, the country maintained its place in the upper ranks in technological and scientific infrastructure (in 2022, it **ranked 19th in technological infrastructure and 3rd in scientific infrastructure**). It is thought that the development of a legal system for technological development, the strengthening of government support, and the advancement of digitalization in South Korean society were rated highly in technological infrastructure. It is assumed that scientific infrastructure was ranked third in the world thanks to the development of legislation to encourage research and innovation, the protection of intellectual property rights, and the active transfer of knowledge between industry and academia; there was likely an awareness of South Korea as a country that is developing systems to make use of the strong knowledge it has built up through R&D. It can be said that scientific infrastructure is a huge strength of South Korea.

(2) IMD's Digital Competitiveness Ranking

Next, this paper introduces the Digital Competitiveness Ranking, which is closely related to science and technology.

The Digital Competitiveness Ranking[146] uses international indicators of digital competitiveness created and published by IMD to analyze, score, and rank the degree of transformation in policy, business models, and society in general through the development and use of digital technology by country. The digital competitiveness ranking uses three categories for the main factors influencing digital competitiveness: knowledge, technology, and future readiness, and these are calculated based on 52 standards and indicators associated with each factor.

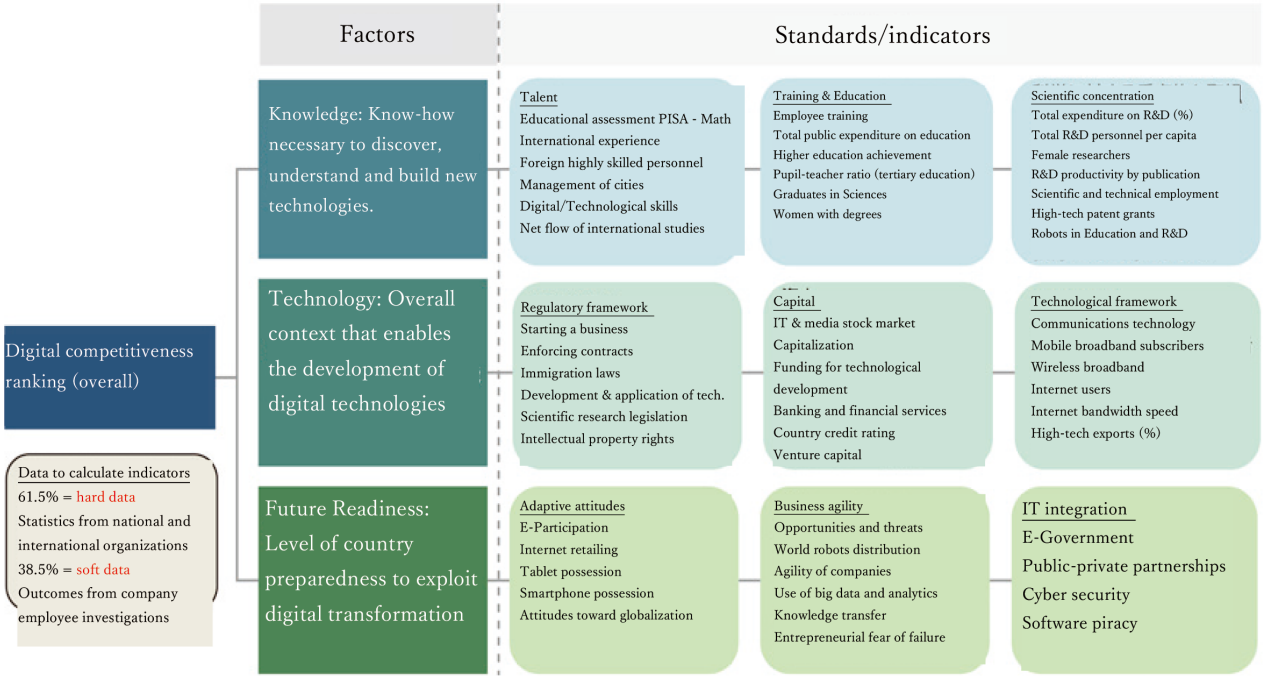


Figure 3-16: Details of standards and indicators for the Digital Competitiveness Rankings

Source: Ministry of Internal Affairs and Communications "Investigative research on the use of digital technology for post-COVID economic recovery"

146 The full text of the Digital Competitiveness Ranking 2022: https://www.imd.org/centers/world-competitiveness-center/rankings/world-digital-competitiveness/

South Korea was ranked 8th in 2022 (Japan was ranked 29th). Its rank has varied from 19th in 2017 to 14th in 2019, 10th in 2019, 8th in 2020, and 12th in 2021. **Among the various Asian countries**, it is **second** to Singapore (4th). In 2022, it was assessed as being 16th in knowledge (15th in 2021), 13th in technology (13th in 2021), and 2nd in future readiness (5th in 2021).

A more detailed look shows that in the Future readiness field, it was ranked first for E-participation, the same as 2021, and thanks to the stimulation of impersonal transactions, the country was also ranked first for Internet retailing; its smartphone possession was fourth, and **its adaptive attitude toward new technology was first overall**.

Moreover, South Korea was ranked third in the indicator for robot usage, 16th for agility of companies, and 2nd for entrepreneurial fear of failure, **coming 2nd overall for business agility**. Notably, its entrepreneurial fear of failure rose significantly, from 16th in 2021 to 2nd; as is noted in this paper, it is thought that this evaluation was due to the complete abolition of the joint liability system for corporate representatives to reduce burdens for entrepreneurs should they fail.

The country's ranking in IT integration also rose, from 16th in 2021 to 14th, with E-government coming 2nd and government cyber security capacity coming 6th.

In the Technology area, South Korea demonstrated a great leap in **regulatory framework, going from 44th to 15th**; it appears that the revisions to the three data laws introduced in this paper, as well as the substantial softening toward regulations for technology with the introduction of the regulatory sandbox system, contributed to this increase in rank.

In Knowledge, e-government was ranked 2nd, as was total expenditure on R&D (%), and total R&D personnel per capita was also top level, in 3rd place. However, the international experience indicator in Talent came 59th, Foreign highly-skilled personnel came 49th, and female researchers came 53rd—all harsh evaluations.

South Korea is becoming a leading digital power, not only from an Asian perspective but from a global one; beyond everyday levels with the popularization of smartphones, the digitalization of the government is progressing daily, and business areas are also moving forward. Although there are still walls in areas such as female researchers and use of foreign talents, the progress of digitalization can surely be seen as positive.

3.1.5 South Korea's science and technology capabilities based on the WIPO's Global Innovation Index

How does the WIPO rate South Korea's science and technology capabilities? This section will start with the Global Innovation Index.

(1) WIPO's Global Innovation Index

WIPO's Global Innovation Index 2022 (GII)[147] is an index introduced in 2007 by the WIPO (World Intellectual Property Organization), INSEAD (Institut Européen d'Administration des Affaires), Cornell University, and others for the global members of WIPO, to gain an understanding of the overall picture of innovation (an important element in economic development) and provide information necessary for each country to formulate policies and create economic strategies. In 2022, it carried out an assessment based on 81 indicators that made up seven areas: (1) Institutions, (2)

147 Full text: https://www.wipo.int/global_innovation_index/en/2022/.

Human capital and research, (3) Infrastructure, (4) Market sophistication, (5) Business sophistication, (6) Knowledge and technology outputs, and (7) Creative outputs.

In the 2022 GII, South Korea was ranked 6th, a fall of one position from 2021. Although its rank fell, it came first in the Asian region for the second year running (Japan was 13th). Among the 81 indictors, South Korea was ranked first in the world for the following seven:

(1) Patents by origin/bn PPP$ GDP, (2) PCT patents by origin/bn PPP$ GDP, (3) Industrial designs by origin/bn PPP$ GDP, (4) Researchers, FTE/mn pop., (5) Research talent, % in businesses, (6) Government's online service, and (7) E-participation.

The Commissioner of the Korean Intellectual Property Office commented, "The resources South Korea has invested in innovation are effectively leading to innovative outcomes, and when we were compared to countries with similar living standards, I believe our innovation capabilities earned a high evaluation. Even in a harsh social environment, the government and companies have continued to invest; this has led to results, and I think it has also greatly contributed to the diffusion of knowledge. Being ranked first in Asia for two years running amidst a global economic crisis is a major encouragement."[148]

However, there are areas that received harsh evaluations as well as fields that did well; "Cost of redundancy dismissal," "FDI net inflows, % GDP," "GDP/unit of energy use," and "Printing and other media, % manufacturing" were ranked 111th, 112th, 97th, and 95th respectively, among the lower ranks. As these rankings cover 132 countries, this is quite low, and improving these fields will be a big challenge.

(2) Top 100 Science and Technology Cluster Ranking

This section will cover the top 100 Science and Technology Cluster Ranking published by the WIPO.

The Science and Technology Cluster Ranking selects 100 cities with the most science and technology research outcomes, such as patent applications and paper publications. It is not exaggeration to say that these cities lead global science and technology.

The US and China have the highest number of top 100 cities, with 21 each. South Korea ranks fourth (four cities) following Germany (10th) and Japan (5th). France, Canada, and India also share the same fourth rank as South Korea.

The figure below shows the top 30 cities. Asian countries account for the majority, showing remarkable progress in Asia. In particular, East Asian cities stand at the top of the world, with Tokyo-Yokohama coming first, followed by Shenzhen–Hong Kong–Guangzhou in second, Beijing in third, and Seoul in Fourth. This signifies the major development of science and engineering fields in Asian countries.

[148] See https://www.donga.com/news/article/all/20220929/115724497/1.

Top 100 cluster rankings

Rank	Cluster name	Economy	PCT applications	Scientific publications	Share of total PCT filings, %	Share of total pubs, %	Total	Rank 2013-17	Rank change
1	Tokyo-Yokohama	JP	113,244	143,822	10.81	1.66	12.47	1	0
2	Shenzhen-Hong Kong-Guangzhou	CN/HK	72,259	118,600	6.90	1.37	8.27	2	0
3	Seoul	KR	40,817	140,806	3.90	1.63	5.52	3	0
4	Beijing	CN	25,080	241,637	2.40	2.79	5.18	4	0
5	San Jose-San Francisco, CA	US	39,748	89,974	3.8	1.04	4.83	5	0
6	Osaka-Kobe-Kyoto	JP	29,464	67,514	2.81	0.78	3.59	6	0
7	Boston-Cambridge, MA	US	15,458	128,964	1.48	1.49	2.96	7	0
8	New York City, NY	US	12,302	137,263	1.17	1.58	2.76	8	0
9	Shanghai	CN	13,347	122,367	1.27	1.41	2.69	11	2
10	Paris	FR	13,561	93,003	1.30	1.07	2.37	9	-1
11	San Diego, CA	US	19,665	34,635	1.88	0.40	2.28	10	-1
12	Nagoya	JP	19,327	24,582	1.85	0.28	2.13	12	0
13	Washington, DC-Baltimore, MD	US	4,592	119,647	0.44	1.38	1.82	13	0
14	Los Angeles, CA	US	9,764	69,161	0.93	0.80	1.73	14	0
15	London	GB	4,281	107,680	0.41	1.24	1.65	15	0
16	Houston, TX	US	10,852	51,163	1.04	0.59	1.63	16	0
17	Seattle, WA	US	11,558	34,143	1.10	0.39	1.50	17	0
18	Amsterdam-Rotterdam	NL	4,409	78,602	0.42	0.91	1.33	18	0
19	Cologne	DE	7,827	47,161	0.75	0.54	1.29	20	1
20	Chicago, IL	US	6,167	57,976	0.59	0.67	1.26	19	-1
21	Nanjing	CN	1,662	84,789	0.16	0.98	1.14	25	4
22	Daejeon	KR	8,306	26,037	0.79	0.30	1.09	22	0
23	Munich	DE	7,532	31,259	0.72	0.36	1.08	24	1
24	Tel Aviv-Jerusalem	IL	7,076	31,086	0.68	0.36	1.03	23	-1
25	Hangzhou	CN	4,832	48,627	0.46	0.56	1.02	30	5
26	Stuttgart	DE	8,336	18,241	0.80	0.21	1.01	26	0
27	Taipei-Hsinchu	TW	2,721	62,420	0.26	0.72	0.98	43	16
28	Singapore	SG	4,019	46,037	0.38	0.53	0.92	28	0
29	Wuhan	CN	1,796	63,837	0.17	0.74	0.91	38	9
30	Minneapolis, MN	US	6,444	25,157	0.62	0.29	0.91	27	-3
31	Philadelphia, PA	US	3,173	50,847	0.30	0.59	0.89	29	-2

Figure 3-17: WIPO Top 100 Cluster Ranking

Source: WIPO cluster ranking[149]

When it comes to science and technology research outcomes per capita, Daejeon was ranked third in the world. The City of Daejeon includes the Daedeok R&D Special Zone, which has a long history and hosts many research organizations, including KAIST, the Korea Aerospace Research Institute, the Agency for Defense Development, the Electronics and Telecommunications Research Institute, and the Korea Astronomy and Space Science Institute. According to statistics,[150] as the end of 2021 there were 16 government-funded research institutes in the Daedeok R&D Special Zone, as well as 24 government and national organizations, 23 NPOs, 7 universities, and 1,613 companies. Daejeon is famous as a city of science and technology in South Korea.

149 https://www.wipo.int/export/sites/www/pressroom/en/documents/2022gii_clusters_chapter.pdf.

150 For the statistics, see: https://www.innopolis.or.krsub01020201/.

	Scientific publications			PCT applications				
Country	Number of addresses	City-level address accuracy (%)	Publications covered (%)	Number of addresses	Block-level address accuracy (%)	Sub-city-level address accuracy (%)	City-level address accuracy (%)	Applications covered (%)
China	4,836,417	99.0	99.5	643,189	89.0	0.1	10.9	99.9
United States	6,601,955	97.0	98.2	888,439	94.6	5.1	0.1	99.9
Japan	1,225,196	92.3	95.6	593,670	31.5	26.3	40.6	98.8
Germany	1,415,642	97.7	98.5	269,492	97.5	0.5	1.9	99.9
Republic of Korea	809,478	96.3	98.0	252,035	0.1	0.9	79.7	86.9
United Kingdom	1,437,049	96.8	97.9	83,678	64.0	27.6	8.0	99.6
France	1,103,856	93.4	95.5	108,437	90.4	1.9	5.4	98.1
India	786,896	91.9	94.4	42,840	33.0	52.1	13.9	99.2
Italy	1,164,449	95.8	97.3	43,602	91.0	5.2	3.4	99.6
Canada	915,638	98.4	99.0	43,920	96.9	2.6	0.4	99.8
Spain	882,748	97.6	98.6	26,809	80.5	11.7	7.6	99.8
Brazil	684,488	98.5	99.6	9,883	85.5	10.8	3.5	99.7
Australia	878,644	86.1	90.3	21,259	91.7	5.0	2.9	99.7
Netherlands	522,047	97.4	98.6	51,052	85.2	0.3	14.4	99.8
Sweden	306,161	98.0	98.4	44,888	94.7	0.8	4.4	99.9
Russian Federation	400,543	99.0	99.3	14746	90.8	5.0	3.6	99.6
Iran (Islamic Republic of)	456,057	97.3	98.5	1,083	0.2	2.3	93.5	95.5
Türkiye	396,686	96.4	96.7	16,593	45.1	41.8	11.1	98.4
Switzerland	343,054	90.8	92.5	38,982	91.8	1.3	6.8	99.8
Poland	316,725	98.7	99.4	6,477	94.4	4.5	0.9	99.7

Figure 3-18: WIPO's no. of papers published and patent applications by country

Source: WIPO cluster ranking[151]

The figure above shows the number of papers and patent applications by country; South Korea is ranked highly for patent applications, coming fifth in the world and third in Asia, but for papers it is 11th in the world and fifth in Asia.

3.1.6 South Korea's science and technology capabilities based on the WEF Global Competitiveness Rankings

Now, this section introduces an evaluation by the World Economic Forum (WEF).

The WEF Global Competitiveness Rankings are international indicators of international competitiveness created and published by the WEF. They analyze and evaluate 12 factors, including technology and ICT adoption, that contribute to the competitiveness of each country. A new framework was used from 2018 to adapt to the era of the Fourth Industrial Revolution. This new framework used the categories of "Enabling environment," "Human capital," "Markets" and "Innovation ecosystem," and calculated rankings based on standards and indicators associated with these factors.

[151] https://www.wipo.int/export/sites/www/pressroom/en/documents/2022gii_clusters_chapter.pdf.

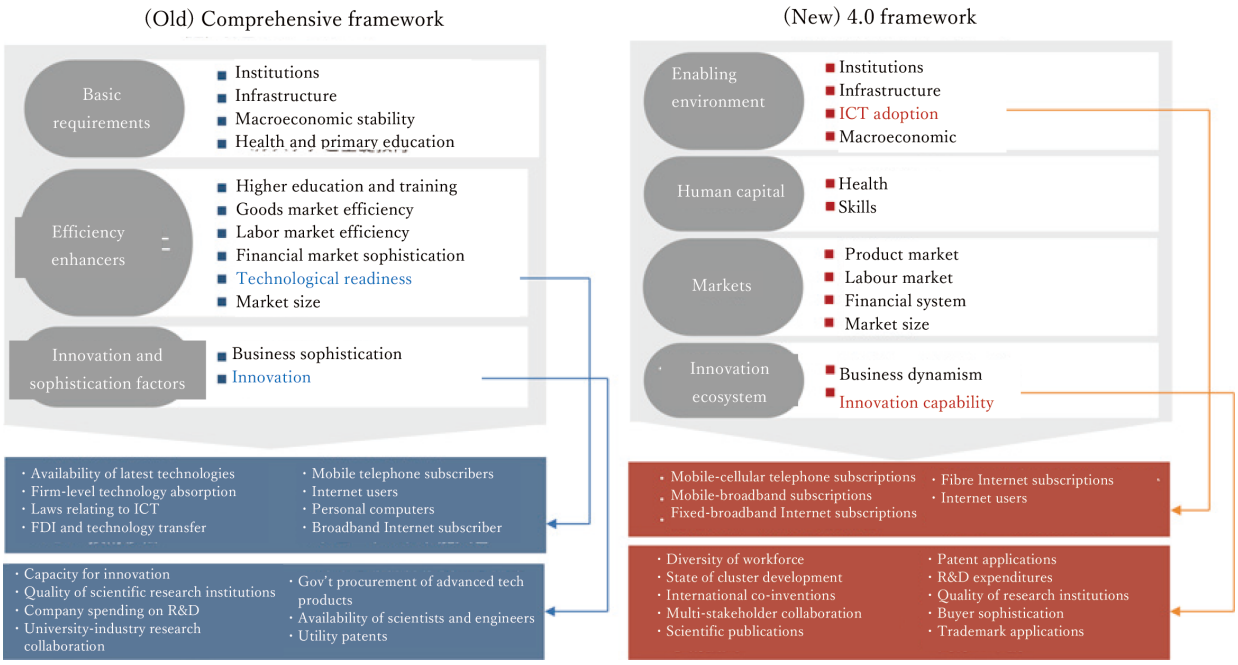


Figure 3-19: Comparison of old and new standards for evaluating the WEF Global Competitiveness Ranking

Source: Ministry of Internal Affairs and Communications "Investigative research on the use of digital technology for post-COVID economic recovery"

The latest WEF Global Competitiveness Report came out in 2020,[152] but this was a special edition on the COVID-19 Crisis, making it a report rather than an evaluation. Overall, WEF assessed South Korea as "a country that used its past experiences to ready systems in response to disease," determined that the core factor behind South Korea's economic change was a shift to a progressive taxation system, and gave an evaluation saying that the country's engagement in long-term investment in research, innovation, and invention as preparation for the future is leading to the creation of new markets.

After the introduction of the new evaluation standards, **South Korea's international competitiveness was ranked 15th in 2018** (Japan was 5th), and **13th in 2019** (Japan was 6th), giving it a high ranking among the 141 countries involved. In the Asian region, it was 5th, following Singapore (1st), Hong Kong (3rd), Japan (6th), and Taiwan (12th).

Based on the 2019 evaluation,[153] South Korea's national competitiveness is high on a global level, but regulatory reform of the labor market is still insufficient, and this is affecting its growth potential. As was also noted in WIPO's GII above, redundancy costs and the ease of hiring foreign labor are issues in the labor market.

When looking at this by field, the country was one rank higher than last year in institutions under **Enabling environment**, coming **26th**. The reason for this was the valuation of the progress of its e-government; while it was **ranked first in terms of e-participation**, the changes in governments cause frequent policy changes, so South Korea was ranked 76th in government ensuring policy stability, giving an overall ranking of 26th. When it came to **Infrastructure**, the country was once again ranked **6th**, with electricity supply and infrastructure for rail, sea, and air

152 WEF "Global Competitiveness Report Special Edition 2020: How Countries are Performing on the Road to Recovery" https://jp.weforum.org/reports/the-global-competitiveness-report-2020/.

153 See WEF "Global Competitiveness Report 2019," https://jp.weforum.org/reports/how-to-end-a-decade-of-lost-productivity-growth.

still ranking high. **ICT adoption** saw the country achieve **first overall rank**, the same as the previous year. Notably, fibre internet subscriptions (1st) and internet users (6th) led to the high evaluation. When it came to **Macroeconomic stability**, South Korea also ranked **1st** for a second year, with its inflation (1st) and debt dynamics (1st) being evaluated positively.

In the area of **Human capital**, South Korea's rank increased in **health** from **19th in 2018 to 8th**. This huge rise is thought to be because of the rise in human life expectancy from 18th to 7th. Skills was ranked 27th, the same as the previous year, but improvements were seen in the quality of vocational training and ease of finding skilled employees. However, drops in education and training levels meant that the ranking was unchanged.

When it comes to **Markets**, the country's rank rose to **59th** from 67th in the product market; it is thought that improvements in the complexity of tariffs and a relaxation of competition in services led to this. However, problems still remain as there are many companies that feel the distortive effect of taxes and subsidies on competition and trade tariffs. Furthermore, the **labour market** fell from 48th to **51st**. While there was an increase in worker's rights, internal labour mobility, pay, and productivity, areas such as redundancy costs, hiring and firing practices, and flexibility of wage determination were the reason for the lack of success in this category. The country rose one rank from 2018 to come 18th in **financial system**, with improvements such as financing of SMEs going from 45th to 37th, venture capitalization availability going from 53rd to 51st, and soundness of banks going from 74th to 62nd. There was no change in market size, the country once again ranking 14th, and apart from falling from 2nd to 3rd in non-performing loans, GDP, etc. did not change.

In the **Innovation ecosystem area**, **business dynamism** fell from 22nd to 25th. Growth of innovative companies and willingness to delegate authority generally maintained the same levels as last year, but attitudes towards entrepreneurial risk (owner's risk[154]) dropped 11 ranks. **Innovation capability** rose from 8th to **6th**. Within this, diversity of workforce fell from 82nd to 86th, but other indicators had generally positive ratings, with buyer sophistication ranked 1st, patent applications 2nd, research institutions prominence 11th, scientific publications 18th, and state of cluster development 25th.

Overall, WEF evaluated South Korea as follows.

South Korea is **a global leader spearheading the ICT sector, and can claim some of the world's highest levels in macroeconomic stability and innovation capability**. It must make improvements in promoting entrepreneurial spirit and domestic competition, and in the flexibility of the labor market. Moreover, while quality of life has improved and poverty is down, growth in productivity has slowed down in recent years. To correct this trend, the country must engage in further proactive investment and bold reforms in R&D, talent, and infrastructure. To improve creativity, **technological development and innovation are important, but South Korea must ensure that social factors such as talent discovery and the labor market develop technology and bring it together**.

[154] A company falling into crisis through fraudulent or deviant actions by the owner is known as owner's risk. Corporate images can be damaged or the company can get into trouble due to individual errors such as scandals, assaults, property disputes, tax evasion and embezzlement that have nothing to do with the company's regular economic activities. See http://japan.hani.co.kr/arti/opinion/24731.html for the above information. In South Korea, where chaebol companies have a lot of influence, the effects of owner's risk are particularly large.

3.1.7 South Korea's science and technology capabilities based on the UN's Global E-Government rankings

Next, this report will cover the UN Global E-Government rankings[155]. Their full title is the United Nations Department of Economic and Social Affairs' E-Government rankings, and they were started in 2003 with the aims of improving the transparency of public policy and accountability via ICT among the United Nations, and encouraging citizens' participation in public policy. Since 2008, these rankings have been given once every two years. They are decided by averaging three indexes, the Online Service Index, the Human Capital Index, and the Telecommunications Infrastructure Index, to produce the United Nations E-Government Development Index (EGDI).

South Korea ranked 3rd in 2022 and has maintained its rank in the top three since 2010. Between 2010 and 2014 it was ranked 1st, it was 2nd in 2020, and it was 3rd from 2016 to 2018 and in 2022. **South Korea is the only country that has maintained its top-three rank seven consecutive times since 2010.**

Table 3-20: South Korea's UN E-government ranking progression

	2010	2012	2014	2016	2018	2020	2022
Overall ranking	1	1	1	3	3	2	3
Online services	1	1	3	5	4	1	3
Telecommunications infrastructure	13	7	2	2	3	4	4
Human capital	7	6	6	18	20	23	23

Online services are evaluated directly by the United Nations Department of Economic and Social Affairs using laws and systems associated with e-governance and website visit assessments as indicators. The evaluation indicators for telecommunications infrastructure are the use rate of the Internet, the number of smartphone users, and the number of wired/wireless broadband subscribers. Human capital is assessed using adult literacy rates, school attendance rates, the expected number of years of education, and the expected number of years of continuing education.

As is evident from the table above, South Korea's human capital ranking is comparatively low, but its online services and telecommunications infrastructure indicators are at the top of the world.

3.1.8 South Korea's science and technology capabilities based on the Nature Index

Every year, Nature publishes the Nature Index of excellent papers published by research organizations around the world. The Nature Index 2022[156] covers papers published from January 1 to December 31, 2021 in 82 superior journals

[155] https://publicadministration.un.org/en/Research/UN-e-Government-Surveys

[156] Nature Index (www.natureindex.com) Annual tables.

selected by Nature, and the ranking of research organizations, and countries and regions is determined by analyzing their share value.[157] For the last 10 years running, the Chinese Academy of Sciences (CAS) has been the research organization that has published the most excellent papers.

As far as South Korea is concerned, **12 of its research organizations are included in the top 500**, with Seoul National University ranking 59th and coming top within South Korea. Seoul National University's rankings were: 2019: 69th, 2020: 66th, and 2021: 59th. The number of research organizations in the top 500 has stayed at 10–13 since 2015, with 13 in 2015, 12 in 2016, 11 in 2017, 13 in 2018, 12 in 2019, 12 in 2020, and 12 in 2021.

After Seoul National University comes KASIT (67th), POSTECH (126th), Yonsei University (147th), Institute for Basic Science (IBS) (180th), Sungkyunkwan University (187th), Korea University (215th), Ulsan National Institute of Science and Technology (UNIST) (220th), Korea Institute of Science and Technology (KIST) (344th), Hanyang University (350th), Gwangju Institute of Science and Technology (GIST) (414th), and Ewha Womans University (500th).

South Korea **ranked 8th in both 2020 and 2021, but its share value has improved since 2020**. Its share value for 2021 was up 2.3% from 2020. South Korea ranked 12th in terms of paper numbers, but achieved the higher 8th rank when it was converted with share value.

American research organizations still demonstrated their strength in the life sciences field, but in South Korea Seoul National University ranked in the top 100 for the first time at 96th, and then greatly increased its ranking again in 2021 at 83rd.

Around 60% (118) of the top 200 research organizations in the Asia-Pacific region are Chinese; 15 of those ranked are South Korean. **In Asia, South Korea ranks 4th following China, Japan (24 research organizations), and India (17 research organizations)**. The rankings of those 15 organizations are as follows.

Seoul National University (22nd), KAIST (27th), POSTECH (53rd), Yonsei University (57th), IBS (65th) Sungkyunkwan University (68th), Korea University (74th), UNIST (78th), KIST (114th), Hanyang University (118th), GIST (138th), Ewha Womans University (173rd), Pusan National University (176th), Kyung Hee University (181st), Kyungpook National University (184th).

When it came to the **top 100 research organizations in the life sciences field in the Asia-Pacific region**, China ranked 1st (52 organizations), Japan 2nd (18 organizations), and Australia 3rd (13 organizations). **South Korea came 4th with seven organizations**. Looking at each of their rankings, Seoul National University was 13th, KAIST 29th, Yonsei University 59th, IBS 75th, Korea University 82nd, POSTECH 87th, and Sungkyunkwan University 100th.

This report has looked at evaluations of South Korean science and technology by various international organizations, and to summarize, South Korea is extremely advanced in digitalization and its infrastructure is also excellent. The popularization of its Internet and the acceptance of digital technology amongst its people is high, and e-government and the digitalization and online use of public services is established, making it a country where everyday life is very convenient. However, there is still room for a lot of improvement in areas such as the flexibility of its labor environment, the diversity of its talent, and its use of foreign talent.

Moreover, while improvements are being made, instability resulting from changes in administration leading to frequent policy changes and the large number of regulations for new industries are notable, and the country still

157 Measured by AC (Article Count) and FC (Fractional Count).

cannot be said to have an environment that facilitates the establishment of companies, which is also an issue.

Although there were no major fluctuations in the country's ranking by number of papers in terms of science and technology outcomes, progress was visible in the number of citations and share value. The number of patent applications is also increasing steadily, and there is an increasing tendency for results from R&D.

3.2 Evaluations of strategy

Next, this paper will explore evaluations of policies enacted for the era of the Fourth Industrial Revolution, and any remaining future challenges for South Korean society and its science and technology.

3.2.1 Evaluation of legal systems and policy coordination

(1) Outcomes from policy adjustments and the relaxation of regulations

First, the series of policy adjustments and the introduction of new systems created the environment needed for the development of different new industries, technology, and talent in the era of the Fourth Industrial Revolution, and became an institutional base that supports favorable development. The Fourth Industrial Revolution creates huge change in the overall economy and society, so the coordination of policies and systems that can cope with these changes is vital. In this sense, the South Korean government's actions in coordinating appropriate policies in a timely manner can be praised.

With regard to the relaxation of regulations, how was the revision of the three data laws—the most important change—taken in South Korean society?[158]

First, companies connected to the Fourth Industrial Revolution, which greatly relies on data, expressed joy at being able to use pseudonymized information to push forward through R&D. Data sharing between companies is now possible, and expectations for the development of technology and the economy have grown. Consumers anticipate increased quality of life and convenience thanks to companies, public organizations, and financial institutions processing and using data to provide innovative services.

From the consumer standpoint, people have become able check information scattered in different financial institutions and medical institutions via one app, and this has been well-received by many. They can save the time and effort it would take to download multiple apps, and rather than simply provide information, they can use products that suit their economic status and health situation and receive advice; one major advantage is that, if MyData is used effectively, consumers can make use of various financial and medical services.

Of course, there are also people who are worried about leaks of personal information and invasions of privacy. In particular, in the case of pseudonymized information, large amounts of personal information can be used free of charge for various types of research and statistics if it just undergoes a pseudonymization process, and companies can share pseudonymized information between them, so some people have expressed criticism that it is actually easier to identify an individual with this system. Moreover, the possibility of personal information being misused for politics in

[158] References for this section: https://www.dokdok.co/brief/nae-gaeinjeongboyi-mirae-deiteo3beob-ihaehagi;
https://newsroom.koscom.co.kr/19219;
https://brunch.co.kr/@jaeyunchoi/18.

the future has also been pointed out, similar to the Facebook-Cambridge Analytica scandal in the US.

Balancing the protection of personal information with the public interest is a long-running debate, but from the author's perspective, revising the three data laws is a positive thing. In addition to the increasing added value of information extracted from Big Data, quickly reading trends from data and collecting large amounts of pertinent information are important challenges for companies. In these circumstances, it is conceivable that the revision of the three data laws was an inevitable choice. In fact, among the major countries, South Korea is ahead in focusing on developing the data industry, as is shown in the table below. To paraphrase, developing the data industry is a global development trend, and an indispensable sector to winning in global competition. The development of society and the economy greatly relies on companies, and it is conceivable that fostering an environment in which companies can act easily was a necessary initiative for the government. The challenge is how to use the data safely, and the proposed revisions of the three data laws were considered for almost two years from submission to approval, so it is thought that the country did ensure sufficient discussion and enacted necessary measures.

Table 3-21: Status of the development of the data industry in major countries

Country	Data industry	Time of introduction	Main content
US	Big Data Research and Development Strategic Plan	2016	· Supporting R&D for Big Data technological development · Strengthening infrastructure
EU	Data economy development strategy	2017	· Clarifying the right of access to data and legal responsibilities · Establishing provisions to protect personal information and for its legal use
Japan	Plan to realize Society 5.0	2017	· Supporting the creation of platforms based on data · Creating an innovation venture cycle system
China	Big Data development plan	2017	· Widening (opening) data access · Supporting platform technology

Source: National Information Society Agency (NIA), "Strategies for the stimulation of the data industry in major countries"

As is evident from the data below, the data industry in South Korea experienced rapid growth with the revision of the three data laws. According to MSIT's "Survey of the Status of the Data Industry 2021,"[159] **the market size of the data industry went from 13.7547 trillion won in 2016 to 20.0024 trillion won in 2020**. In recent years, **the average yearly growth rate of the data industry has exceeded 13%**, and the stimulation of the data economy has been remarkable.

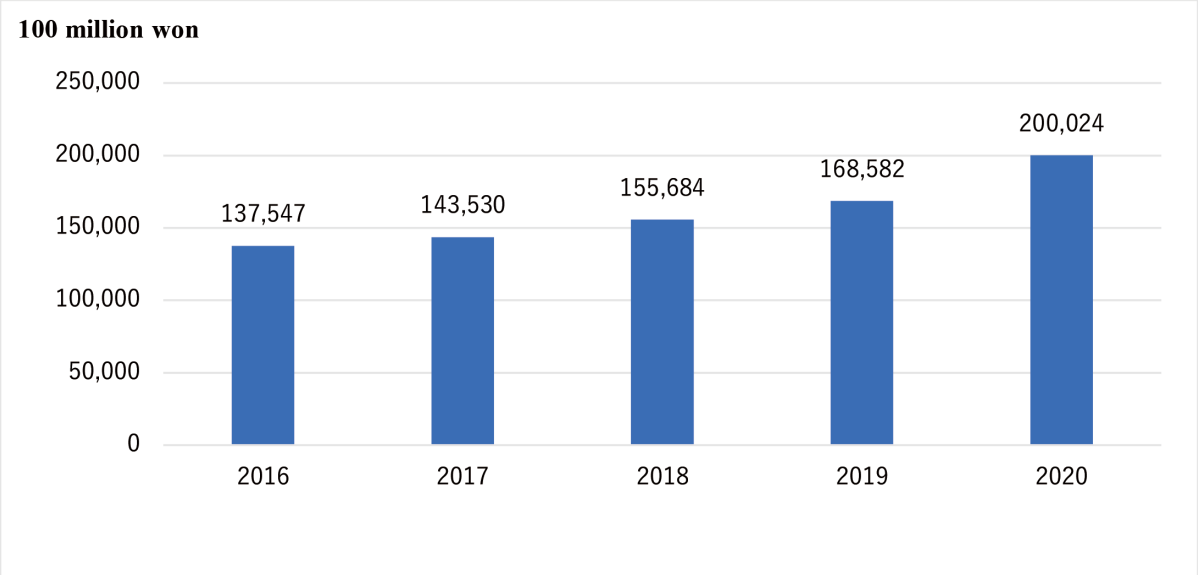


Figure 3-22: Size of the data industry market

Source: MSIT "Survey of the Status of the Data Industry 2021"

[159] Full text: https://dataonair.or.kr/2021-data-industry-status-survey/

Moreover, **as of September 2022, the cumulative number of MyData subscribers reached 54.8 million**.[160] This was the number just nine months after the service was launched in January 2022. The Financial Services Commission commented, "Based on the favorable reception of the MyData project, the scope of the MyData provided will be expanded from December. Users will be able to check information such as pensions, the status of various tax payments, credit card statement information in real-time, communications costs, and home management fees."[161]

The strategy for 5G, the pillar of networks, can also be evaluated positively with the world's first successful smartphone infrastructure commercialization. In fact, to create a 5G network and induce investment, the government increased tax credits from 2–3% to around 6% for private-sector 5G construction costs, and strove to spread 5G infrastructure.[162] 5G users exceeded 17.8 million people in August 2021, with more than 170,000 base stations. Moreover, 5G equipment exports reached 7.9 trillion won in 2020, with the country having the second-largest global market share in 5G terminals.[163]

One successful case of AI[164] **was the South Korean medical AI "Dr. Answer**."[165] First, when Dr. Answer was used to diagnose an intractable infant disease that had taken around five years to diagnose, it successfully named the illness in 15 minutes. When diagnosing intractable infant diseases, over 1,800 genes can cause developmental disorders, so many doctors struggled and were unable to grasp the name or cause of the illness even with up to several thousand genetic tests for developmental disorders, but Dr. Answer was successful in naming the illness based on vast amounts of Big Data.

Introducing a case study:

A patient with a developmental delay that meant they were unable to sit or roll over until they were three years old had undergone many tests and been in and out of hospital for years, but the name of their illness was unclear. However, Dr. Answer's genetic tests diagnosed them with congenital myasthenia. After this, the child was given neurotransmitters, and was able to crawl in just a month.

Furthermore, Dr. Answer's colonoscopy SW increased accuracy from the conventional 74% to 92%. It is thought that the shorter diagnosis time and accuracy possible with Dr. Answer is equivalent to cuts of 672 billion won a year when converted to costs.

The government's efforts have been highly rated, and South Korea reached first rank in the 2020 OECD Digital Infrastructure, first in Omdia's 5G network evaluation, first in Open Signal's 5G network evaluation, and second in the UN's E-Government Development Index.[166] Moreover, in Oxford Insights'[167] "Government AI Readiness Index" it

160 PUBLIC NEWS, "A smarter financial secretary: Scope of MyData information widens," (October 2020), http://www.psnews.co.kr/news/articleView.html?idxno=2015436.

161 NEWISIS, "Scope of information-checking widens with financial MyData," (October 2022), https://newsis.com/view/?id=NISX20221019_0002053378&cID=15001&pID=15000.

162 See Office for Government Policy Coordination, "Four years of results from the Moon Jae-in government, achievements in promoting national policy issues," (May 2021), p195.

163 See joint release by relevant ministries, etc., "The outcomes of the Fourth Industrial Revolution and future challenges,"(March 2022), p3.

164 See Government of the Republic of Korea, "Faster and more accurate disease diagnosis! South Korean AI Doctor Answer," (April 2021), https://post.naver.com/viewer/postView.naver?volumeNo=31211079&memberNo=30808385&vType=VERTICAL.

165 A medical AI developed through Korean government investment of around 50 billion won over three years from 2018.

166 See joint release by relevant ministries, etc., "The outcomes of the Fourth Industrial Revolution and future challenges," (March 2022), p5.

167 https://www.oxfordinsights.com/

went from 26th in 2019 to 7th in 2020.

(2) Challenges remaining in policy coordination centered on D.N.A.

On the other hand, as was noted in the evaluations by various international organizations in 3.1, the country must further increase the flexibility of its systems to accept new technologies and services. Its sandbox system in particular is based on positive regulation (see the definition in 2.2.4)—there are high hurdles to its use, and many people have voiced the opinion that its adaptability and coordination are ineffective. Although the government is attempting to shift from positive regulation to comprehensive negative regulation (see the definition in 2.2.4), it has become clear that there are limitations to changing a system in a short period of time.[168]

Additionally, although the country has commercialized 5G, there are frequent network malfunctions, so people have expressed uncertainty as to the stability of the network. According to the Korea Institute for Industrial Economics and Trade's "An understanding of competitiveness in the communications equipment industry and policy direction,"[169] "South Korea has succeeded in being the fastest in the world to commercialize 5G, but its competitiveness in core technologies and goods and its supply of materials and components is unstable, so its competitiveness is low compared to the US, China, and Europe; currently, with the exception of some companies that stand out in international competition, there is little to no progress among SMEs, and there are few talents and companies with high levels of expertise. Countries around the world have already gone beyond 5G and are preparing for 6G. We should aim to strengthen our infrastructure rather than our speed, and go for stability in technological competitiveness and the supply of parts."

In the case of AI, concerning ethics issues have come to the fore. In December 2020, South Korea launched is first AI chatbot, Lee Luda.[170] This AI, which was capable of conversation, was developed by South Korea's ScatterLab Pingpong Team, and its smooth communication, as if talking to a real person, created a stir; it quickly became popular among people in their teens and twenties. However, the service was cancelled after just one month. The case was trouble due to the following ethical problems.

- When asked what she thought about sexual minorities and people with disabilities, Lee Luda responded with dislike and aversion, raising the issue of discrimination against minorities.
- The AI gave many answers counter to common sense, leading to criticism. E.g., when asked her opinion of Hitler, she said he was interesting.
- There was the frequent problem of users constantly sending sexual expressions and messages to Lee Luda.
- When asked about the learning data collected, in an interview the developer answered that they had collected data from conversations on KakaoTalk, a paid service, triggering a debate over whether this was a violation of personal information. In contrast to the response of the developer, who said that they had used the information gathered with appropriate filtering, there were actually cases in which if a specific keyword was entered, the person's real name and address would be displayed in the chat; the situation escalated into a lawsuit, and the company in

168 See joint release by relevant ministries, etc., "The outcomes of the Fourth Industrial Revolution and future challenges," (March 2022), p7.

169 See Korea Institute for Industrial Economics and Trade, "An understanding of competitiveness in the communications infrastructure industry and policy direction"(June 2022), https://www.kiet.re.kr/research/economyDetailView?detail_no=2700.

170 For information about Lee Luda, see https://namu.wiki/w/%EC%9D%B4%EB%A3%A8%EB%8B%A4(%EC%9D%B8%EA%B3%B5%EC%A7%80%EB%8A%A5)#s-1.

question ended up paying a fine of 103.3 million won for violating the Personal Business Act.[171]

Lee Luda's service was stopped for around a year, and then renewed; in March 2022, the service was relaunched as 2.0, but did not attract as much attention as in the past.

Thus, while the use of D.N.A. is advancing, this is accompanied by frequent social problems, so it is necessary to continue improving systems and infrastructure in general.

3.2.2 Evaluation of strategies for the development of new industries centered on the Big 3

(1) Outcomes left by strategies for the development of the Big 3 industries[172]

The ongoing investment in the Big 3 industries has led to considerable improvement in the competitiveness of these industries. In particular, the fact that they achieved visible results in the environment of the COVID-19 pandemic is very highly praised.

First, the **Big 3's exports** have increased year on year since 2019,[173] and **reached a new high of 63 billion dollars in 2021**.

In future automobiles, electric vehicles and hydrogen vehicles had become popularized by the end of 2021, reaching a cumulative total of 250,000 vehicles, with fast charging spots in over 165,000 locations. At the end of 2022, the Hyundai Motor Company is expected to be the second in the world after Germany to commercialize level three autonomous driving.[174] It held the **highest share of the global market for hydrogen vehicles in 2021** (53.5%).[175] In 2021, electric vehicle and hydrogen vehicle exports were 6.9 billion dollars[176] and secondary battery exports were 8.7 billion dollars,[177] both of which were historic highs.

In the case of system semiconductors, exports in 2021 were around 40 billion dollars, the best-ever result. The country had also significantly strengthened its competitiveness in the foundry area, with the **world's second-highest market share in foundries and the highest share in memory semiconductors**. The government has further increased investment in domestic semiconductor companies, with an expectation of investing 510 trillion won over the 10 years from 2021, and its investment in 2021 reached 5.16 billion won.

The bio-health field has also produced many results; first, **it set a historic record with authorizations for five items for new, domestically developed drugs in 2021**. Moreover, there was visible progress in the development of domestically made COVID-19 vaccines. **Export contracts for drug development and bio-machines broke records**

171 The investigative process confirmed that 600,000 people's KakaoTalks had been collected without permission.

172 For the performance of the Big 3 industries, see the policy briefing Innovative Growth Big 3 Promotion Conference, (April 2022), https://www.korea.kr/news/pressReleaseView.do?newsId=156505620.

173 37.9 billion dollars in 2019, 48.8 billion dollars in 2020.

174 ZDNET KOREA, "Hyundai Motor Company to achieve level three automobile commercialization at the end of this fiscal year, second in the world" (September 2022) https://zdnet.co.kr/view/?no=20220915164909.

175 The Hyundai Motor Company's global market share in hydrogen vehicles was 45.3% in 2019, 69% in 2020, and 53.5% in 2021.

176 3.3 billion dollars in 2019, 4.6 billion dollars in 2020.

177 7.4 billion dollars in 2019, 7.5 billion dollars in 2020.

at 13.3720 trillion won,[178] and outsourced production ordered by other countries and technology transfers from other countries to South Korea also increased[179] in this field. On top of this, venture capital from the bio/medical field in 2021 grew by more than 480 billion won compared to the previous year, making up 21.9% of all venture capital. From 2015 to 2020, there was an average of 410 new ventures in this field, an increase of a factor of 1.3 when compared to the average of 321 ventures from 2010 to 2015.[180]

(2) Challenges remaining in the development of new industries

South Korea certainly produced results with its strategies to foster the Big 3 industries, but these industries are hot areas that are the focus of the US, Japan, and Europe, as well as South Korea. Notably, recent trends have been for each country to strengthen supply networks, mainly domestically, and to provide focused support for their own industries. So-called self-centered policies are being actively developed.

In the semiconductor field, competition between Samsung Electronics, INTEL, and TSMC is expected to become fiercer; for South Korea to win this global competition, it must proactively handle the above.[181] Hong Nam-ki, Minister of Economy and Finance, stated, "Development support accounts for 50.1% of the 463 R&D projects in the Big 3 areas, but breaking down regulations accounts for just 12.5% overall, so encouraging and stimulating private-sector investment remains an issue. Actual sites point out that there is still a lack of talent and many inconsistent regulations, and this must be tackled quickly."[182] To paraphrase, these industries are limited with only government schemes, and active movement and investment from the private sector would influence their victory, but in South Korea, the private sector is still reliant on a few large companies such as Samsung Electronics.

Now, what overall challenges remain in new industries?

As is widely known, when it comes to new industries, an essential topic is the platform companies that represent the digital industry.

In South Korea, the market capitalization of the Kakao Group, which became well-known through KakaoTalk is the fifth largest at 116 trillion won (as of 2021), after Samsung Electronics, SK, LG, and Hyundai Motors. The first to fourth-largest companies are chaebol businesses with long histories, but the Kakao Group is a new company founded just over 12 years ago. Between January 2021 and January 2022, the top three companies by increasing market capitalization in South Korea were the Kakao Group, NAVER, and HYBE, and all of these are platform companies.[183] In fact, it is no exaggeration to say that platform companies are a valuable presence that drives the Korean economy. The South Korean government has also asserted the position of supporting the growth of new industries and platform

178 5.3706 trillion won in 2018, 8.5165 trillion won in 2019, 10.1488 trillion won in 2020, 13.3720 won in 2021.

179 AstraZeneca, Novavax, Moderna, Sputnik V, ZyCoV-D etc.

180 See Korea Research Institute of Bioscience and Biotechnology, STEPI, National Biotech Policy Research Center, "Bio SME and venture company statistics 2020" (December 2022), https://www.bioin.or.kr/board.do?num=318886&cmd=view&bid=data_stat&cPage=1&cate1=all&cate2=all2&s_str=.

181 See Financial Newspaper, "Hong Nam-ki: Big 3 performance made visible, private investment expected to go ahead" (February 2022), http://www.efnews.co.kr/news/articleView.html?idxno=94463.

182 See Yonhap INFOMAX, "Hong Nam-ki: Visualization of Big 3 support outcomes, inducing private investment is an issue," (September 2021), https://news.einfomax.co.kr/news/articleView.html?idxno=4168485.

183 See SPAP, "The light and dark of platform companies, seen from KakaoTalk's communication failure: the South Korean government's response?" (November 2022), https://spap.jst.go.jp/korea/experience/2022/topic_ek_15.html.

companies, but has not been able to properly handle the shock to existing industries caused by the appearance of new industries. Here, this paper will introduce several examples.

・The problem of conflicts between old and new industries:

A representative example of trouble that occurred during the paradigm shift in existing industries brought on by the digital industry was an app to call a taxi. TADA,[184] a platform company offering ride-sharing services, was founded in South Korea in 2018. It is similar to taxi services that can be called via an app, but more accurately, it rented 11-person vans from the new company SOCAR and offered these with a driver, so legally it was a rental car company rather than a taxi company (Article 34 of the old Passenger Vehicle Transport Business Act).

Its fees were set slightly higher than regular taxis, but a vehicle could be dispatched straightaway with a single app, they did not forbid anyone from riding, and drivers were not allowed to chat with customers, all of which differentiated it from existing taxi services, and within a year of its founding the service spread so quickly that it exceeded 1.25 million users. However, in the existing taxi business, there were claims that TADA had abused the Passenger Vehicle Transport Business Act, and there was a lawsuit. To summarize the claim, to run a passenger vehicle transport vehicle business, people need permission from the Minister of Land, Infrastructure and Transport, and in addition, using rental cars to operate the business was a legal violation. However, if the person is using a van that can carry between 11 and 15 people, it falls outside of the Act. TADA cleverly made use of this exception. The company had also obtained permission from the Ministry of Land, Infrastructure and Transport and the city of Seoul. Regardless, the resistance of the taxi world was more intense than expected; there were demonstrations that lasted for days and mass rallies, and even instances of suicide, so with the situation deteriorating the government revised the law in December 2019. The revised act is also known as the "Anti-TADA Act," and limits the use of vans for 11 to 15 people for sightseeing purposes only.

・The problem of inconsistencies in professional employment fields: In South Korea, new types of platform services started to be provided in fields of "professional employment," such as the law, medicine, and taxation. LAWTALK[185] is a platform company that provides online consultation services by lawyers, and became popular because information such as the expertise of the lawyers, the lawyers' fees, and cases they had solved was all publicly available. However, the Korea Bar Association was against online law offices, and in May 2021, they added a clause in their code of ethics for lawyers which forbade lawyers from joining LAWTALK. On LAWTALK's part, they claimed that they only connected lawyers to clients, and were not involved in any way in setting lawyers' fees, demanded the removal of the clause, and started a constitutional complaint;[186] the conclusion has yet to be decided.

Moreover, a platform called Gangnam Unni, which had also expanded into Japan, allowed users to check and post hospital information relating to plastic surgery and medical treatments, events (campaign information), comments, and

[184] For the example of TADA, see Woman Chosun, "TADA illegal? What is the focus of discussions?" (November 2019), http://woman.chosun.com/news/articleView.html?idxno=62469; Yonhap News, "New stage: law against TADA," (December 2019), https://www.yna.co.kr/view/AKR20191205099051003; "NAMUWIKI: TADA," https://namu.wiki/w/%ED%83%80%EB%8B%A4(%EC%84%9C%EB%B9%84%EC%8A%A4)#s-6.1.

[185] For information about LAWTALK, see "NAMUWIKI: LAWTALK" https://namu.wiki/w/%EB%A1%9C%ED%86%A1(%EC%84%9C%EB%B9%84%EC%8A%A4) .

[186] A constitutional complaint is carried out by someone whose basic rights as guaranteed by the constitution have been violated through the use or non-use of public power. This system allows them to directly request a review of the unconstitutionality of the use or non-use of public power in a constitutional court, and gain relief for their basic rights. (Constitutional Court Act, Chapter IV, Section 5)

more. In other words, its role was to be an "intermediary" between consumers and plastic surgery hospitals. However, it came to light that a representative from the company fraudulently received commissions from certain hospitals (a total of 176 million won) and sold coupons, etc., so they were sentenced to eight months' imprisonment and two years suspended sentence.[187]

・**The problem of platform company monopolies:** The Kakao Group has grown so big that it is referred to as the Kakao Empire, with just over 100 subsidiary companies and influence so great that it has connections to all services. In October 2022, a fire broke out in the Kakao Group's data center, and a series of Kakao services stopped for at least 15 hours, having a significant effect on the daily lives of service users.[188] This is said to be the harmful consequence of the platform company monopoly in South Korea. In addition, it frequently takes action to eliminate the platforms of rival companies, freezes prices between companies to dominate the market, and meddles with product and information algorithms.

Thus, there are many cases in which the growth of new industries is in conflict with the profits of existing industries, so the country needs to explore ways for both to coexist. If the government seriously wants to support the development of new industries, it must handle the clashes between the old and the new in a timely and appropriate manner. Its regulations for TADA can clearly be said to be inappropriate. TADA had never broken any existing laws, but the government was aware of public opinion and revised the law in a way that was disadvantageous to TADA, causing it enormous harm. Moreover, if a certain company grows so big that it can impede the expansion of other companies, the government should enact measures in advance to counter adverse effects and find ways to respond. The Kakao Group's fire incident led the South Korean government to consider regulations for platform companies for the first time, but it has to be said that this was clearly a late response.

3.2.3 Evaluations of policies to support SMEs, venture companies and startups

(1) Outcomes of policies to support SMEs, venture companies and startups

Thanks to considerable support for SMEs and venture companies, the "second venture boom" has arrived in South Korea.

The first venture boom took place from the late 1990s to the early 2000s, and mainly focused on dot com companies with the development of IT; the second boom came around 20 years later. With the shift in government focus from large companies to policies for economic growth so that SMEs and venture companies could lead innovation, this boom could be the result of extraordinary support for venture companies and startups.

187 See Doctors Times, "Gangnam Unni representative, eight months imprisonment, two-year suspended sentence" (January 2022), http://www.doctorstimes.com/news/articleView.html?idxno=217627.

188 See Financial News, "Kakao stopped by fire, a complete halt on regular days and weekends," (October 2022), https://www.fnnews.com/news/202210161834574640.

Table 2-23: Comparison of venture booms

	First venture boom	Second venture boom
Business model	Mainly ventures in software and IT industries*, especially dot-com companies. *The percentage of SW and IT industry companies went from 30% in 2000 to 20% in 2020.	The venture boom occurred in diverse fields such as bioscience, medicine, and distribution*. *The percentage of companies in these three fields went from 19% in 2007 to 45% in 2020.
Venture investment	Mainly direct investment (59%) The average investment per venture company in 2000 was 1.06 billion won Investors had little experience or knowhow	Indirect investment through fund-of-funds (direct investment = 2%); average investment per venture company in 2020 was 2.02 billion won Many skilled venture capitalists
Venture entrepreneurs	Many people from the IT affiliate companies of large companies inspired by the introduction of the Internet	Diversified, centered on people in existing venture companies
Foundational infrastructure	Innovation accelerating centers	More diverse, specialist, and larger facilities promoting business creation Also an increased tendency for planning companies that specialize in business creation
Globalization	Mainly encouragement for domestic investment	Global expansion, such as encouragement for foreign investment and unicorn companies

Source: Naver Encyclopedia of Knowledge "Strategies by keyword: Second venture boom"[189]

Before moving onto the details, below is a simple summary of the outcomes of SMEs and venture companies in list form.

- **Venture investment reached a historic high (7.6802 trillion won in 2021)**
- **The number of unicorn companies increased to 23 companies**
- **Competitiveness of companies that introduced smart factories increased significantly**
- **To compensate for the disadvantages in the name recognition of SMEs and to increase their competitiveness, the public-private sector launched Brand K, a national shared brand**
- **Designation of South Korea's first regulation-free special zones**
- **Stimulation of online and smart stores**
- **Creation of welfare platform for SMEs**
- **Launch of a committee for mutually beneficial cooperation and coordination to prevent SMEs being harmed by technology plagiarism or unfair business practices**

189 https://terms.naver.com/entry.naver?docId=6597756&cid=69317&categoryId=69317

In terms of the outcomes of support policies, first, **the amount of venture investment more than tripled in four years, going from 2.7793 trillion won in 2017 to 7.6802 trillion won in 2021**. To further encourage venture investment, the government kept up its unceasing efforts, formulating the "Venture Investment Promotion Act" in August 2020. The number of venture investments, the amount of investment given each time, and the number of companies receiving investment all reached record highs, with 2,483 companies receiving an average of 3.15 billion won of investment in, on average, two or three parts.[190]

The number of unicorn companies also continued to show a trend of vigorous increase. In April 2017, there were **only three unicorn companies, whereas at the end of June 2022 (first half-year) this had risen to 23**. The Ministry of SMEs and Startups made a statement saying, "In 2021, seven companies were selected as new unicorn companies, and in the first half of 2022 a further five new companies were added. Although companies are in a difficult position due to rising interest rates and other factors, to achieve even these outcomes is extremely praiseworthy. Notably, in the KOSDAQ market during the same period, companies with a market capitalization value of 1 trillion won or more dropped from 71 at the end of last year to 36 this year; when compared to this, I believe we have made great strides toward becoming a venture power."[191]

Companies that had introduced smart factories increased productivity by 30% on average, and gained at least three employees. On top of this, their cost prices (costs) were reduced by 15.9% and defective products by 43.5%.[192] In September 2019, the government launched Brand K, a national shared brand in the public and private sectors, to support the overseas expansion of SMEs with undervalued name recognition whose brand power was low compared to their technological capabilities and product quality. A total of 133 products (39 in 2019 and 94 in 2020) expanded overseas as Brand K via foreign online shopping malls, Korean halls, export consultation meetings, and Korean wave sales events. In 2020, companies that introduced smart factories and companies that used Brand K increased their sales by 30.7% compared to the previous year, regardless of the COVID-19 pandemic. South Korea expects to continue focusing on advertising via specialty Korean wave content and flagship stores.[193]

From 2018, as part of the program to support SMEs, South Korea has designated and developed companies with potential and innovation as **"Globally strong small businesses"**[194]**.** (Eligible companies have sales of more than 10 billion won but less than 100 billion won and exports of 5 million dollars or more.) Each year, 2,000 companies are designated, and these companies receive 200 million won of support for foreign marketing expenses over four years; as a result of stronger support through a government-local government-private cooperation system, **in FY2019 company average exports increased by 4.3%**.

190 See policy briefing, "Venture investment increased to 78%, 7.6802 trillion won, historic high," (January 2022), https://www.korea.kr/news/policyNewsView.do?newsId=148898565.

191 See policy briefing, "Unicorn companies with a corporate value of 1 trillion won or more reaches 23 companies, increase of five"(July 2022) https://www.korea.kr/news/policyNewsView.do?newsId=148903855.

192 See Ministry of SMEs and Startups, "Two and a half years of the Moon Jae-in administration, Ministry of SMEs and Startups 10 major outcomes," (November 2019), https://blog.naver.com/bizinfo1357/221702162612.

193 For details about Brand K, see Office for Government Policy Coordination "Four years of results from the Moon Jae-in government, achievements in promoting national policy issues," (May 2021), p236.

194 For details about globally strong small businesses, see Office for Government Policy Coordination, "Four years of results from the Moon Jae-in government, achievements in promoting national policy issues," (May 2021) p236.

Regulation-free special zones[195] were also newly introduced in 2019 to welcome the time of the Fourth Industrial Revolution. If an SME with new technology is struggling to commercialize due to regulations, it can verify its new technology and release its new products in the regulation-free special zone. This is also useful in stimulating local regions and developing regional economies and new industries.

[195] For details about regulation-free special zones, see policy briefing, "Regulation-free special zones," (December 2021), https://www.korea.kr/special/policyCurationView.do?newsId=148899705.

Feature: Cases of successful SME's and venture companies[196]

This feature introduces several cases of successful SMEs and venture companies that achieved innovation with government support.

(1) SME: Jeil Chemical Co., Ltd.

Founded in 1991, this company is a manufacturer of synthetic resins and plastics. It had 72 employees in 2020, and sales of 50.56 billion won.

Secrets to success: (1) The company continued R&D while experiencing several financial crises, including the IMF Crisis. It focused on producing epoxy resins for 27 years, and made it to number one in the world in the global and domestic markets for epoxy resin materials for PCB.

(2) It made good use of government support. The company received technology development support from the government from 2016 to 2018, and was able to apply this to the field of high-functioning composite materials.

(3) It pursued open innovation. Through co-work with others in the business, it aimed for integration with the chemicals industry, which opened access to information and technology. Government-industry-academia cooperation and multi-national corporation collaborations allowed it to increase its technological capabilities while carrying out joint research using diverse methods. It was also involved in joint research with a German company, and secured customers for its products.

(2) SME: IPITECH Co., Ltd.

This company was founded in 2015, and manufactures polymer films and thin-film coating films. At the end of 2020, it recorded sales of 1.3 billion won.

Secrets to success: (1) This is a representative example of a company with expertise and an abundant spirit of challenge. Its representative, Lee, was originally a polyimide researcher, meaning they had a wealth of expert knowledge, and after the company was founded, they developed original functional polyimide solutions and TPI coating films. The company succeeded in producing fluorinated polyimides in South Korea, when these had been under Japanese export control.

(2) The company is engaged in ongoing research that exceeds the status quo. After developing TPI coating films, it succeeded in developing films for 2-layer FCCL, said to have a higher degree of technological difficulty than films for 3-layer FCCL. As these are light, thin, and have a higher degree of integration than existing films, they are used for smart devices and printed circuit boards with various levels of viscosity.

[196] These success cases are taken from the Korea Small Business Institute, "Evaluation of SME policies and future challenges: R&D field," (August 2022), https://db.kosi.re.kr/kosbiDB/front/pdfViewer?path=MjEyNl8lRUMlQTQlOTElRUMlODYlOEMlRUElQjglQjAlRUMlOTclODUlMjAlRUMlQTAlOTUlRUMlQjElODUlRUQlOEYlODklRUElQjAlODAlRUMlOTklODAlMjAlRUQlOTYlQTUlRUQlOUIlODQlRUElQjMlQkMlRUMlQTAlOUNfUm5EJTIwJUVCJUI2JTg0JUVDJTk1JUJDJTIwKCVFQyU5RCVCNCVFQyVBMCU5NSVFQyU4NCVBRCkucGRm.

(3) Venture company: TOP & C Co., Ltd.

Established in 2014, this company manufactures cell pouches for secondary batteries and had five employees. It succeeded in manufacturing aluminum pouch film domestically, when this had been a Japanese monopoly.

Secrets to success: (1) The company persistently focused on research. As part of government-industry-academia joint research, it focused on product development, but coating four membranes with microunits isn't straightforward, and the research took six years. But the company did not give up, and its repeated trial and error allowed it to produce research outcomes that others could not.

(2) The company was victorious with its highly innovative products. In 2020, TOP & C was selected as one of the Startup 100, and received support from the government for R&D and commercialization. Its product was the same thickness as Japanese DNP films (153㎛), and excelled in performance, including electrolyte resistance, thermal bonding level, and formability. It produced less than 5% defective products when compared to products from existing facilities, and above all it doubled productivity at one fifth of the cost, creating a product with strong competitiveness.

(4) Venture company: INNOTIONTECH Co., Ltd.

This company was founded in 2019 and had 25 employees; it is engaged in plasma coating and metal surface processing. In 2020, it recorded sales of 241.72 million won, and was selected as one of the "Startup 100."

Secrets to success: (1) The company gained an accurate understanding of client companies' needs. In other words, it accepted regular mentoring and technological guidance as to the needs of the large companies that are its clients, carried out detailed assessments of samples needed by customers, responded rapidly, and focused on becoming number one in sales in the bio/make-up field. In particular, providing the coating technology for the plastic packing materials needed by the major company AMORE PACIFIC led it to success.

(2) The company focused on improving the quality of its products on a day-to-day basis. It added functional nano-thin film materials to its existing mold, and greatly improved performance. As well as improving quality, this increased the period of use, leading to reduced costs, which was the key to popularity.

If one looks at cases of success other than these companies, they have the following points in common. (1) They worked on research and technology development on a day-to-day basis, (2) they had an accurate understanding of contemporary demand and customer demand, (3) they made use of government support, and (4) they had excellent leaders and talents with expertise and passion.

(2) Challenges remaining in policies to develop SMEs[197]

While the policies to support SMEs and venture companies led by the Moon administration have often been evaluated positively overall, many people have pointed out that the government generally focused on establishment (company founding), and was insufficient in areas such as the development of core technologies and talent. To summarize, based on past trends, if government policy support is strengthened and investment increased, the number of companies established will rise proportionally, but to maintain stable growth without major changes in government policy, it is necessary to start strengthening from the development of core technologies and talent.

Moreover, in many cases support for SMEs and venture companies was short-term, for one to three years, so people said they could not achieve ongoing development or continuing innovation. At the very least, support for companies that deal with technologies that count as new challenges and innovation should last for longer periods of time.

Moreover, some people feel that splitting this based on the type of technology (leading innovation technologies, catchup technologies, growth improvement technologies, and regeneration and conversion technologies) and developing support policies that suit each of these would be more effective and lead to the expected results.

The necessity of prioritizing stronger regional collaborations rather than increasing amounts of support and widening the scale of support has also been pointed out. 80% of existing venture investment is concentrated in metropolitan areas, so funding support for regional companies is scarce. People have voiced the opinion that strengthening collaboration and cooperation centered on players such as venture companies at the heart of each region and inventors, entrepreneurs, and investors before their companies are established should be systematically prioritized.

Moreover, when it comes to the pattern of company foundation in South Korea, the main method is to use business models that have been successful in advanced countries as benchmarks, meaning innovation and globalism is low. The ratio of foreign customers is around 14%, lower than the word average of 23%. Given the characteristics of South Korea, relying only on domestic demand will limit economic growth, so expanding overseas is an inevitable choice, and to accomplish this a qualitative increase in the levels of R&D, infrastructure, investment, and talent is required.

3.2.4 Evaluation of strategies to strengthen basic research and foster talent

(1) Outcomes from strategies to strengthen basic research and foster talent[198]

The strengthening of South Korea's basic research was also introduced in the Nature Index South Korea special feature in May 2020,[199] which acknowledged its efforts and the improvement of its research levels. The year-on-year increase in financial support from the government for basic research, as well as the ongoing investment, are highly

[197] Regarding this challenge, see Korea Small Business Institute, "Evaluation of SME policies and future challenges: R&D field," (August 2022); Korea Small Business Institute, "Evaluation of SME policies and future challenges: Founding ventures field," (December 2021); Korea Small Business Institute, "Evaluation of SME policies and future challenges: regulations and policies field" (December 2021). The three documents can be found via the link below:
https://eiec.kdi.re.kr/search/search.do?kwd=%EC%A4%91%EC%86%8C%EA%B8%B0%EC%97%85%20%EC%A0%95%EC%B1%85%ED%8F%89%EA%B0%80%EC%99%80%20%ED%96%A5%ED%9B%84%20%EA%B3%BC%EC%A0%9C&category=TOTAL&srchFd=&logicOp=undefined&date=1&startDate=&endDate=&curPage=webcontent&pageSize=20&sort=r&pageNum=1

[198] For information about these outcomes, see Office for Government Policy Coordination, "Four years of results from the Moon Jae-in government, achievements in promoting national policy issues," (May 2021), p212–217.

[199] https://www.nature.com/collections/aeigjdecdj?utm_source=internal&utm_medium=referral&utm_campaign=nindx-AS_JP_Korea2020&utm_content=NatureIndex_NatureKorea

rated. However, more praiseworthy than the increased money was the fact the government listened to people on the ground and researchers. Researchers wanted to be able to take the initiative with regard to research expenses, research topics, and research periods, and hoped for an environment in which they could concentrate solely on their research, and the government enacted measures in response to this.

First, the South Korean government started running the KIURI program to support postdoctoral researchers in 2020 and the Sejong Science Fellowship program in 2021 so that young researchers could continue their research with peace of mind, and many young researchers have received ongoing support. It also gives support so that young researchers who had just started their research careers can establish themselves as researchers, including support for first research projects and first innovation laboratories.

For graduate students, it introduced the stipend system that offers support for living expenses for both master's and doctoral students. Many other countries provide support for doctoral researchers, but very few countries give financial support to master's students each month to secure their basic living, and this shows South Korea's commitment to fostering researchers.

Among young full-time faculty members (science and technology), the percentage of people responsible for basic research R&D projects increased from 41.4% in 2016 to 78.4% in 2020. The fact that the government raised the number of projects, as well as focused on maintaining environments and implementing dedicated projects where female researchers who had given birth and were raising children could return to work without interrupting their careers is thought to have contributed greatly to this rate of increase.

The "Science and Technology ICT Talent Nurture Plan in Response to the Fourth Industrial Revolution" published in 2018 aimed to reach targets of fostering 90,000 people by 2022, and in 2020 had already fostered 64,000 people. Moreover, 772 graduates from science and technology master's and doctoral courses who were finding it hard to find employment were able to participate in training and R&D projects in companies, with 353 people with doctorates receiving the opportunity to train at government-funded research institutes. A total of 1,698 people were able to find employment through matching researchers and engineers to companies via government-led job fairs (data from the end of 2020).

On top of this, for companies, securing research talent, one of the important constituents of research that contributes to R&D, is key to securing their competitiveness. However, many companies hesitated to actively work on this due to the burden of HR expenses, etc. In recent years, the government has strengthened support for this, shouldering part of the burden of HR expenses and offering tax deductions for costs associated with R&D; this has had a positive effect on companies fostering researchers, and increased the number of doctoral talents obtaining employment with companies.

(2) Challenges remaining in basic research and fostering talent

On the other hand, looking at funding projects for researcher-led basic research from 2017 to 2021, 26,291 projects failed to produce results, and the financial cost of this was 1.8 trillion won. Here, "no results" means projects that did not produce any SCI papers or patents. However, there are concerns that these projects without results were not

properly managed or followed-up, or the research expenses were wasted.[200]

KISTEP's report, "Proposal for the direction of support programs for researcher-led basic research,"[201] expressed doubt as to whether the quantitative increase of support funds should be handled as an indicator of the increased strength of basic research in the first place. In other words, with the change in administration, the support funds for basic research themselves had grown, but the opinion was that the quality of basic research had not changed significantly. Previously (around 20 years ago), investment in basic research was considerably less, so quantitative increases were necessary, but now it is conceivable that the greater need is to find ways of using support funds more effectively and accurately and policies that reflect researcher needs more thoroughly.

Furthermore, people also call for measures to ensure that when each ministry develops support programs for basic research, they share and exchange investment plans and strategies for support, reduce overlapping programs, and support basic researchers in as many areas and fields as possible. As long as the compartmentalized bureaucracy continues, it is likely that improvement will be difficult in the short term, but currently, each ministry only reveals its overall aims and is unable to share the specific details of its targets, scope, and direction, so it is sometimes impossible for researchers to grasp the intent of programs or the direction for which they are aiming. In addition, a lot of support systems for basic research are separated by academic field, so there are researchers that cannot receive appropriate support due to the problem of their category among these systems; these people must also be considered.[202]

With regard to fostering talent, the author is concerned that South Korea is becoming an unbalanced society, with overwhelmingly more science and technology talents. With its policies to foster research talent and technology talent in the era of the Fourth Industrial Revolution, the university entrance examination system has been revised (in a direction favorable for science and technology[203]), and South Korea is becoming a society in which an overwhelming majority of people go on to study science and technology. In universities, the focus is on fostering practical talents who can become immediate assets in real life, and there are now many curriculums linked to employment, including the contract courses. It is thought that with this, technology talents and science and technology talents in new industries will certainly increase, but "university" is coming to mean a place that fosters expert talents who are only concerned with employment (becoming specialist schools), so there is the strong impression that students are placing less emphasis on their knowledge of the humanities and the basic education that they should have. This may be useful as a way of solving a temporary shortage of talent, but over a longer span of time, a society that focuses only on science and technology will no doubt become unbalanced, and there is a danger that it will fade into an environment

200 See Yonhap News, "Large increase in basic research support projects with no results, management needed," (September 2022) https://www.yna.co.kr/view/AKR20220923105100017.

201 KISTEP, "Proposal for the direction of support programs for researcher-led basic research," (October 2021), full text: https://www.kistep.re.kr/flexer/view.jsp?FileDir=/board/0031&SystemFileName=202105271259343341.pdf&ftype=pdf&FileName=202105271259343341.pdf

202 For the details of this paragraph, see KISTEP's "Proposal for the direction of support programs for researcher-led basic research," (October 2021), p21–21.

203 South Korea stopped dividing between the humanities and sciences in high schools in 2018 and now carries out integrated education; with this, the university entrance examinations made math a required subject in 2022. Entrants can choose (1) calculus and geometry, or (2) statistics and probability, but students who want to enter science and technology tracks must select (1). Thus, in fact, the implicit rule is that (1) is for science and technology subjects, and (2) is for the humanities. To paraphrase, people who chose (1) can select either science and technology subjects or humanities, so even if they fail at getting into a chosen science and technology subject they can still apply for a humanity, but (2) means they can only choose humanities, so more than 80% of applicants select (1). It must be said that this is an absolutely beneficial system for science and technology. See "NAMUWIKI: University entrance examinations" https://namu.wiki/w/%EB%8C%80%ED%95%99%EC%88%98%ED%95%99%EB%8A%A5%EB%A0%A5%EC%8B%9C%ED%97%98/%EB%AC%B8%EC%A0%9C%EC%A0%90%20%EB%B0%8F%20%ED%95%B4%EA%B2%B0%20%EB%B0%A9%EC%95%88#s-2.

in which it is hard to foster talents with individuality or diversity, so it is thought that appropriate policy adjustments are needed.

To conclude, this chapter has analyzed outcomes based on various strategies, and the challenges remaining for the future of science and technology in South Korea.

Now, how will the new administration face these challenges?

The following chapter, Chapter 4, focuses on introducing the new administration's national policy issues in science and technology.

4 Prospects for Science and Technology in South Korea

The South Korean administration changed in May 2022, with Yoon Suk Yeol becoming the new president. In contrast to the Moon Jae-in administration, what science and technology policies will the conservative Yoon administration keep in mind, and what is its science and technology vision? Here, this chapter will add some commentary focused on the national policy issues in science and technology faced by the new administration.

4.1 The main policies of the new administration

4.1.1 National policy issues in science and technology for the new administration

The Yoon administration published 120 national policy issues in July, together with its vision of "The Republic of Korea again achieves major progress as a country of the people where everyone lives well together." There are seven policy issues relating to science and technology, which come under the larger target of "creating infrastructure for progress that can take the lead with science and technology."

(1) Redesigning a science and technology system for national innovation

Target: To promote the redesign of the national science and technology system for an era of 100 trillion won of national R&D, to emerge as a scientific and technological power with the joint power of the government and the people.

Author's comment: This 100 trillion won matches the R&D expenses in the public and private sectors. In 2020, the private sector recorded 71 trillion won and the government spent 22 trillion won, giving a total of 93 trillion won. The private sector statistics for 2021 are still incomplete so an accurate total cannot be given, but based on the rate of R&D growth among private companies (7.5% from 2011 to 2015, 8% from 2016 to 2020) and the government's investment in R&D (27.4 trillion won in 2021 and 29.8 trillion won in 2022), one can estimate that the total is close to exceeding 100 trillion won. R&D investment, which started with 1.2 billion won in 1963, has grown to 100 trillion won in around 50 years. Thus, South Korea is the fifth country in the world to enter the "R&D 100 trillion won club," following the US, China, India, and Japan. It started its R&D investment later than advanced countries, but public-private cooperation has closed the technological gap in a short space of time, the country has secured world-class technological capabilities in industries such as electronics, semiconductors, steel, and shipbuilding, and its ICT infrastructure has reached number one in the world.

Main details:

(Strengthening the role of science and technology) The country will shift to a science and technology policy that will make it possible for South Korea to become an economic power and a country with strong security and happiness through innovation in science and technology infrastructure.

- To solve the issues faced by the country, such as carbon neutrality and an aging society, the government will create a science and technology system that clarifies tasks and strengthen government-industry-academia collaboration by shifting toward leadership by the private sector and regional areas.
- It will reorganize the Presidential Advisory Council on Science & Technology (PACST) and strengthen civilian participation and cooperation and coordination between departments, etc.

(Aiming for qualitative growth in R&D) The country will maintain the level of the R&D budget as 5% of government spending, and create a medium to long-term investment strategy and a strategic R&D budget distribution and coordination system.

- The government will promote preliminarily feasibility studies that can respond flexibly to technological and environmental change, implementing preliminarily feasibility studies only for R&D projects that are 100 billion won or more. It will improve evaluation systems to create outcomes with high levels of utility, and create a support system that can make use of outcomes.

(Strengthening the science and technology level in the private sector) The country will strengthen support for private-sector R&D by further expanding tax incentives, and identify potential problems as quickly as possible through assessments of the effects of technology.

- The government will devise R&D support that is suited to different innovation capacities and types in companies, to maximize the vitality of private-sector growth.

(Research support) The country will create a national research data platform, support the shift to digital technology in universities and research organizations, and develop digital research environments to enable researchers to create innovative outcomes with high levels of originality.

- The government will strengthen support for researchers by developing research administrative systems, improving systems associated with research administration, and increasing the rights of researchers. Promoting international joint research and joint use of facilities will stimulate joint research.

Anticipated result: Recreating the science and technology system will help realize the goal of becoming one of the five great science and technology powers, develop the economy, and contribute to strong security and to the happiness of the people.

(2) Becoming one of the five great science and technology powers through core technology that overwhelms other countries

Target: To strengthen core technologies that are vital to the national interest and security in order to win in global competition in an era of technological hegemony, and to combine the abilities of the nation to grow as a power.

Author's comment: South Korea's goal of being one of the five great science and technology powers refers to becoming a science and technology power on par with the US, the EU, China, and Japan. South Korea has caught up to the advanced nations over many years, and accomplished economic and technological development. The way it has caught up has certain merits, such as reducing the risk of pioneering new markets and being able to utilize infrastructure created by advanced countries, but in the era of the Fourth Industrial Revolution, South Korea must secure core technologies for new industries, and it is clear that the catch-up method will not generate innovation. Until now, the market share of the country's so-called main industries— automobiles, steel, and ships—has continued to fall, but emphasizing increasing investment in core technologies and securing core technologies even more that it has

in the past lies behind this situation.

Main details:

(Increasing investment in core technologies) The country will designate semiconductors, displays, secondary batteries, next-generation nuclear energy, hydrogen, 5G/6G, biotechnologies, space, mobility, quantum, AI, robots, and cyber security as maximum priority core technologies for economic growth and national safety, aiming to secure technologies that other countries cannot catch up to.

- The government will start a private sector joint council that crosses departments, establish a strategic roadmap, expand R&D investment to secure core technologies, and create a foundation for core technology through medium and long-term R&D programs.
- It will create a technological and industrial foundation to foster digital biotechnologies that can respond to the shift to biomass, etc. and so the country can grow into a power in quantum technology.

(Establishing a special act) The country will establish the "Special Act for the Nurturing of National Core Technologies" needed to create a command center to develop core technologies, ensure priority investment in R&D, foster talent, and for systems for domestic and international cooperation.

(R&D projects) It will plan and promote R&D projects according to the capabilities of each department, especially technology development projects that encourage private-sector investment and are able to produce visible outcomes. The country will carry out plans and management centered on private-sector experts and concentrate the creation of practical outcomes through government-industry-academia partnerships.

- The government will designate universities and research organizations as core research hubs and stimulate government-industry-academia joint research.

(Widening the scale of technology) The country will increase support for scaling-up programs and funding that can commercialize research outcomes from universities and research organizations, and strengthen one-stop support systems leading to business creation from laboratories.

(Developing infrastructure) South Korea will create science and technology infrastructure such as 5G, 6G, quantum cryptography communications networks, KPS, supercomputers, etc., to promote the growth and integration of innovative technologies and industries.

(Strengthening international cooperation) The country will strengthen technology cooperation with advanced countries, especially Europe and the US, encourage joint research and excellent talents, and promote infrastructure sharing in global projects. Precedents for reference: Joint (quantum) technology research center established jointly by the US and the EU, the newly established Asia-Pacific Infectious Disease Shield (APIS).

Anticipated results: The systematic development of innovative technology is expected to enable the country's growth as one of the five great science and technology powers that lead the technology hegemony.

(3) Supporting basic research with autonomy and originality and striving to foster talents.

Target: Expanding researcher-led challenging R&D with originality and creating a foundation.

Strengthening the role of universities as hubs for fostering research talents and science and technology research and supporting science and technology talent in categories of young people, women, and middle-aged and senior people.

Author's comment: South Korea has the most researchers relative to its population. It strives to foster talent in the

field of science and technology in particular, formulating a Basic Plan for Nurturing and Supporting Scientific Talents once every five years. Investment in basic research started in the 1990s, and where it had a delayed start, the results were small compared to the investment. However, the government has increased its investment in basic research year on year, investing 2.03 trillion won in 2020 and 2.35 trillion won in 2021 in basic research that is highly original and challenging. As a percentage of GDP, South Korea's basic research is 0.68%; this surpasses 0.5% in the US and 0.4% in Japan (2019). With regard to the small size of the results when compared to the investment, the opinions given include that it is difficult for young people or non-full time staff to take charge of an R&D project, that mainstay researchers who take on practical leadership roles in real life are not treated appropriately, that ultimately easily evaluated projects are taken on. It is thought that this is a time when, rather than increasing investment, the government should focus on where and how to invest. There is a visible awareness of these problems when it comes this national policy issue.

Main details:

(Basic research that is highly challenging and original) The country will create basic research environments based on the principle of "support but no interference."

- The government will increase investment in researcher-led basic research and mission-orientated basic research that reflects national demand, and strengthen system infrastructure for qualitative growth.
- It will increase investment for support programs according to the level of the researchers, from young researchers to top researchers who represent South Korea.

(Improving research capabilities in universities) The country will support universities as the foremost hubs for fostering basic research and S&T talents.

- The government will reorganize support systems, dividing university basic research programs by academic type, characteristics, integrated research, and other categories.
- It will strive to foster and secure science and technology talents in core technologies.

(Fostering talent across the full cycle) The country will systematically support S&T talents from youth to middle- and older-age.

- The government will increase scholarship systems and opportunities for research in South Korea and in other countries so that young people can concentrate solely on research, and widen and reorganize the S&T military service system (officers specializing in science and technology, expert research personnel).
- It will create support systems in accordance with the career histories of female researchers and their return to work, and nurture female researchers in new industries and new technologies.
- To give opportunities for middle-aged and senior researchers to find new jobs, the government will expand education to enable them to shift their work, and provide employment environments where excellent researchers can engage in research even after retirement age.

Anticipated results: The top researchers in basic research fields will double.

This will develop research talents in core technologies to the level of the G5 (the five advanced nations: US, the UK, France, Germany, Japan).

Author's comment: As is well known, there is obligatory military service in South Korea, and many people's studies and careers are affected by the blank during their time in the military. A system for officers specializing in science and technology would be a system that offers an alternative to military service for elite talents in science and technology

(undergraduates) who would carry out R&D for three years in the Agency for Defense Development. A system for expert research personnel would be a system that offers an alternative to military service wherein (1) people with master's degrees (designated subjects) work for three years in a specified place, (2) doctors of science and technology carry out research for three years, or (3) people with grade four in their examination for military service (supplementary role) obtain a degree in a science and technology subject and work for three years in a research laboratory affiliated with an SME. In any case, these systems have been considered to avoid a research or career blank for science technology talents.

(4) Becoming a country with a hegemony over the digital economy through public-private cooperation

Target: As the world competes over the digital shift and technological hegemony, the country is to combine public and private capabilities to strengthen technological infrastructure such as AI, data, and clouds, which are at the heart of digital innovation for the nation and society, and develop new industries such as the metaverse and digital platforms to grow into a country with a hegemony over the digital economy

Main details:

(A leading AI nation) The country will promote large-scale challenging AI R&D to secure the highest levels of AI technology, and promote programs to develop AI semiconductors that are the core of AI.

- South Korea will create computing infrastructure that supports the use of AI in universities and middle-income companies (a dedicated AI data center in Gwangju and next-generation supercomputer are to be introduced in 2023), and expand AI integration by completely adapting AI in all fields, including disaster education, education, and welfare.

(Integration of public and private data) It will establish a national data policy command center and open data needed by the private sector, transforming the country into a power in data innovation by creating industrial infrastructure that is easy for users to search and use.

(Development of clouds and SW) The country will make priority use of private-sector clouds and commercial SW to enable the growth of competitiveness in clouds and SW, which are the core infrastructure of AI and data; create an environment centered on Software as a Service (SaaS) and work to secure SW innovative technology.

(Securing new technologies that will break barriers) South Korea will lead a technological revolution through the promotion of public-private joint large-scale R&D projects in core fields to accumulate technology, a national strategic asset.

(Stimulating the metaverse economy) It will formulate a special act on the metaverse and identify metaverse services that will support everyday life and economic activities, which will stimulate the economy, and create trusted infrastructure through blockchain.

(Innovation and fair digital platforms) The country will promote innovation in and the growth of platforms, and establish a strategy and a private sector-led autonomous regulatory system to maximize the creation of social value.

Anticipated results: The country is expected to realize the following by 2027: to rank in the top three global AI nations (it ranked sixth in 2021), to more than double economic value in the data market (23 trillion won in 2021), to obtain a top five share of the global metaverse market (it ranked 12th in 2021), to secure digital technology capabilities at the world's highest level (in 2020 South Korea's level was equivalent to 88.6% of the countries with the highest

technological capabilities in the world, and it aims for the equivalent of 93% in 2027).

(5) Building a world-class network and accelerating digital innovation

Target: To strengthen 5G and 6G network infrastructure and improve network safety and the country's ability to handle cyber security, enabling the creation of safe and strong digital infrastructure.

To raise national digital competitiveness by accelerating digital integration and innovation by region and by industry.

Main details:

(Leading 5G and 6G) The country will spread 5G networks to areas across rural areas, so they cover areas with rural farming villages (by 2024), welcoming a true era of 5G by expanding differentiated 5G networks and integrated services.

- The government will strengthen next-generation technological innovation such as 6G and satellite communications, and industrial infrastructure, including developing companies and fostering talent.

(Strengthening national digital safety) South Korea will ensure the digital safety of the networks and SW that connect society and strengthen the safety of everyday life for citizens by digitalizing main safety management and making it intelligent.

(Strengthening cyber security) It will foster 100,000 cyber security talents by 2026, and support the growth of companies through the spread of security cluster model regional hubs.

(Stimulating digital certificates) The country will introduce new certification technology such as blockchain and biometrics, and improve systems that strengthen user convenience and support the creation of new markets.

(Digital innovation in industry and regional areas) It will create comprehensive support systems that will accelerate digital innovation all economic fields, and create digital innovation hubs that cross regions.

- The government will foster new digital industries (2023) by nurturing regional digital talents (ICT Innovation Square) and large-scale projects (100 major regional experience digital innovation projects, etc.).

(Popularization and accessibility of digital technology) South Korea will operate digital problem-solving centers that make it easy for people to become familiar with digital technology, create super high-speed networks in areas with rural farming villages, and further spread free WIFI.

It will provide necessary support for young people and seniors so they can reduce their digital usage costs.

Anticipated results: The country will aim to preempt 6G standards and develop core technologies (48 by 2026), and secure the initiative in future networks.

- Developing the security industry (aiming to go from 12.6 trillion won of sales in 2021 to 20 trillion won in 2027) will strengthen industrial competitiveness.
- This will develop regional digital innovation hubs and raise the digital levels of people without detailed knowledge of digital technology.

(6) Becoming a space power and raising the curtain on the Republic of Korea's space age

Target: To secure competitiveness in the space field, stimulate a human-centered space industry, and promote space development that will drive social and economic development.

- To improve space infrastructure and take on the challenge of becoming one of the seven major space powers

through systems and policies to support this.

Main details:

(Strengthening governance) The country will reorganize its governance with leadership and expertise in diverse fields, including R&D, national security, industrialization, and international cooperation, to become an advanced space nation.

- It will coordinate the policies of various departments and engage in organizational and functional design in which private-sector expertise can play an active role. To stimulate the space industry, it will promote the establishment of a new aerospace agency.

(Stimulating the space industry) The government will promote the transfer of public sector technology to the private sector, and strengthen the private-sector space level in the new space age through improvements to the system to increase corporate participation.

- The country will identify and develop space industry clusters centered on regions in which the domestic space industry is concentrated. It will strengthen support for these space industry clusters, including creating space development infrastructure and support for R&D talents.

(Original technologies) The government will secure original projectiles through next-generation projectile development, develop the Korean Positioning System (KPS), and raise the technology level in space development fields.

- South Korea will cooperate with advanced space development countries and proactively participate in domestic and international space pioneering projects.

Anticipated results: The country will expand the space development fields, starting with the launch of the Nuri[204] (June 2020), and the launch of the lunar explorer Danuri[205] (August 2022).

South Korea will become one of the seven major global space powers, with excellence in everything—projectiles, satellites, lunar exploration, and global positioning. Currently, the six major space powers consist of the US, Russia, China, Europe, Japan, and India.

(7) Realizing regionally led innovation by securing the sovereignty of regional science and technology

Target: To create a cyclical system wherein R&D ⇒ business creation/business growth ⇒ new industry/job creation ⇒ economic growth ⇒ reinvestment in R&D, by strengthening the innate capabilities of regions based on science and technology.

Main details:

(Raising levels of innovation) The country will stimulate basic research in regional universities and secure research competitiveness. Increasing regional innovation projects that suit the region's characteristics will contribute to regional

[204] Related article: https://spap.jst.go.jp/korea/experience/2022/topic_ek_08.html

[205] Related article: https://news.yahoo.co.jp/articles/fb7851bd19ac724890d3c88401be39156a44adef

innovation.

- South Korea will promote core technology R&D foundational medium and long-term projects led by regional areas.

(Promoting open integrated research) The government will create a system for government-industry-academia collaboration in regions and support concentrations in spaces.

- By spreading special R&D zones (wide-area special zones, small-giant special zones), improving levels, and designating new research and industry promotion complexes, the government expects to create science and technology innovation and new industry on a base level.

Author's comment: In South Korea, certain areas are legally designated as special R&D zones for the development of new technologies and to develop new businesses with the outcomes. Of these, the wide-area special zones include Daedeok, Gwangju, Daegu, Busan, and Jeonbuk R&D Special Zones. The small-giant R&D special zones refer to small-scale, high-density intensive spaces (TOWN) centered on innovation hubs in universities, research institutes, and companies; these are located in 12 areas, including Hongneung in Seoul and Seo-gu in Incheon. It is thought that science, technology, and innovation in regional areas will advance centered on these locations.

(Systems to support growth) The country will strengthen regional science and technology thinktank functions, reflect regional characteristics, and establish and enact region-specific strategies for science and technology development and plans for nurturing.

- It will provide a legal basis to support science, technology, and innovation according to regional characteristics, led by local authorities.

(Diffusion of science and technology culture) The country will spread scientific culture in regional areas and increase its familiarity by expanding scientific culture programs and infrastructure according to each region, and supporting scientific culture funding.

Anticipated results: The country will realize innate innovation and growth by establishing excellent science and technology talents and support in regions.

4.1.2 The 12 major national strategic technologies of the new administration[206]

Next, this section will introduce the fields of science and technology that are the focus of the new administration.

On October 27, 2022, MSIT published PACST's National Strategic Technology Nurture Plan (with President Yoon leading the PACST), as well as 12 major national strategic technologies and 50 sub-specific technologies to secure technological hegemony in global competition. One can say that these make up the **main science and technology strategy for the next five years (the Yoon administration) in South Korea**.

In the background of its declaration of these 12 national strategic technologies, the government stated, "It is clear from the example of the US' export controls on semiconductors that science and technology is now a core

[206] For details concerning 4.1.2, see https://spap.jst.go.jp/korea/experience/2022/topic_ek_22.html; MSIT, "National Strategic Technology Nurture Plan," https://www.msit.go.kr/bbs/view.do?sCode=user&mId=113&mPid=112&pageIndex=&bbsSeqNo=94&nttSeqNo=3182291&searchOpt=ALL&searchTxt=.

element that determines a nation's economy, industry, international relations, and diplomacy. Our country must create a concrete strategy to win in the competition for technological hegemony. Thus, we have determined 12 major strategic technologies and increased investment, and will take the measures needed to revise laws and restructure organizations."

This plan emphasized the fact that the US is investing 33 billion won in semiconductors, AI, and quantum through the CHIPS and Science Act, and that Japan is investing 500 billion yen in space, biotechnology, and quantum technologies, among others, through the Economic Security Promotion Act, and analyzed that South Korea must also strengthen its investment in designated fields.

South Korea's 12 major national strategic technologies refer to the following fields:

(1) Semiconductors and displays, (2) secondary batteries, (3) advanced mobility, (4) next-generation nuclear energy, (5) advanced biotechnology, (6) aerospace and marine technologies, (7) hydrogen, (8) cybersecurity, (9) AI, (10) next-generation communications, (11) advanced robotics and manufacturing, and (12) quantum

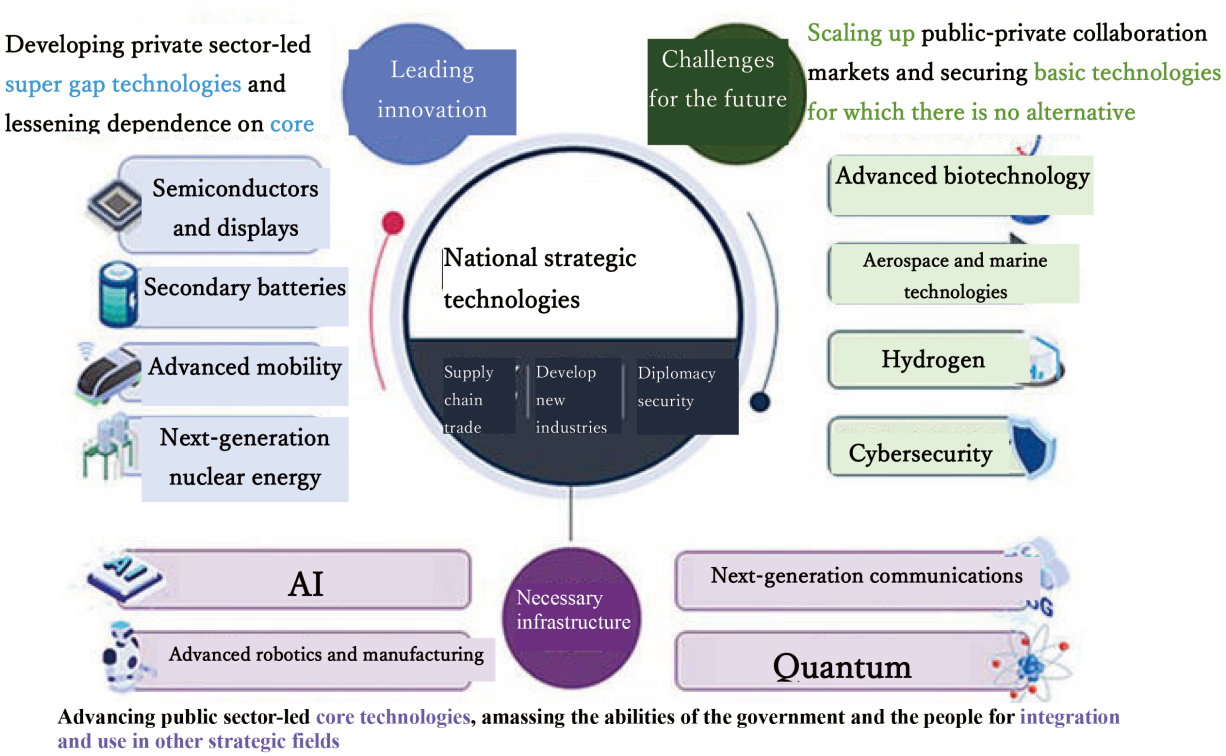


Figure 4-1: The Yoon administration's 12 major national strategic technologies

Source: SPAP (Science Portal Asia Pacific[207])

*Explanation of the above figure:

◇ Leading innovation: Technologies to support South Korea's economy and industry with a significant bidirectional ripple effect

◇ Challenges for the future: Technologies that will determine core interests from the perspective of rapid growth and national security

◇ Necessary infrastructure: Common core and essential basic technologies for electrical technology and industry in the context of a systemic shift

207 "South Korean government, announces 12 national strategic technologies (50 sub-specific technologies) and development plan," Science Portal Asia Pacific, December 8, 2022, https://spap.jst.go.jp/korea/experience/2022/topic_ek_22.html

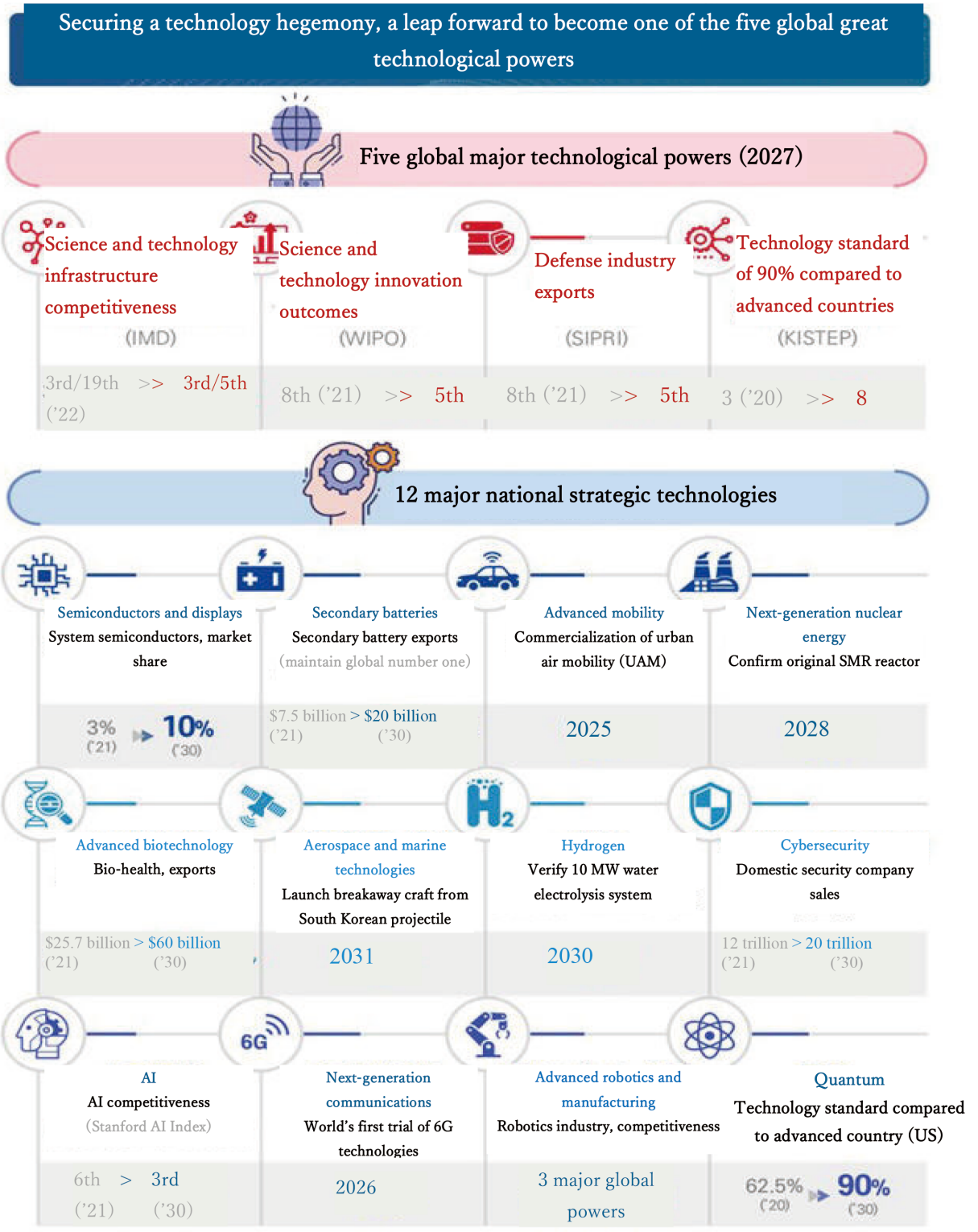


Figure 4-2: Targets of the 12 major national strategic technologies and expected outcomes

Source: SPAP (Science Portal Asia Pacific[208])

208 https://spap.jst.go.jp/korea/experience/2022/topic_ek_22.html

Of these, **quantum, next-generation nuclear power, and semiconductor technologies** are considered to be the most important core technologies.

Quantum is currently in a very early development stage, and the government has determined that once quantum computing and ultra-precise quantum sensors are developed, it will be able to quickly take the lead in the global market. In the case of semiconductors, there is an expectation of generational change in power semiconductor devices, going from silicon-based to compound-based devices, so to secure a hegemony in the future semiconductor industry, device development is a must. With regard to next-generation nuclear power, it is thought that the development of small-modular reactors (SMR) will help secure energy sources and reach carbon neutrality, securing a competitive position in the global market. The government has also identified 50 further sub-specific technologies, and announced the direction of its technology development in the short, medium, and long term. For example, particular focus will be on synthetic biology technology in the advanced bio-field, on high-performance low-power AI semiconductors in the semiconductor/display field, and on 6G technology in the next-generation communications field. In the future, sub-specific technologies will be mission-orientated and have set goals, and the expectation is that the country will put effort into areas such as R&D investment, international cooperation, and fostering talent.

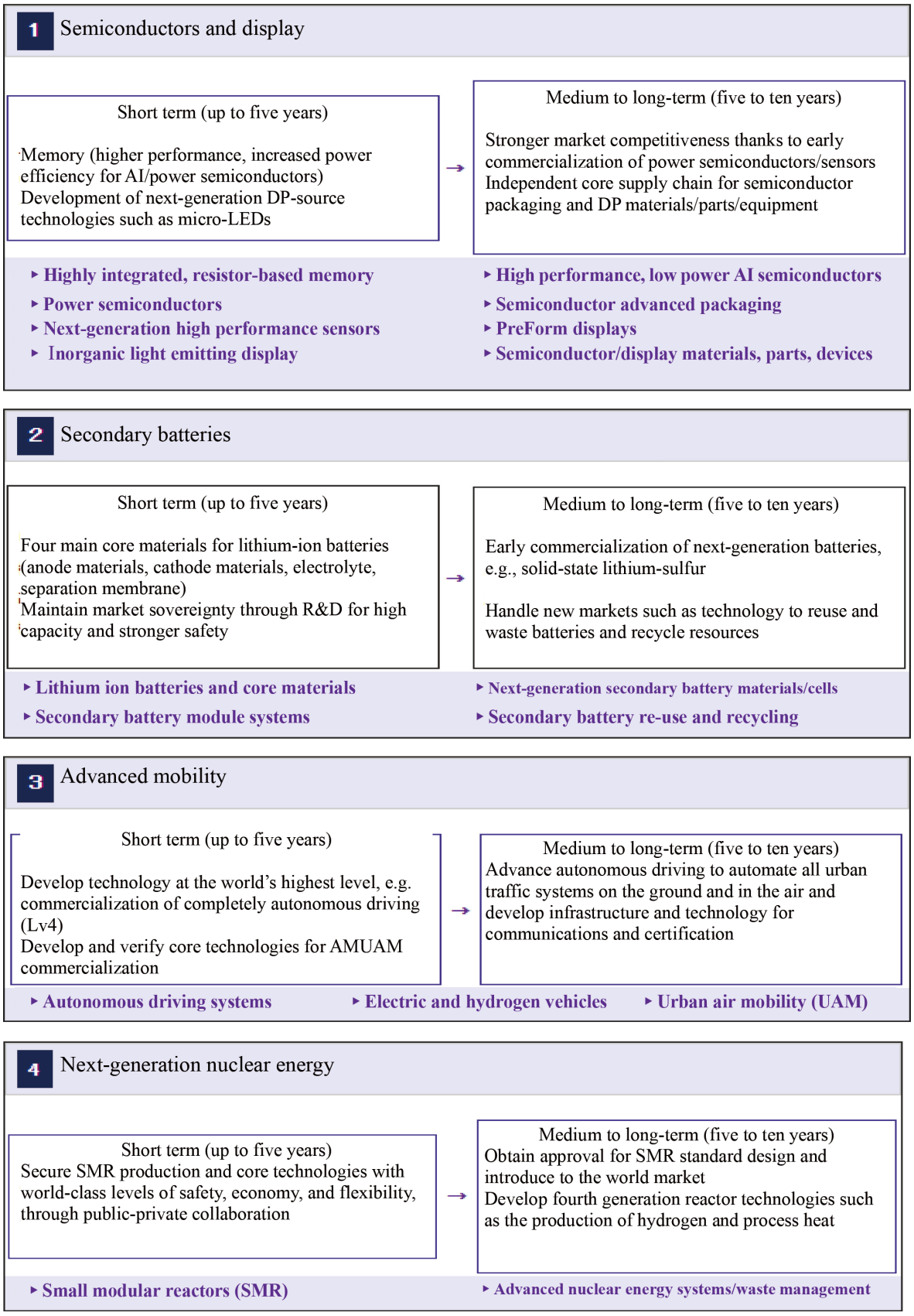
The government has also re-emphasized **public-private cooperation to secure super gap technologies and technologies with no alternatives in the national strategic technology fields**.

It has stressed the promotion of national strategic technology projects with the government and people working toward the same goal and investing together. The expectation is that the government will set clear targets to be resolved, and each industry will participate in every process from the target-setting onwards, which will raise South Korea's technology standards, capacity, and market maturity. It will also offer support to enable the creation of visible outcomes within five to seven years, by affording private-sector experts high levels of discretion over planning, managing, and evaluating issues, and carrying out detailed inspections of their outcomes. From 2023, using urgency and influence as standards, MSIT will first manage the high-need next-generation nuclear power and quantum fields via national strategic technology projects, and plans new investment of 265.1 billion won in technology development; it will select eight additional projects by the end of 2023 (four projects selected by the start of 2023 ⇒ launch in 2024/ four projects selected by the end of 2023 ⇒ launch in 2025).

MSIT has increased its R&D investment in the 12 major national strategic technology fields by around 10%, going from 3.74 trillion won in 2022 to 4.12 trillion won in 2023. It has also undertaken a detailed analysis of the current state of research talents in South Korea and other countries, and expects to enact plans to secure appropriate talents, with consideration given to system improvements, education curriculums, and support systems. It also plans to further strengthen foreign partnerships and industry-academia research cooperation. With regard to system security, it is keeping in mind the formation of the "Special Act on the National Strategic Technology." From now on, South Korea will carry out its National Strategic Technology Nurture Plan without any obstacles, aiming to make a great leap forward to secure technological hegemony and become a global technology power; in so doing, the country will expand the number of strategic technology fields with technological standards of at least 90% of those of advanced nations with the most advanced technologies from three fields (semiconductors/displays, secondary batteries, next-generation communications) to at least eight fields. By continuing to expand its market share in the fields where South Korea's strengths lie, the country expects to focus on securing core technologies and widening the gap between it and other countries.

The short-term and medium and long-term targets of the 12 major national strategic technologies are shown in the

figure below.



5 Advanced biotechnology

Short term (up to five years)	Medium to long-term (five to ten years)
Secure mRNA vaccination platform that can be developed in a few months Create dielectrics unique to the people of South Korea and bio-Big Data	Secure pipeline for genetic and cell therapy on par with advanced countries Advance synthetic biology-based bio-manufacturing and production

- **Synthetic biology**
- **Genetic/cell therapy**
- **Vaccines and treatments for diseases**
- **Analysis and use of digital health care**

6 Aerospace and marine technologies

Short term (up to five years)	Medium to long-term (five to ten years)
Develop core technologies for multi-stage combustion cycle rocket engines Launch the first navigation satellite providing ultra-precision positioning, navigation, and temporal information	Secure original space exploration capabilities by developing next-generation rockets Develop core component technologies for independent lunar exploration, lasers and optics observation

- **Large multi-stage combustion cycle engines**
- **Advanced aviation gas turbine engines/parts**
- **Space observations and sensing**
- **Arrive on moon, explore lunar surface**
- **Marine resource exploration**

7 Hydrogen

Short term (up to five years)	Medium to long-term (five to ten years)
Secure basic technology for water electrolysis hydrogen production (1-2 MW level) Develop core technologies for gas hydrogen storage and transport and hydrogen power generation	Verify quasi-commercial level (10MW) water electrolysis system and Ensure domestic production of core materials and parts, and create commercial-level liquefaction plant (5 tons/day)

- **Water electrolysis hydrogen production**
- **Hydrogen storage and transport**
- **Hydrogen fuel cells and power generation**

8 Cyber security

Short term (up to five years)	Medium to long-term (five to ten years)
Develop basic technology such as AI-based security control/automatic response Technology for rapid analysis and response to ICT device/SW weakness (firmware, etc.)	Future digital infrastructure (mobility, cloud, 6G, etc.) Independence of cyber security system

- **Data/AI security**
- **Networks, clouds, security**
- **Analyze and respond to digital weaknesses (supply chain security)**
- **New industry/virtual fusion security**

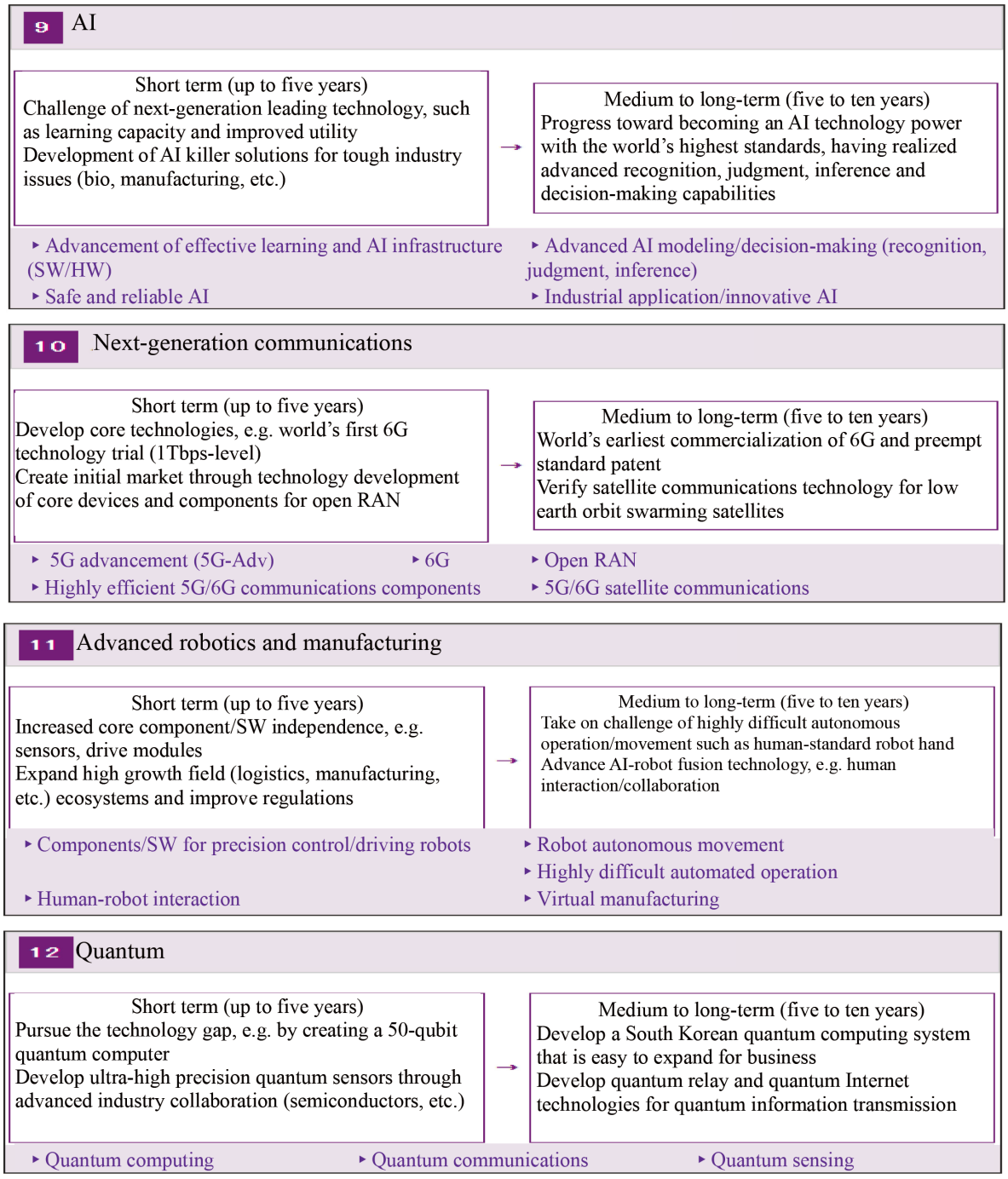


Figure 4-3: Short, medium, and long-term targets of the 12 major national strategic technologies

Source: SPAP (Science Portal Asia Pacific)[209]

[209] https://spap.jst.go.jp/korea/experience/2022/topic_ek_22.html

4.1.3 MSIT's R&D budget and five major tasks

With the new administration's seven major national policy issues in science and technology and the 12 major national strategic policies, MSIT first determined "creating a new national innovation system based on public-private cooperation and contributing to the country and society through the spread of leading technological innovation and digital technology" as a measure that runs through all its policies, and published five innovation tasks to support this measure.

Task (1) Create flexible R&D systems to secure technological capabilities for the creation of a gap between South Korea and other countries.

The country has selected strategic technologies (top-down), and to meet the goal of strengthening these technologies MSIT will introduce an integrated system for R&D budget distribution and coordination for cross-ministry projects and make flexible use of the budget. It will also create a public-private consultation body (a public-private collaboration management system) to enable private-sector leadership when implementing projects, and introduce a structure so that ministers and company CEOs can engage in joint management. Here, private-sector experts (PMs) will be responsible for actual project designs. MSIT will also make improvements to the R&D preliminary feasibility study system, such as those shown in the table below, to enable it to respond to the changes in the environment.

Table 4-4: Changes in the preliminary feasibility study system

	Before improvements	After improvements
Eligibility	50 billion won or more project expenses	100 billion won or more project expenses
Period	Uniform: 9–11 months	Within six months for 3,000 won or less
Details	Unable to make revisions after passing the preliminary feasibility study	In the case of sudden environmental changes (e.g., COVID-19, export controls), plans can be changed even after passing the preliminary feasibility study

Task (2) Induce private-sector investment using diverse methods, including joint public-private development and technology transfer to the private sector, and select new industries with promising futures based on technological development.

MSIT will break through technology bottlenecks through public-private cooperation in fields such as quantum, biotechnology, and 6G, which are limited only by government ability, and secure global competitiveness. Technologies among the country's so-called strengths (semiconductors, small-scale nuclear power generation, and new digital industries) will receive full-blown support so they can realize market expansion in a short timeframe. Space, which is normally government-led, and space technologies such as satellites, will shift to leadership by private companies, and all processes, from design to manufacturing and launch, will be completed in the private sector.

Task (3): Work on both fostering practical talents who can respond to private-sector needs and the time-consuming fostering of research talents.

Practical talents have the ability to quickly respond to private-sector need, and KAIST and other organizations have already introduced an intensive one-year degree project in September 2022. Universities are collaborating with companies and companies are involved with educational curriculums—company-contract based projects to foster practical talents have also been launched, through which graduates work at these companies.

When it comes to fostering research talents, in addition to conventional post-doctoral support programs and projects to nurture basic research talents, MSIT expects to run projects that differentiate, for example support for excellent postdoctoral researchers to carry out research in other countries and super-long-term support projects.

Task (4): Further strengthen the use of AI, software, and data, aiming for the world's highest levels. Engage in full-scale promotion of social digitalization through digital diffusion.

MSIT will secure AI technologies at the highest levels in the world and realize AI integration in industry and all areas of society through highly challenging R&D projects and data collaboration and use.

It will also support market expansion in new industry fields, such as the metaverse, OTT, and platforms, as well as supporting young people in business creation and the growth of excellent digital companies. It will support the corporate digital shift through vouchers, and promote regional digital innovation through collaboration with specialized regional industries and companies.

Task (5) To increase familiarity with digital technologies, etc. among people who lack digital knowledge, as non-contact meetings and the move online continues, and to resolve social issues based on platforms.

MSIT will further strengthen payment plans to make it easy for everyone to make use of smartphones, through a dedicated payment system for seniors and increased gigabytes of use for young people. It will also spread WIFI in public spaces across the country, and further expand super high-speed networks so even people in rural farming areas can use stable networks.

It will promote small companies' sales through the use of platforms, and make sure everyone can receive an education on platforms.

By focusing on the digital in everyday life, such as health, safety, and the environment, MSIT will advance innovation so that everyone can experience a digital society. It will also further expand various postal services, and transform post offices into service institutions closely connected to everyday life.

Author's comment: The author has summarized the Yoon administrations keywords as follows, based on its national policy issues, R&D budget, and MSIT's tasks. (1) Selection and concentration, (2) public-private cooperation, (3) full-blown promotion of digitalization, (4) budgetary integration and flexible usage.

The Yoon administration is focused on the above-mentioned main technologies and cutting-edge technologies, and is strengthening investment in selected and concentrated strategies. This can also be seen from the budgetary rate of increase; compared to the previous year, there have been budgetary increases of 8.5% in semiconductors, 31.1% in secondary batteries, 50.5% in next-generation nuclear energy, 13.2% in space, 36.3% in quantum, 11.7% in AI, and 8.9% in cybersecurity.

It is also working to strengthen public-private cooperation even more than before, to make use of the capabilities of private companies with private leadership in science and technology fields. The Yoon administration has lowered corporation tax, reducing the highest Moon administration tax rate of 25% to 22%. Companies subject to the highest tax rate have sales of more than 300 billion, which in South Korea consists of 103 companies, the top 0.01%, including Samsung electronics. In other words, this is an advantageous reform for large companies. In fact, to foster SMEs, the Moon administration significantly strengthened support for SMEs and venture companies, but the outcomes were insignificant, and it is still the case that many R&D outcomes are produced by large companies. The Yoon administration is continuing to strengthen support for SMEs, but is also aiming to maximize the potential of large companies. It has consistently taken the position that a society in which companies can easily play an active role is a shortcut to economic stimulation, increased employment, and stability.

Table 4-5: Changes in corporation tax

Sales	Moon Jae-in administration tax rate	Yoon Sul Yeol administration tax rate
Less than 200 million won	10 %	10 %
200 million to 500 million won	**20 %**	**10 %**
500 million to 20 billion won	20 %	20 %
20 billion to 300 billion won	22 %	22 %
More than 300 billion won	**25 %**	**22 %**

The **2023 MSIT R&D budget is 18.8 trillion won.** South Korea aims to increase the gap from other countries with its main technologies, including semiconductors, secondary batteries, next-generation nuclear energy, hydrogen, and 5G/6G technology; when it comes to cutting-edge technologies, it includes technologies from fields such as space, aviation, quantum, biotechnology, AI and robots, and cybersecurity.

Table 4-6: Breakdown of MSIT's FY2023 R&D budget of 18.8 trillion won

Preempting technologies for future innovation: 2.216 trillion won	Fostering talent and basic research: 7.7813 trillion won	Full-blown promotion of digital innovation: 1.8993 trillion won	Spreading technologies for everyone's happiness: 6.6773 trillion won
<Breakdown>			
Creating a gap with main technologies: 816.1 billion won	Creating a system to foster talent: 1.4347 trillion won	Digital platform governance: 28.5 billion won	Support for people who lack digital knowledge: 136.6 billion won
Joint public-private development in cutting-edge technologies: 785.4 billion won	Researcher-centered basic research: 5.8737 trillion won	Development of new digital technologies: 552.7 billion won	Diffusion of R&D outcomes: 674.3 billion won
Entering the age of the space economy: 491.8 billion won	Fostering digital talents: 365.4 billion won	Development of new digital industries: 1.0332 trillion won	Acceleration of carbon neutrality: 163 billion won
Future mobility: 117.3 billion won	Strengthening international technology cooperation: 107.5 billion won	Digital media content: 279.5 billion won	Enriched postal services: 5.6999 trillion won

Above, this report has looked at the science and technology fields that are the focus of the new administration and at MSIT's tasks, but what is the new administration's vision for the future? Here, the author will give their opinion.

4.2 The new administration's vision for the future

After the change in administration, what changes will occur in South Korea's science and technology? Below, the author gives their thoughts about six areas.

(1) Restructuring of organizations with the aim of reforming the compartmentalized bureaucracy

The Yoon administration abolished the Presidential Committee on the Fourth Industrial Revolution (PC4iR) and established the new Digital Platform Government Committee. In addition to inheriting the work of the PC4iR, this

committee is charged with the goal of uniting the separate ministries, who carry out their work in a compartmentalized bureaucracy, into a single government. The overlap of work between ministries and low effectiveness of the compartmentalized bureaucracy has been pointed out for many years.

The vision of the Digital Platform Government Committee is for all ministries to collaborate through data, providing more convenient services to the people, and for the government to implement smart administration that works based on AI and Data. One can probably expect the formation of committees to bring different ministries together via the Digital Platform Government Committee, and a government with stronger collaboration between ministries.

Then, the Office of the President of the Republic of Korea established a new Special Aid of Education and Science and Technology on a ministerial level; the president listens to the aide's advice concerning science and technology, and together they develop discussions.

Under the umbrella of the Ministry of Foreign Affairs, the administration established the new Overseas Koreans Agency, which will strengthen the network of Koreans living in other countries and improve the support and treatment of Koreans overseas. With regard to fostering talent, in the past, South Korea has focused on projects to invite foreign experts to South Korea, but did not work on a strategy to recall people. With the decreasing birthrate and aging society leading to a seriously decreasing population, it seems that the country has started to look at Koreans living in other countries. In the future, it is assumed that the government will explore strategies to recall Korean talents living overseas.

In addition, the status of the Ministry of Patriots and Veterans Affairs has been raised, though this is not terribly relevant to science and technology. It is said that this is a measure to improve the treatment of people with individual merits and democratic merits who have contributed to the country.

It can be said that the Yoon administration is not engaged in a great deal of organizational restructuring.

Relieving the tiredness and disadvantages of frequent reorganizations and concentrating on programs and policies will conceivably lead to more efficient work and policy stability.

(2) Continuing investment in science and technology

It is thought that investment in science and technology will increase further.

South Korea's 2021 R&D budget exceeded 100 trillion won, and it is said that the country has finally raised the curtain on a 100-trillion-won age. The Yoon administration's published 2023 governmental R&D budget is 30.7 trillion won, exceeding 30 trillion won for the first time. MSIT's R&D budget has also increased from last year, and it is predicted that the ongoing investment in science and technology will, at the very least, be maintained during the Yoon administration's time.

The characteristics of the Yoon administration are select and concentrated investment. In other words, it is thought that investment will be concentrated in core technology fields. It has already clarified in its national policy issues that digital innovation and developing and securing strategic technologies that can open a gap between South Korea and other countries are main priority science and technology issues, and investment is likely to be concentrated in the 12 major advanced technology fields introduced in 4.1, including quantum technology, semiconductors, and AI.

This way of investing is the best choice for South Korea. Due to the country's resources and size, it cannot match the US or China, so if it doesn't strategically narrow down its fields of focus, it has no way to win in the global competition in science and technology.

(3) Efforts to foster talent in advanced technology fields

It is vital that South Korea nurtures emergent industries by spearheading innovation, and there is a widely shared awareness in South Korean society that success here lies in fostering talents in this field. Therefore, it is thought that the government will strongly promote collaboration with the 12 major advanced technology fields to foster talents in core technology fields.

At the heart of this lie the Yoon administration's three talent-related policies, set out from 2022 to 2023: the **"Policy to Nurture Semiconductor Talent" "Comprehensive Plan to Nurture Digital Talent," and "Strategy to Nurture Talent in Cutting-edge Fields."**

Furthermore, the government's track of fostering practical talents, such as the contract courses that match increasing demand and potential supply, will further expand the number, quality and fields of talents fostered; that this will expand into other South Korean universities can be considered a certainty.

(Note 1) The "Policy to Nurture Semiconductor Talent"[210] declares that the country will **foster 150,000 semiconductor talents by 2030.** There are three strategies for this: (1) increasing the capacity of semiconductor subjects in universities and graduate schools, (2) strengthening government-industry-academia collaboration through large-scale semiconductor R&D projects, (3) creating hubs to foster semiconductor talents centered on universities.

(Note 2) The "Comprehensive Plan to Nurture Digital Talent"[211] calls for the expansion of the innovation sharing university program and SW-centered university program currently taking place, for efforts to foster talents, from gifted individuals to university students and research talents, and to **foster 1 million digital talents by 2026.**

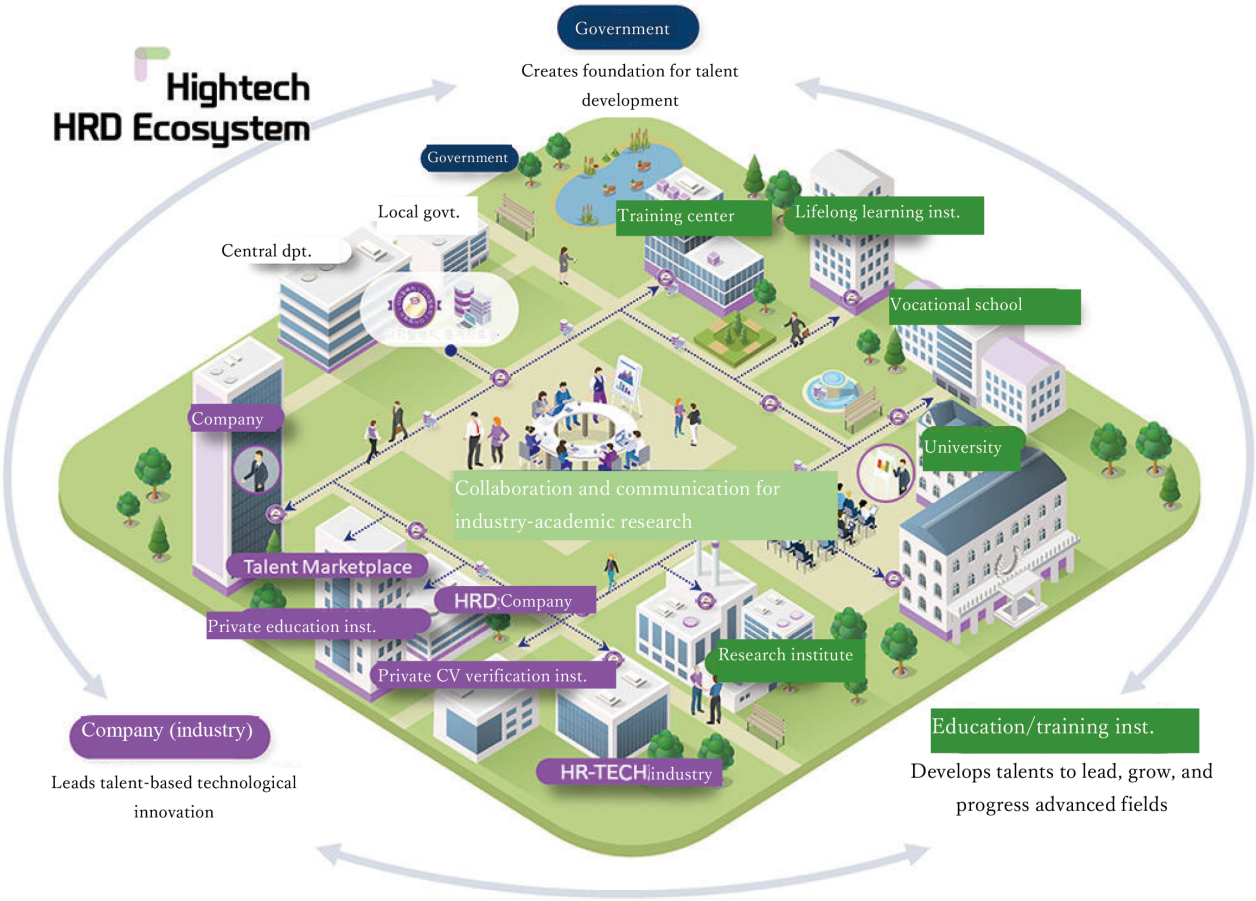
(Note 3) The "Strategy to Nurture Talent in Cutting-edge Fields"[212] has selected five core fields to be strengthened ((1) Aviation, space, and future mobility, (2) bio-health, (3) advanced parts and materials, (4) digital technology, etc., (5) environment and energy).

[210] See https://spap.jst.go.jp/korea/experience/2022/topic_ek_13.html

[211] See https://www.hrstpolicy.re.kr/kistep/kr/policy/policyPlanKorDetail.html.

[212] See https://spap.jst.go.jp/korea/experience/2023/topic_ek_10.html.

The formation of an ecosystem with a virtuous cycle that supports talent development in high-tech fields



Education/training inst.

Develops talents to lead, grow, and progress advanced fields

- Diverse education management, on and offline
- Support for integrated/comprehensive education
- Shares information to develop talents (education curriculum, personal capacity, etc.)

Company (industry)

Leads talent-based technological innovation

- Participates in education to develop talents
- Shares information to develop talents (employment, skills)
- Collaboration and communication for industry-academic research

Government

Creates foundation for talent development

- Creates information distribution platform to develop talent
- Improves education, research, training regulations
- Stronger cooperation for industry-academic research
- Monitors (reviews) talent development

Figure 4-7: Image of the Yoon administration's desired society

Source: SPAP "South Korean government, joint departmental announcement of strategy to foster talent in advanced fields"

(4) Supporting basic research for ten years or more

The focus has started to turn to long-term basic research lasting 10 years or more.

In July 2022, the South Korean-American mathematician June Huh made big news in South Korea when he won the Fields Medal. The high levels of interest in Professor Huh also increased attention on basic research, and MSIT made use of the June Huh boom to start to discussing strengthening basic research;[213] this was reminiscent of when former golfer Pak Se-ri won the LPGA tour, leading to golf becoming popular and a number of world-class players being produced. As is well known, South Korea has not yet had anyone win a prestigious prize in the field of science and technology, such as a Nobel Prize (excluding Kim Dae-jung), Turing Award, Pritzker Architecture Prize, or Prix Galien. Fostering researchers on a world-class level is a long-running challenge for South Korea. MSIT has determined that an environment to support long-term research is absolutely vital to foster these researchers, and in 2023 it introduced a new program to support basic research for 10 years or more.

Basic research involves long-term work, taking a considerable amount of time from when it starts until it leads to outputs. The Institute for Basic Science (IBS) received much criticism during budget distribution for its lack of results when it was initially established, but now 10 years have passed, it is producing visible outcomes, and positive assessments have risen.

The Yoon administration may not be able to expect wonderful outcomes in the short term from the program to support basic research over 10 years or more, but if it continues, the day it produces fruit will surely come.

(5) Strategies to support companies, especially large companies

When it came to support for companies, the Moon Jae-in administration strengthened support for SMEs and venture companies to an unheard of level; in contrast to this, the Yoon administration is focusing on policies that are also beneficial for large companies, such as lowering the corporation tax for large companies.

The Yoon administration reduced the Moon administration's highest tax rate of 25% to 22%. Companies subject to that highest tax rate are companies with sales of 300 billion won or more; in South Korea, this means 103 companies, the top 0.01% (e.g., Samsung Electronics), are subject to this tax. This is therefore an advantageous reform for large companies.

In fact, the Moon administration greatly increased support for SMEs and venture companies to enable SME growth, but the major R&D outcomes are still coming from the large companies, However, this is not unexpected. The R&D level of SMEs differs from that of large companies from the start. One of the main characteristics of the South Korean economic structure is that, rather than being a pyramid where large companies, mid-tier companies, and SMEs coexist in good balance, it has been divided into large companies and SMEs for a long time. Large companies have a monopoly over many R&D resources, so there can be no expectation of any great change with only a few years of concentrated support for SMEs.

The Yoon administration has decided to continue strengthening support for SMEs while aiming to maximize the potential of large companies, but there are no obvious policies to support SMEs as of yet.

When it comes to corporate support, the basic stance of the Yoon administration is that a society in which large

[213] See Financial News, "No star researcher is born without carrying out research for at least 10 years," https://www.fnnews.com/news/202208291803070526.

companies can easily play an active role is a shortcut to economic stimulation, increased employment, and stability. Therefore, it is thought that, for now, it is focusing on policies to further increase productivity in large companies rather than on developing SMEs. Once could say that it has formed a policy environment in which South Korean companies with international competitiveness, such as Samsung Electronics, can more easily become active on the world stage.

(6) Stimulating international cooperation in science and technology

Finally, with COVID-19 calming down, there are visible signs of activity in international science and technology cooperation.

The first Japanese-Korean summit meeting in three years took place in 2022. Then, in March 2023, Yoon Suk Yeol visited Japan, and the Japanese-Korean relationship moved dramatically. Since the Yoon administration took over, they have re-started "shuttle diplomacy" for the first time in 12 years. It is thought that President Yoon is seriously working to improve the relationship between Japan and South Korea.

Putting Japan aside, as the tense relationship between the US and China continues due to the China-US trade war, South Korea is proactively creating strategic partner relationships with other countries rather than either China or the US.

First, the country's friendly relationship with the United Arab Emirates (UAE) should be noted; in 2023, President Yoon decided to make the UAE his first destination for a diplomatic visit, and the leaders of the two countries held a meeting.[214] During this meeting, the UAE made it clear that it would invest 30 billion dollars in South Korea. This investment is expected to be mainly used for hydrogen, renewable energy, the defense industry, and industries such as nuclear power; with this, it also became clear the two countries expect to strengthen cooperation in new industries, healthcare, and cultural industries too. After the meeting, the countries signed 13 memorandums of understanding (MoU), including MoU on nuclear power and energy, investment, the defense industry, and climate change fields, in the presence of both heads of state. A lunch for state guests took place after this, and was attended by a large number of representatives from major Korean companies, including the heads of Samsung Electronics, the Hyundai Motor Company, SK, and GS Energy; this served as advance notice that there will be a boom in South Korean companies expanding into the UAE.

Following on from the UAE, President Yoon visited Switzerland, emphasizing his intent to further strengthen scientific and technological cooperation between the two nations on the occasion of the 60th anniversary of friendly relations between South Korea and Switzerland. Meanwhile, when President Yoon was visiting Switzerland, the Vice Minister of MSIT attended a ceremony to mark the completion of the Vietnam-Korea Institute of Science and Technology (V-KIST). In this way, President Yoon is breaking new ground with new business opportunities and international cooperation by actively expanding scientific and technological cooperation with countries in Southeast and Central Asia, with which there has not been much correspondence before.

In terms of advanced technology fields such as quantum technology, the Yoon administration is continuing to emphasize the importance of international cooperation with the US, China, Japan, and countries in Europe.

214 For details, see https://spap.jst.go.jp/korea/experience/2023/topic_ek_01.html.

Yoon Suk Yeol has a unique background as the first President who was a public prosecutor. He may engage in ways of promoting policies and programs that are different to those of conventional politicians—in a good way. The Yoon administration will reach its first anniversary in May 2023; what science and technology policies will it set out, and what kind of international cooperation programs will it develop on this occasion? The answer will be worthy of note.

To Japan, South Korea is a key partner for cooperation, both from the perspective of science and technology cooperation, and from the perspective of global competition, and attention will continue to be paid to the science and technology trends in South Korea.

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Acknowledgements:
This report was reviewed by Jeong-Gook Hong, Chair of the Korean Scientists and Engineers Association in Japan.
I would like to take this opportunity to express my sincere gratitude.

Research Report

APRC-FY2022-RR-07

South Korea's Science and Technology in the era of the Fourth Industrial Revolution

Published March 2024
ISBN 978-4-88890-921-1

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