

Model Of Development Of "Smart Industry" In The Republic Of Korea In The Conditions Of Innovative Economy

Tairova Zarnigor

¹Tashkent University of Applied Sciences, Gavhar Str. 1, Tashkent 100149, Uzbekistan

zarnigor.zt@gmail.com

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Abstract: The article examines the South Korean model of smart industry in a country with an innovative economy within the context of the integration of advanced technologies such as automation, artificial intelligence, and data analytics into manufacturing and production processes. The study's relevance lies in the Republic of Korea's exemplary success in the economy, attaining a leading position in international trade through robust and practical policies. This success is attributed to four factors: 1) creating a favourable business environment by maintaining the lowest tax burden among OECD countries; 2) implementing targeted policies since the 1960s to promote exports; 3) actively participating in negotiations to conclude free trade agreements (FTAs) with developed and developing countries, recognising exports as a key growth factor; and 4) diversifying its presence in global markets. Furthermore, the shift of the world economic centre from the traditional West to the East, specifically the Asia-Pacific region, underscores the Republic of Korea's sustained economic development through pragmatic relations with countries in the region. Overall, the smart industry model in an innovative economy aims to drive continuous improvement and growth through the strategic adoption of cutting-edge technologies and practices.

1 INTRODUCTION

In recent years, the Republic of Korea has emerged as a global leader in the development of "Smart Industry" within the framework of an innovative economy. With its strong emphasis on technological advancements and a robust industrial ecosystem, Korea has successfully positioned itself at the forefront of the fourth industrial revolution. This revolution, characterized by the integration of digital technologies into traditional industries, has paved the way for the emergence of smart factories, smart cities, and smart infrastructure.

Driven by a vision to enhance productivity, efficiency, and sustainability, the Korean government has been actively promoting the development and adoption of cutting-edge technologies such as artificial intelligence (AI), Internet of Things (IoT), big data analytics, and robotics. These technologies have been integrated into various sectors including manufacturing, energy, transportation, healthcare, and agriculture, transforming them into intelligent and interconnected systems.

The development of smart industry in Korea has not only revolutionized traditional manufacturing processes but has also catalyzed innovation across multiple sectors. By leveraging advanced automation, data analytics, and real-time monitoring, Korean industries have achieved higher levels of precision, agility, and customization. This has resulted in increased competitiveness in the global market, as Korean

companies are able to deliver high-quality products and services at a faster pace.

Furthermore, the Republic of Korea's commitment to fostering an innovative economy has created a conducive environment for research and development (R&D) activities. The government has established numerous innovation centers, research institutes, and technology parks to facilitate collaboration between industry, academia, and research institutions. This collaborative ecosystem has fueled the creation of groundbreaking technologies and has nurtured a culture of entrepreneurship and innovation.

2 MATERIALS AND METHODS

After the Second World War, South Korea had favorable conditions for the development of its economy. Despite having a large number of low-skilled workers, the country was able to open up to the world, primarily to the American market. Natural resources were scarce, there was no capital, and the domestic market was relatively small and technologically underdeveloped.

In order to accumulate all resources, a large number of multi-profile corporations, or chaebols, were established with state support. This became the first premise of the Korean "economic miracle". Another premise was the high level of diligence of the population.[1]

Starting from the 1960s, economic programs were developed based on five-year plans. The first five-year

plan (1962-1966) focused on the initial steps towards successful industrialization. The main emphasis was placed on the production of electricity, mineral extraction, oil refining, and cement production. The second five-year plan (1967-1971) aimed to modernize industry and develop sectors capable of producing products that were previously imported, such as steel production, machine building, and chemical production.

The third five-year plan (1972-1976) focused on the rapid development of export-oriented industries, particularly heavy and chemical industries, including machine building, electronics, petrochemicals, and oil refining. The fourth five-year plan (1977-1981) aimed to increase competitiveness in international markets by producing high-quality goods. The strategic focus was on developing high-tech industries such as machine building, electronics, and petrochemicals. As a result, heavy and chemical industries grew by 51.8% in 1981, and the share of exports in total production increased to 45.3%.

The fifth and sixth five-year plans focused on developing high-tech industries such as electronics, semi-conductors, and information technology. The seventh (1992-1996) and subsequent five-year plans continued this trend.

Research demonstrates that the South Korean Republic, among other countries in South-East Asia, has successfully established sustainable connections between favorable macroeconomic conditions and competitiveness in product and economic rivalry. This aligns well with modern economic theory and empirical research.

While the South-East Asian countries, including the Republic of Korea, have benefited from various models of modernization in their economic development, the distinctive feature of the state's leadership in all areas is considered essential for the transformation of the national economy.

Over the past 40 years, the replicability of strategies employed by traditionally developed countries and the application of export-oriented economic development models have played a significant role in the dynamic growth of the South Korean economy. However, such external economic policies lost their significance after the global financial crisis in 2008. Different sectors in the global economy shifted from labor and capital (industrial economy) and knowledge and information (knowledge-based economy) to innovative technologies and creative ideas (creative economy). The creation of new types of goods has become a driving force for economic growth, with creative and innovative ideas being manifested in internet-based technologies, smartphones, social networking services (SNS), and other modern technologies. Creative economy encompasses various fields such as advertising, architecture, design, film industry, interactive entertainment, music, software development, computer hardware, television, radio, mobile content, and gaming. These activities involve the utilization and creation of

intellectual property. If we were to represent the formula of creative economy, it would be as follows:

$$\text{Creative Economy} = \text{Intellectual Property} + \text{Innovation} + \text{Cultural Industries} + \text{ICT (Information and Communication Technology)}$$

This formula captures the essence of the creative economy and its contribution to economic growth.

The main directions of the policy pursued by the government of the Republic of Korea in the field of creative economy are aimed at integrating science and technology with industry and culture through information and communication technologies (ICT), creating new jobs and additional value. The development of the creative economy potential is based on the expansion of activities and business types in the field of information technology applications, as well as increasing the level of knowledge in the field of information and communication technologies.

The Republic of Korea has identified five main strategic objectives in the creative economy:

The first objective is to create a favorable economic environment for establishing specialized businesses and ensuring the protection of creative activities. In order to develop the Korean economy in line with this objective, the government provides financial support to specialized businesses established based on creative ideas. In addition, a guarantee and security system has been established to reduce financial risks for venture businesses. If a venture business faces bankruptcy naturally, the government will completely renew the business. As an example, the Korean government allocated \$8.868 billion for supporting venture businesses in 2017-2020[2]. The adoption of this policy has resulted in the support of startup companies, creation of new jobs, and development of sustainable sectors in the economy. The financial support concept of the Korean government has reached the level of an active investment policy in developing the national creative economy.

The second strategic objective of the creative economy is to support the entry of content and cultural industries into the global market. The content industry is one of the main components of the Korean economy. In 2012, the export volume of this sector amounted to \$4.6 billion[3]. Cultural content activities and their export have several advantages in the development of the national economy:

- a) It is possible to create high-value-added products with low investment costs;
- b) This field has high potential for creating new jobs and markets;
- c) It contributes to the promotion of national brands and the development of tourism business;
- d) The increase in exports is observed as a result of the increase in Korean goods aimed at exports (cosmetics, mobile phones, household appliances, clothing) due to their improved image.

The third strategic objective is to support innovation technology projects. A plan has been developed to support advanced technology startups (in areas such as Internet and software, medical and biotechnology, gene analysis and treatment, production of graphene-based materials, nanotechnology, renewable energy technologies).

The fourth strategic objective is to attract highly skilled professionals and workers from abroad. Within the framework of this objective, a "Visa System for Entrepreneurs" has been developed, which aims not only to attract foreign experts in innovative technologies but also to liberalize the activities of entrepreneurs working in innovative technologies within Korea.

The fifth and final objective is to strengthen international cooperation through scientific and technical projects and information communication technologies. Developing countries have established innovation, scientific, and technological centers, designating them as drivers for cooperation and technology transfer to domestic and international markets. In addition, a policy of international cooperation and support in areas such as combating climate change, medical treatment for epidemics, testing new drugs, hormone production, agriculture, and fisheries technology is being implemented. As part of the government program, at the end of 2013, 13 cooperation centers were established in MDH and CIS countries in the field of science and technology [4].

Thus, the government of the Republic of Korea is paying great attention to the development of technology. By developing information and communication technology applications, it aims to implement concepts of creative economy, create new jobs, and improve living conditions for citizens.

In 2011, the World Bank published a report [5] analyzing in detail the economic development strategy that gave the Republic of Korea the opportunity to achieve unprecedented success. Firstly, the role and place of both the state and private business were clearly defined. Thanks to the government's attention to two main tasks, the country achieved rapid socio-economic development: firstly, ensuring macroeconomic stability through a conservative monetary and financial policy; secondly, investing in education and healthcare programs. The main focus was on market reforms and creating a highly competitive environment in the fields of industry, trade, and finance. All barriers to trade and foreign investment were removed. The success of the Republic of Korea is undoubtedly due to its ability to quickly accumulate capital, effectively distribute resources, and reach a high level of technological development by implementing a strategic development model chosen by the country.

It is important to emphasize that the achievement of these tasks and the development of the advanced economy were achieved through the integration of market mechanisms and state intervention in a targeted manner. The Republic of Korea's "economic miracle"

phenomenon is largely due to the study of the state-business partnership model, where private business played a key role, but all permissions were granted by the government. At the same time, the government never aimed to fully control the business. South Korea's economic growth was achieved through the harmonization of market mechanisms and state management.

In the early 2000s, the Republic of Korea pursued a state policy aimed at developing innovation and human capital in this area, not only promoting innovation in a broad sense but also accelerating the creation of "smart industry," "smart farming," and "smart cities." In 2015, President Park Geun-hye's government developed and adopted the main principles of the "Creative Economy" program at the state level.

As part of this program, in 2015, a strategy for developing industry was presented - "Innovative Manufacturing 3.0." To support this strategy, the Standards Research Council - Smart Factory and the Korea Smart Factory Foundation were established. This organization was created to effectively respond to international trends and standardize local legal regulations in a timely manner. The Ministry of Science and Technology Development and the Ministry of Trade, Industry, and Energy were appointed as key organizations to support this strategy in developing science and technology, as well as supporting small and medium-sized businesses in trade, industry, and energy.

The concept of "smart manufacturing" not only involves the use of robots in production but also encompasses the effective utilization of information technologies to monitor, synchronize, and optimize manufacturing processes. This includes technologies such as Smart Sensors, Cyber-Physical Systems (CPS), 3D printing, Internet of Things (IoT), Big Data, and holograms.

The Republic of Korea's Innovative Manufacturing 3.0 program aims to integrate the entire manufacturing process into the Fourth Industrial Revolution. It seeks to enable the government to enhance and optimize smart manufacturing, as well as increase the competitiveness of the manufacturing industry. To achieve this, the government plans to attract \$172 million (200 billion won) in investment annually and aims to establish 1,500 smart factories by 2020, with the target of doubling this number by 2022. The key feature of this program is the government's support and promotion of smart manufacturing technologies for local small and medium-sized enterprises (SMEs).

The main stages of the development of the "smart manufacturing" model in the Republic of Korea are as follows:

- June 16, 2014: Creation of the "Manufacturing Innovation 3.0" strategy, which identifies the objectives, tasks, and implementation tools of manufacturing. The strategy focuses on the integration of business processes in manufacturing, including planning, design, production, delivery, and sales, through automated

systems known as "smart factories." These factories are equipped with various types of information and communication technologies tailored to the needs of individual customers. This allows for the production of customized products while improving quality and reducing time and costs. [6]

According to the main objective, there are two directions in the adoption of smart manufacturing technology: manufacturing optimization for service enhancement and personalized manufacturing.

Here are the key milestones in the development of the "smart manufacturing" model in the Republic of Korea:

- December 17, 2015: "Smart Manufacturing R&D Roadmap" was established to develop eight key technologies for innovative manufacturing and create an implementation plan for 2016-2020.
- March 18, 2016: "Intelligence Information Industry Development Strategy" was introduced to promote the protection and utilization of information technologies, including artificial intelligence. An investment strategy for 2016-2020 was formulated.
- August 19, 2016: The "National Strategy Project" identified nine national strategic projects, including artificial intelligence, virtual reality, autonomous vehicles, smart cities, and others.
- In early 2017, the Ministry of SMEs and Startups announced the expansion of the Smart Factory/Smart Manufacturing project until 2019 and proposed an investment of \$305 million. This represented a significant increase compared to the previous year. Currently, efforts are ongoing to further expand the project, with the aim of reaching up to 30,000 smart factories by 2022.[7] Every year, private companies aim to create and modernize 2,800 state and 1,200 manufacturing facilities.

The government is actively supporting the training of 40,000 skilled workers in fully automated manufacturing facilities through various educational programs. In order to facilitate the proper establishment of smart factories for small and medium-sized companies, the Ministry of SMEs and Startups (MSS) allocated financial support ranging from \$89,000 to \$133,000 in 2019 for new and existing factories.

The process of submitting, reviewing, and selecting applications has been simplified, allowing companies to expedite the establishment of smart factories. The inspection period, which used to take up to 5 weeks, has been reduced to as short as 2 weeks. Additionally, the MSS is planning to establish innovation centers in 19 technological parks in South Korea to enhance the selection system for companies and provide direct support. By 2022, there are plans to establish 25 experience factories in MSS technological parks, with 5 of them focusing on innovative support projects utilizing robots. Selected companies for pilot projects will receive financial assistance ranging from \$267,000 to \$445,000

if their projects are related to industrial innovations supported by robot utilization. [8]

In 2017, when Mun Jae In became the new President of the Democratic Party, a series of issues related to implementing the innovation strategy were reviewed, along with a focus on the Fourth Industrial Revolution. Based on the gathered experience, the government started developing a new manufacturing strategy. As part of the "Fourth Industrial Revolution," a program was developed that continued the "Innovative Manufacturing 3.0" approach while also expanding it. President Mun Jae In's "I-Korea 4.0" initiative is one of the most important political projects of his administration. [11]

By mid-2019, the overall sales of artificial intelligence (AI) dynamics in the country had exceeded 4.1 million units, which was more than double compared to the previous year. AI dynamics enable the management of various smart devices and provide real-time information to users. The number of subscriptions to Internet of Things (IoT) services also increased, reaching 18.6 million, a growth of 33.2% compared to the previous year.

These figures demonstrate that technology is not only being utilized in industrial factories but is also actively integrated into people's daily lives. By June 2019, the number of 5G mobile service users had reached 1 million. On April 5, 2019, Korea became the first country in the world to launch commercial 5G services, and steps were taken to establish an ultra-fast internet infrastructure capable of delivering speeds of up to 10 Gbps by 2020.

The high achievements in advancing innovation in the country are directly related to the level of investment in scientific research. The following are the expenditures reported by Korea to the Ministry of Science and ICT (MSIT).

NTIS DATA 1,176.6 ten thousand[9] NOV 28, 2023

R&D information 930.3 ten thousand	 R&D Programs 1.5	 R&D Projects 107	 R&D Outcomes 728.1
 Human Resources 82.4	 Institutes 4.3	 Etc 253.1	

It can be seen from the table that the government's support and development program has been effective in attracting private investors. The percentage of government subsidies is decreasing, while private investments are increasing. This is mainly due to the successful utilization of technology by private

companies, their interest in developing technologies, and their satisfaction with the state support mechanism.

According to the Korea Federation of Industries (FKI), the country's research and development expenses reached 75.4 billion dollars (93.1 trillion won) in 2020, accounting for 4.81% of the country's total domestic product. This makes South Korea the largest spender on research and development among 36 out of 38 OECD member countries, second only to Israel.

The report also states that South Korea's investment in research and development increased by 2.54% in 2021 compared to 2001, which is nearly five times higher than the OECD average of 0.53%.

Large companies spent 71.3 trillion won, which accounted for the majority of the expenses, while 21.6 trillion won was spent by the government or other state organizations. However, research and development expenses accounted for only 7.5-8.0% of the total expenses in the past decade, which is lower than the average of 11.4% from 2001 to 2010.

In 2018, South Korea's intellectual property royalty revenues were much lower than the OECD average in terms of research and development expenses, accounting for only 9.9% compared to the OECD's average of 27.7%.

The South Korean government plans to allocate 24.7 trillion won (approximately 19.2 billion dollars) towards research and development (R&D) related to digital innovation in 2023. This information was reported to representatives of Yonhap News Agency and the Ministry of Science and ICT.[10]

Various types of "smart factories" are successfully operating in the Republic of Korea today. For example, at the Changwon plant (a company that produces aircraft engines), Bluetooth sensors have been installed on every machine, and the sensors help monitor each machine during the assembly process. Previously, barcode scanners were used for this purpose, but network managers always had to scan them. New sensors used through the Internet of Things technology make the final product delivery and management process more efficient and accurate. The company installed 2,000 sensors in its factory by the end of 2020, and 20,000 sensors by 2021. The company produces spare parts for world giants such as General Electric and Pratt & Whitney, starting from November 2019. The company plans to reduce production losses by 20% and increase production efficiency by 14% in the near future.[12]

As an example of utilizing advanced technologies to optimize port logistics, we can highlight the companies SK Telecom and Samsung Heavy Industries. They have successfully conducted a trial of remotely managing a shipyard using a 5G-based remote control system, which allows for autonomous and remote-controlled navigation of vessels. This trial aims to significantly improve the safety of maritime operations. It enables real-time monitoring of ships' movements and their precise location, even in busy waters or near obstacles.

It can be said that the Republic of Korea is currently experiencing successful advancements in industrial production through the establishment of "smart factories." According to IMD data, in the 2022 Digital Competitiveness Ranking, the Republic of Korea ranked 8th globally in terms of digital competitiveness.[13]

In Korea, there has been a similar growth observed in the use of robots, e-government adoption, and cyber security. The country remained at the 13th position in terms of technology advancement but dropped from the 15th to the 16th position in the Science Ranking.

Looking at the rankings globally, Denmark took the first place this year, while the United States, which was the leading country in 2021, dropped to the second position. Sweden claimed the third spot. Singapore and Switzerland followed, with China ranking 17th and Japan 29th.

The Ministry of Education and Science of the Republic of Korea announced that among the countries in the Asia-Pacific region, Korea ranked second after Singapore and was ahead of 27 countries with a population of over 20 million, with only the United States ahead of it.

"We will continue to enhance our digital competitiveness by implementing the 'Korean Digital Strategy' proposed by President Yoon Suk Yeol of the Republic of Korea," stated the Ministry of Education and Science.

South Korea claimed the first spot in the Government and Government Services Digitization (GovTech Maturity Index, GTMI) ranking this year.

On November 17th, the Ministry of Government Administration and Home Affairs of the Republic of Korea announced that Korea had taken the first place with a score of 0.999 out of 1 among 198 countries in the world in the GovTech Index, which was announced by the World Bank a day earlier.

The term "GovTech" coined by the World Bank is used to describe the next generation of digital government. This year, the "maturity" of digitization in countries was evaluated for the first time.

The GovTech Maturity Index was calculated by adding scores in four categories: foundational digital infrastructure, digital public services, citizen participation, and institutional support.

Korea ranked first in the categories of "foundational digital infrastructure" and "institutional support," and second in the other two categories, securing the top spot in the overall ranking. Brazil ranked second with a score of 0.975, followed by Saudi Arabia (0.971), the United Arab Emirates (0.961), and Estonia (0.956).

The Vice Minister of Government Administration and Home Affairs, Han Chang-seop, said, "The overall characteristics of our digital government, which is leading the way in GovTech, are closely related to our vision for the future, which is being realized through the digital transformation of the entire government"[14].

CONCLUSION

It should be emphasized that South Korea's innovation development model, the government's vision and progress, identifying the need for innovation, and timely response to new trends in the global economy play a crucial role in the successful formation of the economy. The Korean government's significant attention to human capital not only allows the country to establish a "smart industry" but also enables it to become a leading country in creating an "intelligent society" capable of accepting and utilizing new technologies.

Based on the success of South Korea's "smart industry" model, it is recommended that the Republic of Korea continue to prioritize investment in human capital and technology innovation to support the development of the digital economy. It is essential to establish a comprehensive national strategy for digital transformation and create an environment that fosters innovation and entrepreneurship.

To achieve this, the government should provide incentives for companies to invest in research and development (R&D) and implement policies that promote the development of emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain. The government should also support the development of digital infrastructure, including high-speed internet access and 5G networks.

Moreover, it is crucial to focus on improving education and training programs to ensure a skilled workforce that can meet the demands of the digital economy. The government should work closely with universities and the private sector to develop programs that provide students with the necessary skills for the digital age.

Finally, it is recommended that the government establish partnerships with other countries to promote international cooperation in technology innovation and digital transformation. This will enable South Korea to share its expertise and knowledge with other countries while also learning from their experiences.

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[9] In addition to this, Excellent National R&D Outcomes + Calls for National R&D Programs and Projects + Course Look-up Data = total of 103,730 ✓Achievements marked with ScienceON are information that includes papers (1,721,371), patents (847,669), and reports (210,417) arising from national R&D within R&D Outcomes.

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