STI in History:

# Issues and Policies in the STI Leadership Phase

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## 1. CONTEXT AND STI POLICY ISSUES

The science, technology, and innovation (STI) system of Korea began to enter a qualitatively different development phase in the 2000s. This is partly because of the limits of the previous catch-up model. As a result, this transition to the Korean system has also been influenced by various political, economic, and environmental issues of global dimensions. The Korean system is now being asked to act as a role model for the development of the international community. The local dimension (which has been neglected in the rapid development of the Korean economy) has emerged to formulate a certain position in the STI initiatives of Korea.

The Korean system evolved from a simple system to a complex one in the 2000s, which is reflected in the STI system diversity of actors and issues. Technology-driven development of previous phases was primarily geared towards problem-solving by leveraging foreign technologies. However, this is not without its drawbacks. Two of which are 1) no benchmarking technologies for a handful of large companies and 2) the limitation of economies of scale based on corporate competitiveness in the global market. Therefore, this transition has evolved from a development mode of technology-driven to innovation-driven development.

During the early 2000s, these problems were exacerbated by the socioeconomic challenges caused by the 1997 Asian Financial Crisis and the 2008 Global Financial Crisis. Such financial challenges had a positive impact on the system to focus on core capacity areas, to enhance the venture economy sector, and the adaptation to global standards through massive restructuring and privatization; however, they exasperated social issues of class and regional disparity. In addition, global challenges were further strained due to natural disasters such as the March 2011 earthquake and tsunami in Japan. Through overcoming such challenges, Korea is asked to contribute to solving those global financial and environmental challenges.

The transition from the development mode of the technology drive to an innovation-driven development coincided with Korea's reestablishment of a local government system in 1995 that allowed Korean citizens of voting age the right to elect governors and mayors. Until then, they were directly

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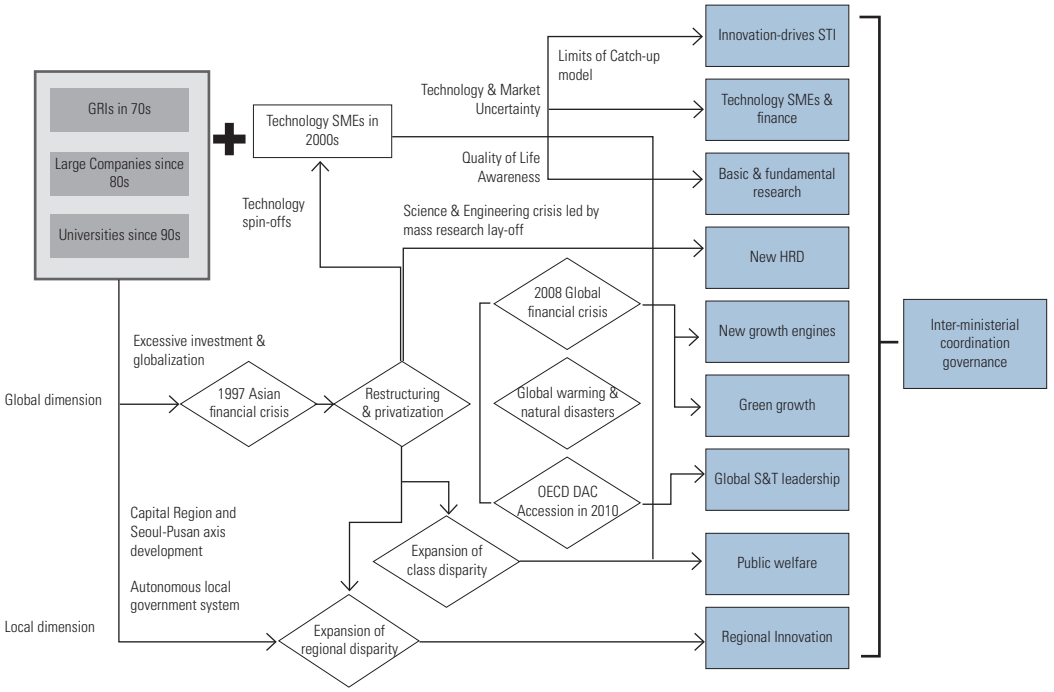
appointed officials by the President; subsequently, it became a political issue to establish balanced national development based on the characteristics of each region. With local autonomy, STI policies resulted in more decentralized decision-making and development strategies

FIGURE. X Framework Conditions and STI Issues in 2000s




STI policy issues identified during the transformation of the Korean system in the 2000s were: innovation-driven STI initiative, promotion of Korea's technology market and technology companies, cultivation of university research, basic & fundamental research, facilitating industry and science partnerships, new human resource development focused on creativity, new growth engines, diverse social, welfare and natural disaster research issues, global networks of research and development (R&D), regional innovation promotion, a comprehensive innovation system, and coordination of ministerial departments for R&D.

## 2. INNOVATION-DRIVEN STI INITIATIVES

It became necessary for Korea to take a different approach in order to become a leader in the STI field. The mode of technological innovation that was predominant during the nation's rapid industrialization became obsolete and no longer beneficial. Technological innovation was mainly oriented toward solving problems by leveraging foreign technologies. Once the 21st century began, Korea steadily began to transform itself from relying on technology-driven science and technology (S&T) initiatives to innovation-driven STI initiatives. This resulted in establishing an innovation path that requires a new approach to STI policy.

New technology development also requires a new social system for the development and utilization of new technologies (MEST, 2010). Technological innovation needs to occur in conjunction with the evolution of social institutions to enhance the creativity of the entire society and facilitate mutually beneficial partnerships among the STI actors. New industry and science relations began to take root since the Korean STI system became more complex. With technological small and medium-sized enterprises (SMEs) becoming part of the R&D system, government research institutes (GRIs), large companies, and universities are being asked to formulate strategic partnerships to overcome the challenges of uncertainties as there are no benchmarking technologies.

Korean Presidents have taken a keener interest in STI policies since the 1997 Asian Financial Crisis (MOST, 2008). This is attributed to a shift from an investment perspective to innovation as the engine of socioeconomic growth in Korea. During the presidency of Kim Dae-jung (1998-2003), the establishment of the National Science and Technology Council (NSTC) and enactment of the *Basic Science and Technology Act* signaled the beginning of the shift (MOST, 2008; MOST et al., 1997; MOFE et al., 2001). Through the NSTC (chaired by the President of Korea) R&D projects were evaluated and coordinated. In addition, the Science and Technology Basic Law (enacted in January 2001) is considered the most basic of all laws related to S&T. The law provided the shift from an S&T approach appropriate for an industrial society to one for a knowledge-based society.

Under the Roh Moo-hyun government (2003-2008), the establishment of an S&T Based Society was one of the administration's key policy initiatives that called for the establishment of a R&D hub in Northeast Asia (MOST, 2008). The administration sought to establish a system related to science and technology (S&T) to socio-cultural and economic aspects of society and produce economic growth by connecting technological innovation to industrialization.

The Lee Myung-bak administration (2008-present) emphasized the role of science and technology to realize the vision of an advanced nation and sharply increased government research investment with and ambitious target of 5% gross R&D investment of GDP (MOSF et al, 2008). It, however, took a different approach to STI policy through the reorganization of a few government ministries responsible for such areas. The Education Ministry and Science & Technology Ministry were merged as the Ministry of Education, Science & Technology (MEST). In addition, the Ministry of Knowledge Economy (MKE; previously the Ministry of Commerce, Industry and Energy) was tasked with the administrative tasks of industrial development and technological innovation.

### 3. CULTIVATION OF TECHNOLOGY SMES AND FINANCE

Technology SMEs are said to be a source of creativity and new business development. The nations and regions that incubate many technology SMEs have shown high productivity in labor and capital. They play pivotal roles to infuse new ideas into indolent large companies that are a necessity for Korean industrial system revitalization. The 1997 Asian Financial Crisis, ironically, provided the impetus to create technology SMEs as the large companies began to close research units through a massive layoff of researchers. These layoffs invoked a public awareness of the science and engineering crisis due to the absence of job security for engineers who when laid off subsequently created their own technology SMEs.

During the Kim administration, the **Act on Special Measures for the Promotion of Venture Businesses** was enacted in 1998 to nurture technology-intensive SMEs as well as venture startups in Korea (Hong et al, 2010). Approximately 2,000 venture startups were established in 1998 and soared to

over 11,000 in 2001, but sharply plummeted after the technology bubble burst. In 2010, however, the number bounced back to over 24,000.

In the 2000s, the government attempted to institutionalize technology transfer and commercialization. With the *Technology Transfer Promotion Act* (2000), three plans of technology transfer and commercialization were established: The First Plan was to establish infrastructure for policy implementation, the Second Plan was to expand technology evaluation activities & financial support, and the Third Plan focused on producing actual outcomes based on selection and concentration.

As part of Korea's technology commercialization, financing for SMEs came from various sources that included legal and institutional measures to insure that such financing would materialize (Hong et al, 2010). Technology development loans from the Korea Development Bank started in the 1980s; in addition, the Industrial Bank of Korea provided loans for technology development and quality improvement to facilitate structural improvement of SMEs. Other key sources of financing originated from the Korea Technology Finance Corporation (1989), the S&T Promotion Fund and IT Promotion Fund (both in 1993), technology development grant from the Industrial Technology Development Fund (1997), loans from the Small & Medium Business Corporation (2005), Korea Venture Investment Fund (2005) and establishment of the Capital Market Law and Korea Finance Corporation (2008).

Regarding legal and institutional arrangements, R&D tax deductions saw an increase in the early 1990s but decreased in the late 1990s due to the 1997 Asian Financial Crisis that engulfed most of Asia including Korea (Hong, et al, 2010). However, financial support for SMEs has increased in the 2000s whereas large corporations reduced.

## 4. PROMOTION OF BASIC RESEARCH AND CULTIVATION OF HUMAN RESOURCES WITH CREATIVITY

Until the 1990s, many Korean industries took the 'path-following' approach and STI activities concentrated primarily on applied and development research; however, universities subsequently refocused their research endeavors that have resulted in innovative basic and core technology research. To facilitate these activities, the Korean government has carried out various programs to assist prominent research centers, persuade universities to concentrate on graduate school and research activities as well as provide fellowship funding to graduate student and professors (*Brain Korea 21*). These programs ultimately produced higher-quality research groups and individuals capable of conducting basic and core technology research.

The Korean government also devised measures to produce more globally recognized research outcomes (MEST, 2010). In 1997, it launched *The Creative Research Initiative Project* with the objective of securing key technologies that would create new future industries by facilitating technological innovation through creative research. Another initiative it started was the *Frontier R&D Program* in 1999 that increased university research funding in basic and core technology and attracted participation by many university professors. Various projects such as "National Research Center (NCRC)" "Medical Research Center (MRC)" and "Advanced Basic Research Lab (ABRL)" were designed to support creative and interdisciplinary research led by individuals and small research teams in the early 2000s.

In August 2005, the Roh administration announced a comprehensive plan called the *Basic Plan* (2006-10) to promote basic research with the objective to increase investment in basic and core tech-

nology research and support creative research by individuals (MEST, 2010). To further this objective, the Lee administration has planned to increase the portion of basic and fundamental research to 50% of the R&D budget and is trying to build a Science and Technology Business Belt that hosts a basic science research institute, and a heavy ion accelerator.

Another objective of the Basic Plan was to address the severe shortage of qualified, trained engineers in the late 1990s. This was triggered by the 1997 Asian Financial Crisis that led to massive layoffs and revealed the shortcomings of government initiated human resource development. However, there has been a strong industrial and social demand to cultivate human resources for the new industry areas of IT, BT, and NT in the era of the information and knowledge economy. The Roh administration enacted the *Special Law on Science and Engineering Support* (2004) to enhance National Science and Technology Competitiveness and established the *Basic Plan* (2006-2010) to nurture and support Science and Engineering Human Resources (MEST, 2010). The Lee government has also pushed to cultivate creative human resources.

## 5. DIVERSIFICATION OF R&D PROGRAMS

Most countries who invest in R&D projects do not limit themselves to knowledge creation but seek to reinforce and strengthen their national competitiveness and capabilities that include economic and military power. National R&D programs are undertaken to provide solutions to address domestic economic and social needs as well as establish and create new knowledge that will serve as a foundation for a knowledge-based economy that will improve security and social welfare for national progress based on the development of public and welfare technologies.

Korea's objective in the pursuit of R&D programs is to strengthen its national competitiveness and establish the nation as a leading global science leader through the enhancement of R&D capability in fundamental science and technology, further industrial technology development, reinforce R&D center capability, develop experts in science and technology, and promote international S&T cooperation.

One such program that established the foundation for such national and international competitiveness is the 21st Century Frontier R&D Program initiated in 1999 (MEST, 2010, MOST, 2008). The objective of this program was to develop core technologies and secure cutting-edge technologies in promising areas by 2010. Selected technologies for development are those that will be able to produce prototype products that enhance Korea's competitiveness within 10 years of the start of development.

The New Growth Engine Program (2008) and Global Frontier R&D Program (2010) are also in the same line of pursuing competitiveness. New growth engines in the high-tech fusion industry are focused on broadcasting-communication convergence, IT-fusion system, robotic application, new material-nano fusion, biopharmaceutical, and medical equipment and value added food. The value-added service industry seeks to concentrate on global healthcare, global education services, green financing, culture content & software, and tourism.

The start of the millennium witnessed the establishment of several technologies that include the Nano-Bio Technology (NT-BT) Development Program established in 2001 (MOST, 2008). Korea declared 2001 as the "Year of Nano-Bio Technology" and intended to deploy available S&T resources toward the development of a Nano-Bio Korea. To achieve this objective, the Nanotechnology Development Program has focused on core research in nano-materials, electronic devices based on

miniaturization technology, computer memory, and molecular-logic devices. Along those lines, the objective of the Biotechnology Development Program is to establish Korea as a leading international biotechnology power comparable to Korea's IT-dominant economy.

Upon taking office in 2008, President Lee announced a *Low-Carbon, Green Growth Strategy* as a new vision to guide the economic development of Korea. The Lee administration unveiled comprehensive measures to increase green technology R&D to spur green growth. Measures designed to increase investment in 27 core technologies included the promotion of fusion green technologies, the expansion of basic and core technology research, persuading old industries to transition themselves to a green transformation and adjust their focus on new growth engines and building infrastructure for green technology. In addition, the government listed 17 new growth engines by dividing industries into three core fields of green technology, high-tech fusion, and value-added service; in addition, it unveiled different short, medium, and long-term development strategies. In regards to the green technology industry, potential new growth engines include the development of renewable energy, carbon-free energy, high-performance water processing, LED applications, green transportation systems, and the creation of a high-tech green city.

Public and social welfare technology development (such as health, environment, disabled caring, and safety) has also seen an increased momentum due to government investment. This is partly because of public awareness of quality of life issues and a change of social values after rapid economic growth. The social disparities spurred by the 1997 Asian Financial Crisis have also influenced the prioritization of national R&D issues. The Roh administration designated "Healthy Life Society" and "National Security and Prestige" as two of five national S&T challenges. In addition, the Lee administration also included "Overcoming Global Challenges such as natural resources, environment, and foodstuffs." in the seven national science and technology development targets.

## 6. GLOBAL STI LEADERSHIP AND LOCAL AUTONOMY

To accelerate the Korean catch-up model, foreign technology resources were essential and Korean engineers creatively benchmarked foreign technologies during the rapid economic growth. However, it now needs to develop strategic global R&D networks that include strategic outsourcing and the inducement of foreign R&D resources because the Korean system has been confronted by technology protection and currently lacks benchmarking technologies. The Roh administration tried to induce various foreign research institutes; however, those endeavors were unsuccessful. After its acceptance into the Paris based Organization for Economic Cooperation and Development (OECD) in 1996 and as a member of its Donor Assistance Committee (DAC), Korea is being asked to contribute more to the development of global society and solving global challenges especially for developing and less-developed countries.

In recent years, Korea has achieved considerable S&T development through increased and closely coordinated international cooperation. Until the 1990s, most of the international relationships with foreign partners were limited to technological imports or assistance of a reciprocal nature; in addition, many of the partnerships were limited to developed nations such as the United States, Japan, and several European nations. However, as a newly industrialized nation, Korea understands the importance of a new approach to international cooperation. As a result, it is seeking a more prominent role in the international S&T community and is actively pursuing increased bilateral and multilateral cooperation.

Since 2005, Korea has signed 44 inter-governmental agreements that range from Joint Cooperation Committees that involve joint research funds to overseas cooperation centers and exchanges of S&T missions and scientists. To demonstrate its commitment to S&T policy, the government has dispatched S&T Counselors to eight national organizations: the United States, Japan, Austria, Germany, Russia, China, the United Kingdom, and OECD. In addition, Nuclear Cooperation Agreements have been signed with 18 nations. Korea entered into 138 S&T Cooperation Agreements in 2005 under the auspices of the South Korean Ministry of Science and Technology (now the Ministry of Education, Science and Technology). Of the agreements, 107 are bilateral R&D projects, 19 multilateral R&D projects and 12 joint R&D Centers have been opened in the United States, China, Russia, Mongolia, and Hungary.

Regional innovation programs are a recent development in Korea. These began to grow after local autonomy took effect in 1995; subsequently, four provincial governments requested Korean government financial assistance to form regional industries that considered strategically important. This was intended to support regional industries to overcome structural shortcomings. The pilot projects to boost regional industries in four regions were extended to include nine other cities and provinces that have expanded to promote four strategic industries in each region in 2003. The two cities of Seoul and Incheon as well Gyeonggi Province were excluded from the program. One regional innovation program that has developed is Korea's emphasis on 'techno-parks'. This utilizes the Koreas human resources of universities and commercialization abilities of the private sector and regional innovation system projects to form collaborations among regional innovators. Beside these programs, the Innovation Cluster Program to transform industrial complexes was launched in 2005 with seven pilot projects that was extended to twelve in 2007 and 193 in 2010. Under the Lee administration, the regional strategic industry promotion program and the techno-park program merged as one program in 2008. The Lee administration has also created economic regions with two or three provinces and cities as well as designed programs to promote one or two focus industries in the region; in addition, it has commissioned various local universities for various responsibilities in industry and science cooperation.

Another regional innovation program in Korea is the Daedeok Science Town that was completed in 1992 as a research and education complex. From the mid-1990s when venture companies utilized research results to establish an S&T presence there, the Daedeok Science Town evolved into a technology-intensive and cutting-edge industrial complex that emphasized networks of industry, academic and research institutes. In 2000, Daedeok Science Town became known as Daedeok Valley to emphasize its vision to become a Korean version of Silicon Valley. Daedeok Valley seeks continued progress as it has been legally designated a special R&D zone. As such, Daedeok Science Town has become a benchmarking target of many newly industrialized countries that has made Daejeon a leading S&T city in Korea.

Under the Roh administration, the Daedeok Innopolis was established in 2005. Some benefits included the establishment of a Daedeok Innopolis Committee (led by the then-Deputy Prime Minister of Science & Technology), authorization for the founding of research companies, preferential treatment of state-of-the-art technology companies and foreign-invested enterprises, implementation of R&D projects, and the establishment of Daedeok Innopolis Support Headquarters.

## 7. COMPREHENSIVE COORDINATION

In order for S&T policy to fully shape, Korea increasingly realized that the enhancement of the S&T

system on a national level and drastically raising the country's S&T was vital for long-term competitiveness and growth. Korea recognized that the development of a national S&T sector was crucial to compete on an international level. For this to be achieved, Korea sought to raise its S&T levels to those of the Group of Seven (now G-20) industrialized nations by the implementation of the *Special Law for Science and Technology Innovation* (1997) and formulated the First Five-Year Plan for Science and Technology Innovation. As the new millennium began, Korea increasingly faced tougher global S&T competition but also realized that such challenges brought about greater opportunities. To address these challenges, the *Framework Act on Science and Technology* was enacted in 2001 under the Kim administration. This presented the basic ideology of S&T and development directions and created an institutional framework covering all laws pertaining to S&T. Also under President Kim, the *National Technology Road Map Project* was developed in 2002 as a national plan for science and technology (MOST, 2008).

Under the Roh administration, the objective of S&T policy was to improve economic growth and quality of life standards served as a top government policy priority. One of the goals of the administration was to transform Korea into Northeast Asia's R&D hub. To facilitate such policy objectives, the government established the position of deputy prime minister for S&T and Office of Science & Technology Innovation. Such coordination allowed the government to develop clear, systematic plans and coordinate policies related to industries, human resources and regional S&T innovation (MEST, 2010; MOST, 2008).

The Lee government took a different approach in terms of S&T policy. It sought to strengthen S&T policies to achieve the stated goal of Korea becoming an advance, first-class nation for its citizens to benefit from a powerful nation and caring society. For such an objective to be achieved, the administration established the *National R&D Investment Strategy* (2008) and *Mid- and Long-Term Development Strategy for National* R&D Projects. The administration also advocated an integrated approach adopted for technology innovation to achieve the *Low-Carbon, Green Growth Strategy* and environmental protection as well as energy-related policies.

## 8. ACHIEVEMENTS AND CHALLENGES[1]

### *Achievements*

Since the late 1990s, Korea has steadily increased investments in the S&T sector. In 10 years, R&D spending rose from US$12.8 billion in 1997 to US$33.6 billion in 2007. The compound annual growth rate (CAGR) of overall R&D investment between 1997 and 2006 was 8.9% (the highest rate in the world). In addition, the percentage of total R&D investment to GDP rose to 3.37% in 2008, which was even higher than advanced nations such as the United States and Japan. In addition, the Korean government's R&D budget marked a commensurate rise from 2.9375 trillion won in 1998 to 6.7368 trillion won in 2006 and subsequently 8.1396 trillion won in 2007. From 2005-2007, the government's R&D budget increased at a CAGR of 11.95%, which was considerably higher than the CAGR of its defense expenditures (7.8%), total expenditures (6.3%) and education expenditures (5.7%).

R&D spending among Korean companies expanded at the start of 21st century. The number

[1] Part of this chapter was summarized from MEST (2010).

of corporate R&D institutes soared from 3,060 in 1997 to over 10,000 in September 2004 and surpassed 16,000 in 2008. Accordingly, R&D intensity (total R&D expenses as a % of sales) of Korea's industrial firms rose from 2% in 2000 to 2.4% in 2007. The employment of R&D staff also posted steady growth in conjunction with R&D development. The number of researchers rose from 138,400 in 1997 to 436,228 in 2008. From a private sector standpoint, their progress has been commensurate with the Korean government's emphasis on STI policies. For example, several major *chaebol* (conglomerates) emerged as major players in the 1990s and were supported by production technologies and product development capabilities developed over the years. In addition, equipped with enhanced managerial resources and S&T capabilities, they began to lead the nation's R&D innovation activities that facilitated the establishment of a corporate-led innovation system.

In 2008, the International Institute for International Management (IMD) ranked Korea 31$^{st}$ in terms of national competitiveness, 4$^{th}$ in science competitiveness, and 14$^{th}$ in technology competitiveness. These findings demonstrate that Korea's competitive edge in S&T has advanced significantly to reach world-class levels.

***Challenges***

Despite Korea's overall progress in the S&T field, some areas of improvement need to be made. According to the NSTC, one major issue is the delayed emergence of new growth drivers. Industries such as semiconductors and flat panel displays have fueled the rapid industrialization of the nation; however, no other growth drivers have recently emerged to reinforce these industries. In addition, the government has invested significant R&D funds to identify potential new growth drivers (but none have yet demonstrated any potential).

Although Korean companies have fueled R&D investments and dominated the nation in these areas for many years, SMEs have generally not benefited as much. They also lack the human resources to procure components and materials from global markets in order to obtain high quality goods as well as price competitiveness. Large companies were able to purchase overseas components with a higher quality or lower price than their Korean counterparts that exacerbated the gap between SMEs and their bigger counterparts. The challenges facing SMEs have not been helped by the lack of new growth drivers either. Their decrease in the lack of technological competitiveness in the components and materials industries has been a formidable problem. Lack of SME profitability has reduced the drive for innovation that subsequently resulted in a decline in profits. Consequently, operating income from SMEs has steadily declined from 5.44% in 2000 to 4.31% in 2006. To make matters worse, SMEs comprised only 24.1% of R&D by all companies.

To facilitate the emergence of new growth drivers, it is necessary to create sufficient conditions for the STI actors to strategically cooperate in Korea. The necessary conditions may include creativity enhancement of the entire society, reshuffling, and capacity building of STI actors. Government research institutes that are losing their specific roles, need to be repositioned in the new phase of development. Sufficient conditions may be related to the institutional co-evolution to facilitate the mutually beneficial partnership; in addition, government initiatives need to focus on elevated quality of life standards as a foundation for further creativity. To deal with these complex STI missions and tasks, additional, comprehensive coordination of inter-ministerial innovation programs is requested.

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