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Korea's Science and Technology Manpower Policy:
Focusing on the Special Act on Support for Scientists and Engineers and its Action Plans

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Abstract This paper dealt with the Korean manpower policy in science and technology, focusing on the contents and tools of the Special Act and its Master Plans. After briefly introducing the historical development of the Korean manpower policy from the 1960s to the present, it discussed and analyzed the Special Act and Plans from the framework of personnel development, distribution, utilization and infrastructure. Korea's science and technology manpower policy has focused on fostering and supplying manpower in line with the country's industrial growth strategy. In the early stage of industrial development during the 1960s and 1980s, government research institutes were direct and effective tools for nurturing S&T manpower. Since the 1990s, the importance of university research has increased. The government fostered graduate research manpower through the research-oriented university policy of the BK21 program. After the IMF financial crisis in 1997, the tendency of students to avoid careers in science and technology led to enacting the Special Act (2004) governing the field of S&T human resources. The Special Act has contributed to leveling up the university education system in science and engineering and sophisticated the policy to include entrepreneurship training, spin-off startups, industry-university cooperation, and offering degree programs. The Special Act and the regularly revised Master Plans have been essential tools in systematically managing the science and technology manpower policies of the Korean government.

Keywords S&T manpower policy, S&T manpower, Special Act for Scientists and Engineers, manpower master plans, S&T human resource development

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I. Introduction

This study introduces the background and details of the Special Act on Support for Scientists and Engineers, enacted in Korea to nurture and support human resources for science and engineering majors. It also analyzes the main characteristics of the action plans implementing the special law.

Since the 1960s, Korea has recognized the importance of nurturing manpower in the field of science and technology in the process of industrialization and has enabled manpower in science and technology in various ways. In the course of Korea's economic development, the demand for manpower has changed as the main industries have advanced from light industry to heavy industry and from heavy industry to high-tech industry.

In response, the government focused on nurturing high-quality human resources and invested much money in fostering high-quality human resources with master's and doctoral degrees along with investment in R&D. However, in the late 1990s, private companies' investment in science and technology expanded, and manpower demand increased. The government needed to respond to this issue. The imbalance between the supply and demand of science and technology manpower and the utilization of manpower in science and technology emerged as social problems (Cho et al., 2002). It was argued that more systematic support is needed for talented people to advance into science and engineering. In 2004, the Korean government enacted a Special Act on Support of Scientists and Engineers for Strengthening National Science and Technology Competitiveness (hereafter referred to as the Special Act). Since then, manpower development policies have been promoted through the master plan for nurturing science and engineering talents.

This study discusses the definition of science and technology manpower and the scope of science and technology manpower policy in the Korean context. The manpower policies promoted by the Korean government since the 1960s are summarized in terms of manpower development, distribution, utilization, and infrastructure. Then, the contents of the Special Act and the master plans are analyzed in more depth. The Special Act presents the basic direction of human resource development policy in the field of science and engineering in Korean society. This analysis will give policy implications for developing countries seeking economic development using human capital.

II. Conceptual Discussion and Analysis Framework

1. Definition of Science and Technology Manpower

The concept of science and technology manpower can be discussed based on two criteria: the 'occupation' criterion, which identifies whether or not they are engaged in science and technology work, and the 'qualification,' which identifies a certain level of education and major field. For example, the OECD (1995) defined Human Resources in S&T (HRST) as requiring only one of the two criteria to be satisfied based on qualification (higher education completion) or occupation (work in science and technology). The OECD (2015) Frascati manual classified R&D personnel into researchers, technicians and equivalent staff, and other supporting staff according to job types and qualifications. UNESCO (1984) provided a definition for Scientific and Technology Personnel (STP) as individuals who engage in science and technology activities and receive payment for their work based on their occupation, regardless of any specific qualifications required. The US National Science Board (2021) categorized science and technology manpower based on qualifications, requiring a bachelor's degree or higher, and separate occupational standards. However, in 2021, a proposal was put forth to broaden the scope of science and technology manpower to include all educational levels, eliminate qualification standards, and encompass a wider range of workers.

Compared to international discussions, Korea has defined its science and technology manpower based on both qualification and occupational criteria, with a greater emphasis placed on qualification requirements. However, the definition of science and technology manpower in Korea has evolved over time in response to changes in science and technology policy direction.

First, from the 1960s to the mid-1980s, science and technology manpower was divided into scientists, field engineers, and technicians based on job expertise. A scientist (engineer) is a person who completed a 4-year bachelor's degree in science or engineering or a master's or doctoral degree and was in charge of research and development or master plan management. A field engineer (technical engineer) is a person in charge of guidance and oversight of processing and production design, technology and processes at the production site after receiving professional training from a two-year junior college. Lastly, technicians (craftsmen) receive vocational education and training from job training centers and are in charge of production, manufacturing, and equipment operation.

Since the 1980s, the government's science and technology policy has changed to develop national source technology and capacity building. Accordingly, technicians engaged in simple and repetitive tasks were excluded from the science and technology personnel list. Science and technology manpower was divided into R&D manpower in charge of original technology development and industrial manpower working in the field.

Among them, R&D manpower was identified as science and technology manpower. In terms of educational level, science and technology manpower came to mean high-quality personnel with master's or doctoral-level knowledge. Even after the 1990s, the concept of science and technology manpower was discussed, centering on R&D manpower. Accordingly, science and technology manpower was defined based on academic background and major, and fostering master's and doctoral level manpower was discussed as important. Occupational standards were classified according to the workforce's major; such as science, engineering, medicine, agriculture, forestry and fisheries were included (Byun et al., 2013).

In 2004, the Special Act was enacted. This Act covers science and engineering manpower as a person who majored in science, engineering, and related interdisciplinary convergence fields and who has a degree in science and engineering from an educational institution higher than a junior college or an industrial engineer under the National Technical Qualifications Act, or equivalent qualifications (Article 2).

In summary, the concept of science and technology manpower in Korea has gradually changed from an idea that includes technical manpower and industrial technical manpower, including vocational education, to one centered on R&D manpower. In human resource development, interest in nurturing high-quality human resources has increased, and the types of science and technology human resources have been expanded. This study analyzes the contents and tools of manpower policy based on the period of the developmental stages in S&T policy. In particular, discussions will focus on the Special Act and its Master Plans supporting human resources in science and engineering.

2. Scope of Science and Technology Manpower Policy

There is no agreement on the scope of science and technology manpower policy in Korea, and the scope has been defined according to changes in the policy environment. During the industrialization period, when the light and heavy-chemical industries were promoted, the focus was on manpower development to expand the supply of manpower. Recruiting foreign talent to secure high-quality human resources was also presented as an important policy task. Major policy concerns have emerged around the supply of manpower tailored to technical demand in the production field, re-education of the existing workforce, and securing occupational stability, as the private sector's capacity has strengthened and the industry has advanced. During this process, policy infrastructure was established continuously, including the creation of educational institutions and the enactment of laws. The Special Act on Science and Engineering can be understood as an effort of the Korean government to systematize existing policies to strengthen the competitiveness of human resources in science and technology and to attract outstanding talent to the field of science and engineering. The scope of science and technology manpower policy has changed over time, leading to variations in how each researcher sets and interprets its scope. However, despite these differences, there is a shared approach to science and technology manpower policies. Previous studies in Korea have identified the scope of science and technology manpower policies in terms of manpower development, manpower distribution, manpower utilization, and infrastructure (Um et al., 2007; Noh, 2007; Lee et al., 2008; Byun et al., 2013). For example, Byun et al. (2013) summarized the research results so far and defined science and technology manpower policy as supporting the accumulation of capabilities through education, training, learning, and R&D as well as establishing norms and networks related to all activities necessary for the distribution and utilization of the nurtured manpower. (Byun et al., 2013).

This study utilized perspectives from previous research to investigate the scope of science and technology manpower policies in the four categories listed in <Table 1>. It analyzed Korea’s science and technology manpower policy since the 1960s, dividing it into four aspects: fostering, distribution, utilization, and infrastructure. Drawing on previous studies, the core contents of each category can be discussed as follows.

First, manpower development is an activity to nurture manpower, and the training targets include elementary, middle, and high school students and college (graduate) students. The main means for nurturing manpower differs depending on the target. Improvement of educational programs for acquiring knowledge and skills, learning support such as scholarships, and research support are promoted.

Second, distribution is an activity related to the supply and demand of human resources and the movement and deployment of human resources in the labor market. New labor market participants and the unemployed are the main targets of the policy. Training, employment support, and startup support are promoted as major means.

Third, utilization includes contents related to the operation of manpower. It means developing the capabilities of human resources who have settled in the labor market and creating an environment where they can work. Among those in the science and technology industry, it is related to the incumbent, the vulnerable, and the utilization of overseas manpower. Vocational competency development and research support for incumbents, support for female and retired scientists and engineers, attracting and utilizing overseas human resources, and supporting international research by domestic human resources are promoted.

Finally, infrastructure construction is related to improving legal systems for human resource development, setting up education and research facilities, and supporting human resource policy research, statistics production, and researcher's welfare improvement.

Table 1. Scope of Science and Technology Manpower Policy

Category	Policy Target	Content
Personnel Development	• Elementary, middle and high school students, and college(graduate) students	• Improvement of educational program • Learning support(scholarship, research support) • Career guidance and vocational training
Distribution	• Unemployed, Startup founder	• Employment support(training, subsidies, etc.), startup support
Utilization	• Incumbents, female and retired scientists, overseas S&T human resources	• Research support, vocational competency development support, industry-academia-research cooperation support, technology transfer support
Infrastructure	• Legal system, various facilities related to S&T manpower policy	• Enactment and amendment of S&T related laws, establishing information system, set-up education and research institutions

Source: Authors, based on Um et al. (2007), Lee et al. (2008) and Byun et al. (2013).

3. Research Content

This paper analyzes the contents of the Special Act and its implementation plans. Chapter 3 describes the development process of Korea's science and technology manpower policy from the 1960s to the early 2000s. The historical development of Korea's science and technology manpower policy is described in terms of manpower development, distribution, utilization, and infrastructure.

Chapter 4 describes the main contents and characteristics of the Special Act enacted in 2004 and the process of 5 times revisions of the master plan. The implementing basic plans were analyzed from Personnel Development, Distribution, Utilization and Infrastructure.

In the conclusion of Chapter 5, policy implications that can be confirmed through analysis of the Special Act and the master plans are discussed.

Table 2. Research Framework for Analyzing Master Plan

Category	1st and revised Master Plan (2006-2010)	2nd Master Plan (2011-2015)	3rd Master Plan (2016-2020)	4th Master Plan (2021-2025)
Personnel Development				
Distribution				
Utilization				
Infrastructure				

Source: Authors.

III. Development Process of Korea's Science and Technology Manpower Policy

1. 1960s ~ 1980s

In the 1960s, the Korean government selected light industry to focus on and promoted the transition from agrarian to industrial society. The vocational education system was reformed to nurture skilled workers. In addition, vocational training centers were operated to nurture skilled manpower in industrial settings. On the one hand, the Korea Institute of Science and Technology (KIST), Korea's first government-funded research institute, was established in 1966 to utilize high-quality R&D personnel and attract Korean scientists abroad. From 1968 to 1969, 29 overseas Korean scientists and engineers were invited for two years, and this attempt was more fully carried out in the 1970s. While operating KIST, the government provided necessary funds, guaranteed research autonomy and stability, and ensured fair treatment so that researchers could focus on their research activities (Cho et al., 2002; Byun et al., 2013). At the infrastructure level, a plan for manpower training was established and executed through the 5-year science and technology promotion plans. The Industrial Education Promotion Act (1963) and the Vocational Training Act (1967) were enacted to promote vocational and technical education.

In the 1970s, in fostering the heavy and chemical industry, Korea divided science and technology manpower into scientists, field technicians, and technicians and promoted manpower development policies for each target. The fostering of scientists and engineers was promoted by supporting 4-year universities. Supported universities were designated by region and specialized according to the industries to be fostered. In 1971, the Korea Advanced Institute of Sciences (KAIS), a research-centered graduate school in science and engineering, was established under the Ministry of Science and Technology. KAIS had critically contributed to cultivating high-quality scientists and engineers. In the 1970s, KAIS cooperated with KIST and pursued industry-university collaboration in its educational program.

To nurture field technicians, vocational-technical education institutions were reorganized into junior colleges to perform the function of higher vocational education institutions linked to high schools.[1] Vocational school education was strengthened for skilled workers, and field training for vocational students was introduced. As for the utilization of manpower, in the 1960s, the government also promoted attracting excellent foreign manpower. Through the 1970s, it successfully attracted 225 people permanently and 229 people temporarily (Cho et al., 2002).

Regarding infrastructure, the 3rd Five-Year Plan for Science and Technology Promotion (1972-1976) presented policy directions for the supply and demand of science and technology human resources and training.

Entering the 1980s, the Korean government sought to localize technologies in key industries such as textiles, petrochemicals, electronics, machinery, shipbuilding, and automobiles, while securing technological prowess in high-tech industries such as semiconductors, telecommunications, and fine chemicals. R&D and technological innovation were emphasized, supported by the 5th Five-Year Plan for Economic and Social Development (1982-1986). In the science and technology manpower policy, the axis of manpower training has changed from skilled manpower who received vocational education to high-class manpower training. The government established a manpower training system for high school, university, and graduate school. In 1981, the Korea Advanced Institute of Science and Technology (KAIST) was established by integrating KAIS, a graduate school specializing in science and engineering, and KIST, a government-funded research institute. In 1983, a science high school was established for gifted education; in 1985, the Korea Institute of Technology (KIT), a science and technology college, was established. As a result, an education system for gifted students in science was established, leading to science high schools, KIT and KAIST. In 1989, KAIST was separated from KIST and merged with KIT to become a full-fledged university with all degree levels. In the private sector, Pohang University of Science and Technology (POSTECH) was established in 1986 to nurture science and engineering personnel. In addition, to utilize overseas high-quality human resources, the project to attract Korean scientists and engineers abroad was continuously promoted. After studying abroad, many scientists and engineers returned to Korea and settled in universities and research institutes.

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1 The government established vocational training centers in the 1960s and technical high schools in the 1970s to provide skilled workers and expedite the transition from light industries to heavy and chemical industries.

Table 3. Development Process of Korea's S&T Manpower Policy (1960s-1980s)

Category	1960s	1970s	1980s
Policy Goal	Nurturing skilled workers in light industry	Nurturing field technicians in heavy and chemical industry	Nurturing high-class scientists and engineers
Policy Environment	Transition from Agriculture to light industry	Transition from light industry to heavy industry	Competition to nurture high-tech industries
Personnel Development	- Vocational training for skilled workers - Reorganization of vocational high school curriculum	- Reinforcing field training for vocational high schools - Nurturing science and engineering graduate students	- High school-university-graduate school linked talent development system - Nurturing science gifted students
Distribution	-	-	-Mandatory recruitment by public enterprises for junior college graduates
Utilization	Attracting overseas Korean scientists and engineers	Attracting excellent overseas brains	Attracting excellent overseas scholars
Infrastructure	- Five-Year Plan for Science and Technology Promotion(1962-) - Industrial Education Promotion Act (1963) - KIST(1966) - Vocational training centers	- Five-Year Plan for Science and Technology Promotion(1972-) - KAIS (1971)	- Five-Year Plan for Economic and Social Development(1982-) - KAIST(1981) - Science high school(1983~) - KIT(1985) - POSTECH (1986)

Source: Authors, based on Cho et al. (2002) and Byun et al. (2013).

2. 1990s ~ Early 2000s

In the 1990s, the government's support was focused on establishing an R&D system necessary for industrial technology innovation and developing basic technologies through R&D programs. Manpower policy is also needed to adapt to the new goals. It was intended to enhance competitiveness and investment efficiency by intensively fostering specific fields of a small number of universities.

In particular, education centered on graduate schools was promoted, and the Brain Korea 21 (BK21) program, which selects major graduate schools in each field and provides intensive support, is a key policy. This program has been promoted since 1999; as of 2023, the 4th stage program is being promoted. In 2003, government-funded research institutes jointly established the University of Science and Technology (UST) to promote field-oriented master's and doctorate training. In 2023, 32 government and public research institutes participate in the graduate education of the UST.

In terms of manpower distribution, policies to create jobs for science and technology manpower were strengthened. The intern researcher support project was promoted to allow up-and-coming masters and doctors in science and engineering to work at universities, corporate-affiliated research institutes, and funded research institutes. The government operated science and engineering manpower placement centers in order to support the employment of science and technology manpower actively. In the 2000s, with the enactment of the Framework Act on Science and Technology and the establishment of the master plan, as one of the measures to expand public positions for science and engineering majors, the government sought to increase the ratio of public officials in managerial-level technical positions to 30% by 2008 (Byun et al., 2013).

In terms of utilizing science and technology manpower, through industry-university-institute cooperation master's and doctoral courses in 1991, universities provided lectures in basic and major courses, joint guidance on thesis, and awarding of degrees, and research institutes provided lectures and laboratory guidance on special field majors. A program was also operated to support student dispatch and education expenses. Since 1994, the Brain Pool project has been promoted to invite and utilize overseas advanced scientific brains. Foreign engineers with over 5 years of overseas R&D experience were invited in various fields, including machinery/materials, electricity/electronics/information communication, chemical engineering/life science, resources/marine, and energy. In addition, continuous international cooperation was promoted by providing opportunities for foreign researchers to train at domestic universities and research institutes. In 2003, through the overseas field research support project, young researchers were dispatched to the source of high-tech technology to support their research activities. In addition, a program was operated to provide the technical support necessary for industrial sites by utilizing former and current scientists and engineers as volunteers.

In terms of infrastructure, the Framework Act on Science and Technology was enacted, and the educational foundation for gifted students in science was expanded. First, the Framework Act on Science and Technology established a legal basis for the comprehensive and systematic promotion of Korea's science and technology-related policies. In 1997, the Special Act on Science and Technology Innovation was enacted as a five-year temporary law. A legal basis was established for the promotion of research and human resource development plans for science and engineering universities, support for human resources for companies participating in R&D projects in key countries, and human resource development based on industry-academia-research cooperation. In 2001, the Framework Act on Science and Technology was enacted by integrating the Special Act on Science and Technology Innovation and the Science and Technology Promotion Act. Under the Framework Act on Science and Technology, measures reflecting realistic aspects were promoted, such as establishing plans for fostering and utilizing science and technology human resources, preparing alternatives for revitalizing local and female scientific human resources, discovering and nurturing scientifically gifted students, and preparing support measures for expanding the employment of scientific engineers. Next, the system for gifted science education was expanded. In 2001, Korea Science Academy was established based on the Gifted Education Promotion Act.

Table 4. Development Process of Korea's S&T Manpower Policy (1990s-Early 2000s)

Category	1990s	Early 2000s
Policy Goal	Nurturing high-class scientists and engineers	Nurturing high-class scientists and engineers
Policy Environment	- Financial liberalization - Financial crisis(IMF bailout)	- New technology (IT, BT, NT, GT) emergence - Avoidance of science and engineering by students
Personnel Development	- Project for producing masters and doctorates in basic science and advanced science - Intensive support project for engineering college - BK21 Program(1999-)	- Nurturing science-gifted students - Nurturing and supporting female scientists and engineers - BK21 Program
Distribution	- Intern researcher support program for master's and doctorate manpower - Placing S&T manpower to SMEs	- Expansion of public officials from science and engineering majors
Utilization	- Operation of industry-university-research institute joint master's and doctoral courses - Brain Pool Project(1994-) - Science and technology volunteer corps	- Overseas field research support project
Infrastructure	- Special Act on Science and Technology Innovation(1997) - 5-year plan for STI (1997~)	- Framework Act on Science and Technology (2001) - S&T master plan(2002~) - Korea Science Academy (2001)

Source: Authors, based on Byun et al. (2013).

IV. The Special Act and Master Plans: Contents and Policy Tools

The full title of the Act is the Special Act on Support for Scientists and Engineers to Strengthen National Science and Technology Competitiveness, showing the purpose of enacting the special law. Here, we will examine the Act's main contents, policy tools and implementation plans. When a special law is enacted in Korea, a master plan for its implementation is prepared, and it is usually revised with updates every five years.

1. Background and Purpose of Enactment

From the 1960s to the early 2000s, Korea's science and technology manpower policy successfully led to industrial and economic development but faced a new situation.

First, the need to improve the quality of science and technology manpower has increased. It is because Korea has to develop its own basic and original technologies with the advancement of the industrial structure from imitation to innovation.

Second, as Korea went through the IMF crisis in 1997, the treatment of science and engineering majors became a major social issue. With the IMF financial crisis outbreak, the government promoted personnel reform in public institutions. At this time, the number of researchers at government-funded research institutes was primarily reduced. Businesses also underwent restructuring by reducing R&D investment and the number of science and engineering majors. It has led to a phenomenon in which excellent talents avoid entering the science and engineering fields. The rate of outstanding talent entering the field of science and engineering plummeted, and the phenomenon of hollowing out of graduate schools in science and engineering appeared (Lee, 2012).

Third, in addition, the fact that interest in mathematics and science is at the lowest level in the OECD, the problem of the insufficient education and research environment of domestic science and engineering universities, and the outflow of high-quality experts abroad have emerged as new problems in the science and technology manpower policy.

Accordingly, it was argued that it is necessary to induce excellent talents to go to universities in science and engineering and to prepare a legal foundation to boost morale and improve the treatment of science and engineering personnel (Kang et al., 2003). In April 2004, the Special Act was enacted to strengthen national science and technology competitiveness.

2. Contents of the Special Act

The Special Act makes it clear that the purpose of the law is to contribute to the improvement of national competitiveness and the development of the national economy by nurturing excellent human resources in science and engineering, facilitating their utilization and improving their treatment (Article 1). Specifically, it covers topics related to scientists and engineers[2], such as fostering them, promoting utilization and improving their status, and establishing infrastructure. It was enacted in 2004 and consisted of 4 chapters and 25 articles. Looking at the main contents, chapter 1 stipulates the reason and purpose for enacting laws as a general rule and the responsibilities of the state. Chapter 2 stipulates the implementation of master plans for fostering and supporting science and engineering human resources. Chapter 3 discusses ways to nurture human resources in science and engineering. Chapter 4 contains contents to promote the utilization of science and engineering human resources and improve their status.

The contents of the law are divided into the manpower development, distribution, utilization, and infrastructure aspects of science and technology human resources and are as follows.

First, in terms of human resource development, the Act includes financial support for excellent human resources (Articles 9 and 20), support for the operation of programs for fostering science and engineering human resources at universities and graduate schools (Article 21), and fostering and support of research-oriented universities (Article 11). It can be seen that the focus is on manpower training centered on universities.

Second, in distributing manpower, the government's role in securing jobs for science and engineering workers was presented. It was stipulated that improvement plans be prepared to expand the employment of science and engineering personnel as public officials (Article 13). The central government supported the establishment of science and technology departments in local governments and the deployment of science and engineering personnel (Article 14). The central government allowed local governments to promote the employment of unemployed workers with master's and doctoral degrees through national R&D projects. In addition, it was allowed to support the training of unemployed personnel at funded research institutes (Article 15). Employment promotion for science and engineering personnel was supported not only in the public sector but also in the private sector. When SMEs and

2 The science and engineering manpower supported by the Special Act was defined as a person who majored in science and engineering and related interdisciplinary convergence fields.

venture companies hire science and engineering personnel, they can provide support such as tax reductions to the company (Article 16).

Third, regarding manpower utilization, support for re-education and retraining of science and engineering manpower (Article 12), cooperation between industry, academia and research institutes, and expansion of manpower exchange (Article 17) was stipulated.

Lastly, in infrastructure construction, the establishment and utilization of a comprehensive information system for the supply and demand of scientists and engineers (Article 6), a fact-finding survey on science and engineering human resources, preparation of a balance sheet for inflow and outflow of scientists and engineers at home and abroad (Article 7), the establishment of a research and development job placement center (Article 22), development of R&D service business[3] and establishment of a qualification system (Articles 18 and 19) were specified.

Table 5. Contents of the Special Act

Category	Content	Article
Personnel Development	- Expansion of opportunities for brilliant students to receive scholarships	9
	- Fostering and supporting research-centered universities	11
	- Provision of research subsidies to scientists and engineers	20
	- Support university programs (for example, programs to strengthen research and education between the educational system, and programs to induce talented students)	21
Distribution	- Establishment of improvement measures to expand appointment as public officials	13-14
	- Promotion of R&D projects to foster the employment of scientists and engineers	15
	- Support enterprises to utilize scientists and engineers (for example, giving financial support or tax reduction and exemption)	16
Utilization	- Re-education and retraining of scientists and engineers	12
	- Cooperation and expansion of manpower exchanges between industrial, academic and research circles	17

3 The R&D service business is classified into research and development, which independently conducts research and development in the field of science and engineering or commissioned development, and R&D support business, which supports research and development in the field of science and engineering through the provision of technical information, consulting, testing and analysis. The legal basis for fostering and supporting the research and development service business was changed to the Research Industry Promotion Act enacted in 2021.

Category	Content	Article
Infrastructure	- Establishment and utilization of information system	6
	- Conducting a fact-finding survey, and making an inflow and outflow index of scientists and engineers	7
	- Fostering R&D service business and introduction of national qualifications for R&D service business	18-19
	- Establishment of R&D job placement center	22

Source: The Korean Law Information Center
https://www.law.go.kr/LSW//lsInfoP.do?lsiSeq=83923&chrClsCd=010203&urlMode=engLsInfoR&viewCls=engLsInfoR#0000 (accessed on January 27, 2023)

3. Master Plans for Implementing the Special Act

3.1 Promotion Direction of the Master Plans

The Special Act stipulated that the government should establish a master plan to nurture and support human resources in science and engineering every five years.

The master plan contains the following discussions (Article 4):

1) Nurturing and support to scientists and engineers and developing a system of utilization during the whole life cycle;
2) Expansion of opportunities for scientists and engineers to take public office and improvement of treatment;
3) Support for the results of research and development and the results of technology transfer;
4) Expansion of exchanges of scientists and engineers between enterprises, universities, research institutes, the central and local governments;
5) Development of an information system of scientists and engineers and utilization;
6) Qualitative improvement of education of the science and engineering universities and graduate schools, and strengthening the linkage system between industrial, academic and research circles.

Through the master plan, a system was established to comprehensively present the goals and directions of manpower policies for science and engineering majors and to allow the departments in charge to play their roles in each field. In order to monitor the progress of the plan, the implementation plan and implementation status were inspected on an annual basis. The National Science and Technology Advisory Council deliberates on each year's results.

In August 2005, the 1st Master Plan for Nurturing and Supporting Scientists and Engineers (2006-2010) was established. By 2023, the master plan was established through five rounds. As the government changed in 2008, the 1st master plan was partially revised, making it 5 times in total.

The characteristics of the master plans by period are as follows. First, the 1st master plan focused on fostering, utilizing, and improving the treatment of scientists and engineers. 14 key tasks for promotion in 5 areas were presented. As five major areas, science and engineering university education innovation, core research manpower training, demand-oriented talent cultivation, science and engineering manpower welfare support, and science and engineering manpower infrastructure support, were suggested.

The government focused on helping talented people enter the science and engineering fields. Policy means were proposed to expand the entry into the public sector and promote the employment of science and engineering personnel, to create a foundation for promoting industry-academic-institute linkage, and to promote the commercialization of technology.

Second, in 2008, the Ministry of Education and the Ministry of Science and Technology were integrated through the reorganization of the government. The Ministry of Education, Science and Technology was newly established, and the master plan was revised. While maintaining continuity with the 1st Master Plan, the importance of education was emphasized, and the scope of science and technology manpower was expanded to elementary and middle schools.

Third, the 2nd Master Plan established in 2010 proposed tasks for each policy beneficiary group, such as elementary and secondary schools, universities, and government-funded research institutes. Selected were the following implementation tasks;

1) Enhancement of the understanding, interest, and potential in science and technology in elementary and middle schools;
2) Strengthening education and global research capabilities in universities (graduate schools);
3) Participation in education and creating a research-promoting environment by government research institutes;
4) For the business area, improving the ability of corporate research personnel and fostering research-pursuing companies;
5) In the area of infrastructure, promoting the use of potential manpower and strengthening the policy foundation for science and technology manpower.

Fourth, the 3rd Master Plan established in 2016 presented 12 key tasks of the 6 strategies. The six major strategies include strengthening the employment and startup capabilities of science and technology talents, strengthening the education and research competitiveness of science and engineering universities, expanding the career development and activity base of scientists and engineers, enhancing the creative capabilities of future talents, maximizing the use of potential human resources in science and technology, and manpower in science and technology. The establishment of a foundation for fostering and supporting was proposed. In the 3rd Master Plan, finding jobs for science and engineering personnel and recruiting science and engineering personnel in SMEs emerged as major issues. Considering the unemployment problem of science and engineering majors as the most important factor, it emphasized the strengthening of employment and startup capabilities of science and technology human resources, the improvement of science and engineering university education programs tailored to the field demand such as companies, and the strengthening of science and engineering university research capabilities.

Fifth, the most recent 4th Master plan established in 2021 presented 14 key tasks of the 4 strategies. It focused on cultivating and utilizing manpower in response to changes in industrial technology, such as the spread of COVID-19, trade conflicts between countries, and climate change. Fostering new technologies and businesses, establishing a research base and expanding support for young researchers, strengthening the professional capabilities of science and technology personnel in response to the digital age, and establishing an environment to promote the continuous influx of human resources were suggested.

3.2 Main Contents of the Master Plans

a. Human Resource Development

Since the Special Act was enacted to respond to the avoidance of science and engineering majors, human resource development is the most important part of the master plan. Two areas were largely promoted: university (graduate school) education and elementary/secondary education.

Nurturing excellent talent by strengthening the competitiveness of universities was continuously emphasized from the 1st plan to the 4th plan. It was promoted by fostering research-oriented universities, industry-university-research cooperation-oriented universities, and innovation in university education methods.

First, the BK21 program is a representative example of fostering research-oriented universities. It selected excellent universities and supported master's and doctoral students and postdoctoral researchers. Scholarships for graduate students, labor costs for researchers, and expenses for international events and business operations were provided. It was a program that had been implemented since 1999, but when the results appeared, the 2nd stage BK21 program was included as a detailed task of the 1st plan announced in 2005. The follow-up plan has also been promoted as a detailed task, and as of 2023, the 4th stage of the program is underway.

In addition to regular universities, programs for S&T-centered universities were also operated. In the 2nd Master Plan, the four science and technology universities in Korea, KAIST, GIST, DGIST, and UNIST, were to be fostered as research bases in science and engineering. Furthermore, the role of UST, jointly established by government-funded research institutes in science and technology, was emphasized. Through the 2nd and 3rd plans, the number of students and faculties at UST has increased.

Second, as an example of cultivating talent through industry-university-research cooperation, the Leaders in Industry-University Cooperation project proposed in the 2nd Master Plan can be mentioned. Through industry-academia cooperation, it aims not only to nurture manpower but also to share technology between industry and academia and promote commercialization. In order to nurture talents tailored to the industry, the universities selected for support introduced industry-university-linked courses such as field practice and capstone design. The academic system was reorganized, such as the leave of absence system for entrepreneurship and the introduction of the project semester system. The number of academic professionals, such as professors focusing on industry-university cooperation and professors specializing in business, was also expanded.

Third, it tried to improve university education quality by innovating it. For example, the Advancement for College Education project introduced in 2010 encourages universities to develop curricula and innovate their operating systems voluntarily. Following the university's educational goals and philosophy, innovation in major studies, liberal arts education, and extracurricular activities were supported to nurture talent.

Next, secondary education for elementary, middle and high schools emphasized science education as the Ministry of Education and the Ministry of Science and Technology were integrated in 2008. The master plans proposed plans for reorganizing the curriculum, strengthening teacher expertise, and operating a school for gifted students in science.

First, the curriculum was reorganized. In the 2nd Master Plan, measures to strengthen STEAM education were presented. Mathematics strengthens creative problem-solving skills, science expands experimental exploration, and technology is revised to include cutting-edge science technology and real-life related content. Classes linking science and art education were also expanded. In the 3rd Master Plan, educational support was also strengthened to respond to the digital age. SW meister high school operation, elementary and middle school SW education vitalization project and online SW education were promoted. The 4th plan was to operate an AI-education-leading school to strengthen AI education.

Second, the professionalism of teachers was strengthened. In the 2nd Master Plan, the facilities and manpower possessed by government-funded research institutes and universities were used to operate educational training programs for math and science teachers. The 4th plan includes retraining about 1,000 in-service teachers yearly to become experts in AI convergence education by operating digital education bases (Software Future Prospect Center) in each region.

Third, the policy to nurture scientifically gifted students was strengthened. In the 1st revised plan, the expansion of science-gifted education was presented as a task to be promoted. The 2nd plan linked science-gifted schools and university curricula to induce gifted students to attend university. The 4th plan planned to introduce a science-gifted education program certification system to improve the quality of science-gifted education.

b. Manpower Distribution: Taking Public Positions and Expanding Employment in Businesses

Regarding the distribution of manpower, the 1st Master Plan emphasized support for recruiting science and engineering majors to public positions. However, the government's role was gradually expanded to include employment, entrepreneurship, and employment expansion through linkages with private companies.

The 1st and 2nd plans focused on employment support for scientists and engineers, such as expanding entry into the public sector for science and engineering graduates, supporting SMEs and venture companies to hire unemployed science and engineering masters and doctorates, operating science and engineering manpower placement centers, and holding recruitment fairs.

In the 3rd plan, which was implemented in 2016, plans and activities to strengthen the entrepreneurial capabilities of science and engineering majors were highlighted more than in previous plans. In order to support startups in the field of science and engineering, projects to nurture leading startup universities and the establishment of degree programs customized for startups were promoted.

In the 4th plan, plans were proposed to expand technology entrepreneurship degree courses, expand support for attracting outstanding foreign talents who wish to start a technology-based business in Korea, and support international students' employment in domestic small and medium-sized enterprises.

c. Manpower Utilization: Career Development of Scientists and Engineers

The use of manpower was promoted through the re-education of people in the field of science and technology, activation of industry-university-research manpower exchanges, attraction of overseas manpower, and support for female and highly-experienced scientists and engineers.

First, manpower re-education has been emphasized from the first plan. It entrusted the manpower of industries to industrial colleges and junior colleges for training and established career development support centers at universities to strengthen the re-education.

Second, the vitalization of industry-academia-research manpower exchanges is also an important agenda. When hiring professors, preferential treatment was given to those with experience in the industry, and the number of adjunct professors was expanded. Through the 2nd plan, an academic-research professor system was introduced in which a researcher at a research institute can work as an adjunct professor at a university. A university professor can work as an adjunct researcher to vitalize human resource exchanges between universities and research institutes (Article 37-2 of the Industry-University Cooperation Act).

Third, discussions on attracting and utilizing excellent foreign talents were promoted. An example of attracting overseas talent is the Brain Pool project. Although the project started in 1994, it has been continuously promoted since it was included in the detailed tasks of the basic plan while establishing the second plan. This project supports the personnel expenses and attracts the expenses of outstanding foreign scientists who are invited to joint research by government research institutes and universities. Preference was given to experts in new industries and essential national strategic technologies. In addition, the 4th plan proposed a plan to establish an organization dedicated to human resource exchange support for overseas researchers and conduct a fact-finding survey on foreign researchers' domestic activities to vitalize human resource exchange.

Fourth, ways to utilize women and senior scientists were discussed. It is closely related to the demographic change toward low birth rate and aging population. Regarding the utilization of female manpower, the second plan included measures to support the expansion of women's entry into science high schools and to provide research scholarships to excellent female university students. The 4th plan included re-employment training for women whose careers were interrupted due to maternity and parental leave and measures to support labor costs for female researchers in small and medium-sized enterprises.

For high-career scientists and engineers, the 2nd plan presented support measures focusing on the utilization of the knowledge and experience of senior scientists. Arrangements can be made for science and technology commentators and the re-employment of small and medium-sized enterprises. The 4th plan includes a plan to support high-career scientists and engineers to design their own lives after retirement through career redesign education.

d. Establishing Infrastructure: Status Survey and Information System

The important discussions for the infrastructure were conducting fact-finding surveys and building an information system. The special law stipulated that the government should establish an information system on the supply and demand of science and engineering personnel (Article 6) and conduct a fact-finding survey on the training, utilization, and treatment of science and engineering personnel (Article 7).

The fact-finding survey on the cultivation and utilization of science and engineering personnel was included in the 1st plan, and the establishment of a comprehensive information system for science and engineering personnel was included. Regarding the fact-finding survey, the 4th plan presented a plan to reorganize statistical surveys, such as surveying job migration routes for masters and doctoral students in science and engineering and forecasting mid- to long-term manpower demand for new industries (AI, semi-conductors, future vehicles etc.), and reorganizing existing statistics.

Building a comprehensive information system includes the collection and distribution of information. Regarding information collection, the master plans presented not only information on the current status of science and engineering manpower in universities, research institutes, and companies but also various types of science and technology manpower DB construction plans. For example, in the 2nd plan, the establishment of an information database for Koreans residing in science and technology was included. In the 4th plan, establishing an individual researcher's national R&D performance history information database was included as a detailed task. Moreover, regarding information distribution, the 3rd plan promoted establishing a system to provide online statistics, indicators, and trend information related to science and engineering. In 2018, the Human Resources for Science & Technology Policy Platform was completed as a comprehensive information system for human resources policy.

Table 6. Contents of the Master Plans

Category	1st and revised Master Plan (2006-2010)	2nd Master Plan (2011-2015)	3rd Master Plan (2016-2020)	4th Master Plan (2021-2025)
Personnel Develop-ment	- Fostering research-centered university(BK21) - Operation of a science-gifted development program (revised plan)	- Research support for the sci.-centered graduate school - Industry university-research cooperation program - Improvement of univ. education quality - Strengthening STEM edu. - Expanding UST	- Expanding the role of UST - Reinforcing elementary, middle, and high school ICT and SW education -Strengthen entrepreneur- ship education	- Reinforcing elementary, middle, and high school AI and SW education - Strengthening teacher capacity (AI, SW fields) - Introduction of science gifted education program certification
Distri-bution	- Expansion of public officials from science and engineering majors - Employment support for SMEs/Ventures	- Expansion of managerial-level civil servants from sci. and eng. fields - Employment support for SMEs/Ventures	- Reinforcing entrepreneur ship education and offering a degree course - Fostering leading-universities for startup	- Mentoring & degree courses for technology startups - Startups by overseas talents - Attraction of international students

Category	1st and revised Master Plan (2006-2010)	2nd Master Plan (2011-2015)	3rd Master Plan (2016-2020)	4th Master Plan (2021-2025)
Utili-zation	- Establishment of a career development center in a university - Attracting foreign scientists and engineers (revised plan)	- Introduction of research professor system - Attracting int'l sci. & eng. (Brain Pool program) - Support for women and senior scientists	- Attracting foreign sci. & eng. - Supporting women sci. & eng. - Talent donation program using retired sci. & eng.	- work-study rotation system for SME-employed - Support for women sci. & eng. - Career retraining of senior sci. & eng. - Reinforced attraction of overseas researchers in new industries (Brain Pool +)
Infra-structure	- Conducting a fact-finding survey on utilizing scientists and engineers - Building a comprehensive information system	- Overseas Korean S&T manpower information database - Designation of S&T manpower policy institute for information system	- Establishment of an online comprehensive information system for science and technology manpower	- Database on researcher's R&D performance history - Conducting a fact-finding survey related to new promising jobs

Source: Authors, based on 1st to 4th Master plans.

V. Conclusion: Summary and Implications

Korea's science and technology manpower policy has focused on fostering and supplying manpower in line with the country's industrial growth strategy. In the early economic development stage, the focus was on fostering skilled manpower and field technicians. Foreign Korean scientists were invited and utilized in the areas where high-quality manpower was needed.

In the 1960s, the emphasis was on attracting Korean scientists abroad, and then the policy gradually evolved into utilizing their experience to build government research institutes. KAIST was established in the 1970s to nurture excellent talents in science and engineering. Since the 1980s, with an emphasis on high-quality human resources, science high schools were established to strengthen gifted education in the secondary education system. The Korean government promoted the mandatory recruitment of junior college graduates and the operation of an R&D job placement center to support the employment of scientists and engineers.

At the institutional level, the Framework Act on Science and Technology enacted in 2001 stipulated the training and utilization of scientists and engineers as a legal provision. Korea's science and technology manpower policy has been promoted through the overall sector of the utilization, distribution, and infrastructure of science and technology manpower, with manpower development as the core.

However, after the 1997 IMF financial crisis, the issues such as insufficient education and research environment in domestic science and engineering universities, unemployment of high-quality manpower with master's and doctorate degrees, the outflow of high-quality professionals overseas, and refusal of excellent talents to go to science and engineering became new challenges in the manpower policy. In 2004, the Special Act to support scientists and engineers was enacted to solve the problems.

The Special Act stipulated that master plans should be established and comprehensive policies for manpower in science and technology should be implemented. After the 1st Master Plan was established in 2005, the 4th Master Plan is currently being operated. The characteristics that appeared in the master plans are as follows.

First, the government continued to expand the recipients of support. The 1st plan(2006) implemented the 2nd stage of the BK21 program(2006~2012), targeting graduate students for building up university research capacity, and the 2nd plan implemented various programs to advance university education as a whole, followed by expansion to elementary, middle school and science-gifted high school students and teachers.

Second, regarding the distribution of manpower, the government initially focused on expanding the recruitment of scientists and engineers to public positions and supporting job placement in small and medium-sized venture companies. Since then, the 3rd plan emphasized entrepreneurship competency, degree courses, the university's leading functions, etc. The 4th plan expanded programs, such as entrepreneurship programs (mentoring, degree courses), spin-offs by overseas talent, and attraction of international students.

Third, the utilization of manpower has expanded the target groups to include female scientists and engineers, highly experienced scientists and engineers nearing retirement, and attracting international scientists (Brain Pool Project).

Fourth, in terms of infrastructure, statistical surveys on scientists and engineers were strengthened. A comprehensive information system was established to monitor the information on the need and supply of scientists and engineers. The 2nd plan designated a responsible institute for the information system, and the 3rd introduced an online data system. The 4th planned to manage researchers' R&D performance history.

The Special Act and the continuously revised master plans have been essential tools in systematically managing science and technology manpower policies, which were previously individually dispersed and uncoordinated among ministries. The Special Act and master plans have connected various manpower policies (e.g., BK21, Brain Pool) and responded to new social and technological changes, raising the effectiveness of manpower policies as a whole.

The Korean government has gradually moved away from a supply-led approach of developing scientists and engineers and has shifted to a demand-oriented manpower policy that supplies manpower while considering the needs of industries. Creating new industries and jobs, venturing tech-based companies and spin-offs, facilitating industry-academic cooperation and securing edge-cutting human resources at the global level have gained new importance in the manpower policy, leading to the primacy of the demand side.

Regarding policy implications, two points need to be mentioned. First, in the early stage of industrial development during the 1960s and 1980s, government research institutes were direct and effective tools for nurturing S&T manpower. Korea needed highly educated people to promote the industry. The government established the Korea Institute of Science and Technology (KIST) in 1966 to promote basic technologies for the industry and invite Korean scientists abroad.[4] Afterwards, many government-funded research institutes (GRIs), such as ADD, KDI, KREI, and KIET, were established in the 1970s.[5]

During the initial phase of economic development, GRIs played a significant role as the primary driving force for promoting the economy and industry while also nurturing manpower. The integration of the building of government research institutes, the development of the economy and industry, and the training of science and technology manpower was a crucial aspect of this process.

Second, university research has gained greater significance since the 1990s, following the development of GRIs in the 1970s and the expansion of industry and private companies in the 1980s. Until the early 1990s, universities were

4 “Scientists from abroad received free housing, health insurance, and all moving expenses. While three times those of public university professors in Korea, their salaries were still around 25% of what they were offered in the U.S. Many scientists came back to contribute to the development of their home country. Later, the government established other government research institutes, bringing more professionals back to Korea.” (The footnote is cited from a script of the Global Knowledge Exchange & Development Center exhibition hall in Seoul. visited on 10th Jan. 2023)

5 The full names of the GRIs are ADD(Agency for Defense Development), KDI(Korea Development Institute), KREI(Korea Rural Economic Institute) and KIET(Korea Institute for Industrial Economics & Trade). They were established as leading institutes in the 1970s. In the 1980s, the Daedeok Research Complex was established, which spatially integrated the GRIs, and GRIs specializing in various fields such as electronics, telecommunications, materials, and bioscience were established.

regarded as institutions mainly training human resources to meet industrial demands. However, there was a growing emphasis on university research as a lever for economic development. In addition, Korean universities underwent a rapid transformation from being institutions that primarily focused on teaching to becoming more balanced institutions that emphasized both teaching and research. This significant change led to outstanding developments in Korean universities during the 1990s.

The government has fostered graduate research manpower through the research-oriented university policy of the BK21 program. Since the 2000s, the university education system in science and engineering has changed to focus on entrepreneurship training, spin-off startups, industry-university cooperation, and the offering of degree programs.

The science and technology policy has made Korea’s economic development possible. The development of science and technology inevitably relies on the cultivation of manpower. The contents of the Special Act and master plans in this paper reflect the development of the Korean innovation system, particularly with regard to the GRIs and university research. The findings presented in this paper would have significant implications for comprehending the interdependent relationship between manpower, science and technology policy, and industrial development.

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