EVOLUTION OF REPUBLIC OF KOREA'S R&D SYSTEM IN A GLOBAL ECONOMY

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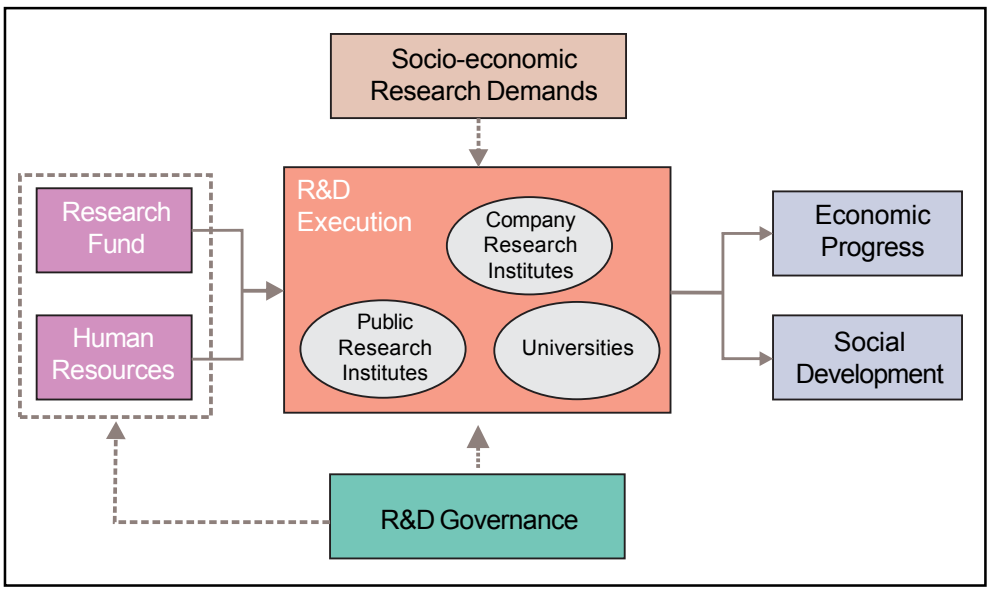
I INTRODUCTION TO REPUBLIC OF KOREA'S R&D SYSTEM

The Republic of Korea has shown a very successful model of economic progress and social development through government intervention. Its research and development (R&D) system has contributed to this success through strategic acquisition of foreign technologies and national capacity building process.

The country's R&D system is conceptualized as evolving, reflecting the continually changing socio-economic demands of the country in a global economy, with the government performing the key role of managing the acceleration and facilitation of R&D contribution to the socio-economic development of the country (Figure 7). Based on this conceptualization of the R&D system, the following sections review Korean experiences of R&D system evolution statistically and diagnose them qualitatively.

Figure 7: Conceptualization of the R&D system for review and diagnosis



The Republic of Korea is well-known for its success in making the R&D system contribute to meeting the nation's socio-economic demands. The system has also shown a strong adaptability to adjust to the continuous changes in the global economy.

A. Inputs to R&D system

The total R&D expenditure in the Republic of Korea continues to increase except for the period of financial crisis from 1997 to 1999 and has risen dramatically from US$4 million in the early 1960s to more than US$27 billion in 2006. The R&D expenditure was 3.23 per cent of the gross domestic product (GDP) in 2006 (Table 3, Figure 8) and this increased in 2009 to US$35 billion – a growth of US$8 billion in just three years.

Government was the dominant source of R&D expenditure before 1980. Since then, the private sector has continued to expand its contribution, registering 76 per cent of the total R&D expenditure in 2006 (Figure 9) against 24 per cent by the government.

Table 3: Expansion of Republic of Korea's R&D system

	1960	1970	1980	1990	2000	2006
Gross expenditure in R&D (GERD) (US$ million)	4	33	428	4,676	13,849	27,346
Government-private sector ratio	97:3	71:29	64:36	19:81	25:75	24:76
R&D ratio in GDP (%)	0.25	0.38	0.77	1.87	2.39	3.23
Research personnel	n.a.	5,628	18,834	70,503	159,973	256,598

Figure 8: Trend of total R&D expenditure and the ratio of R&D to GDP

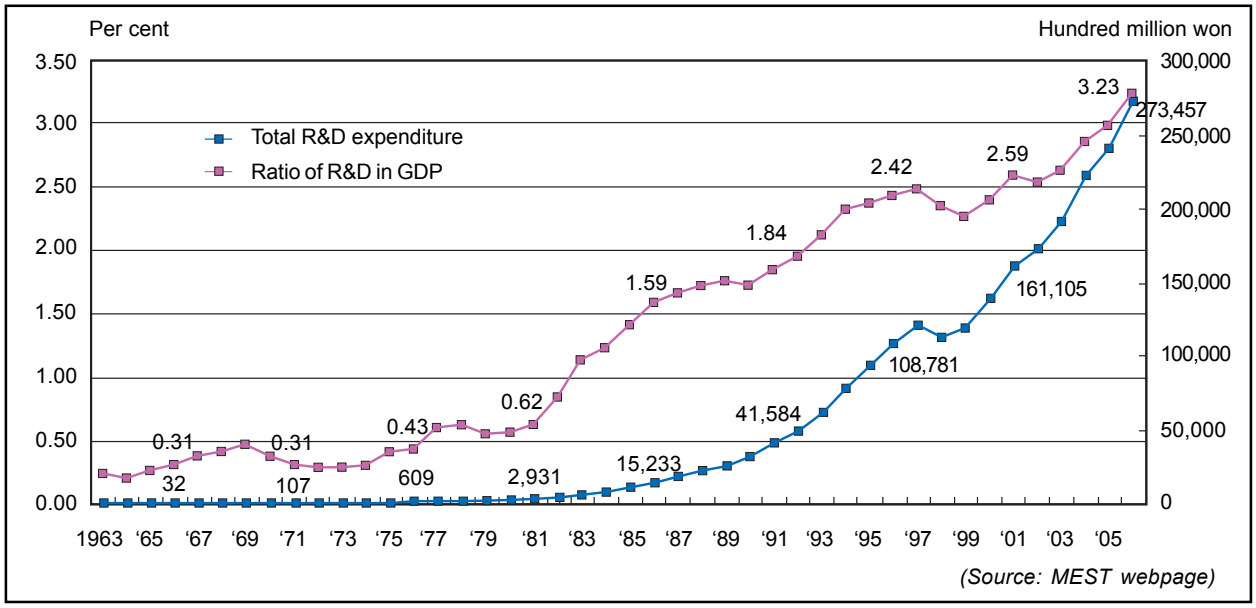
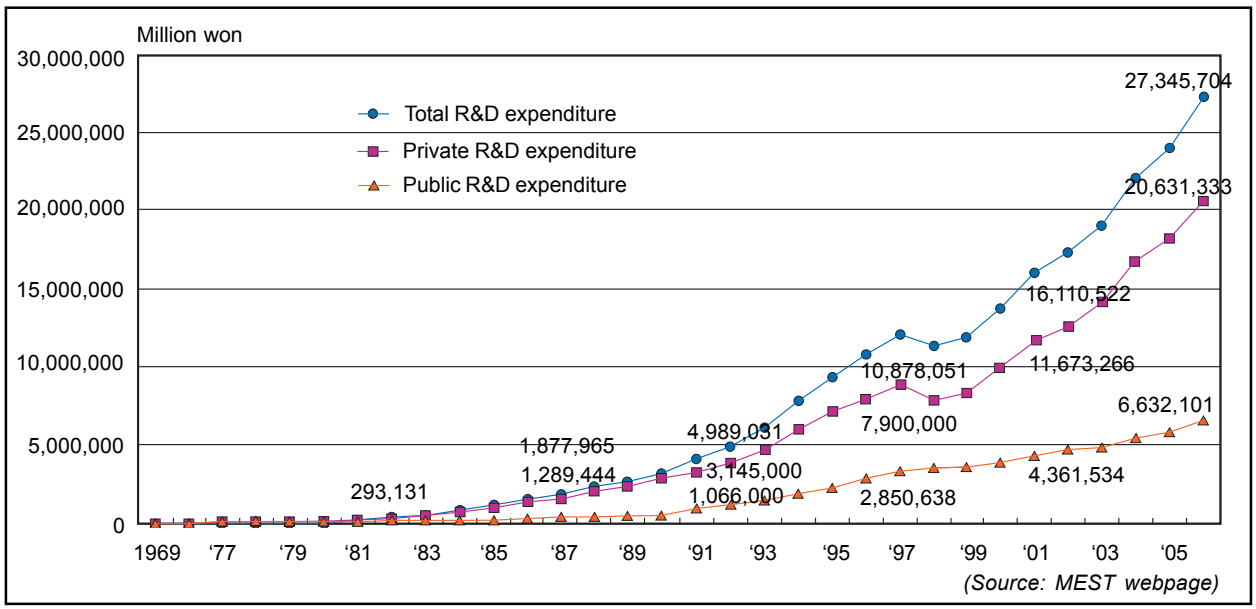
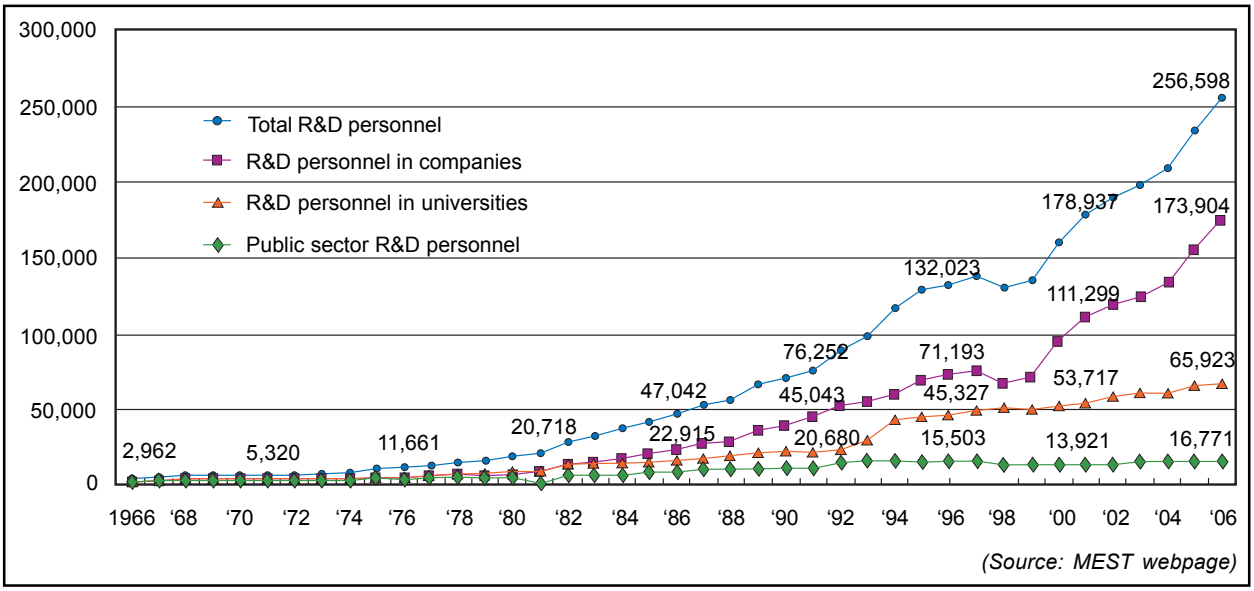


Figure 9: Trend of R&D expenditure by fund source



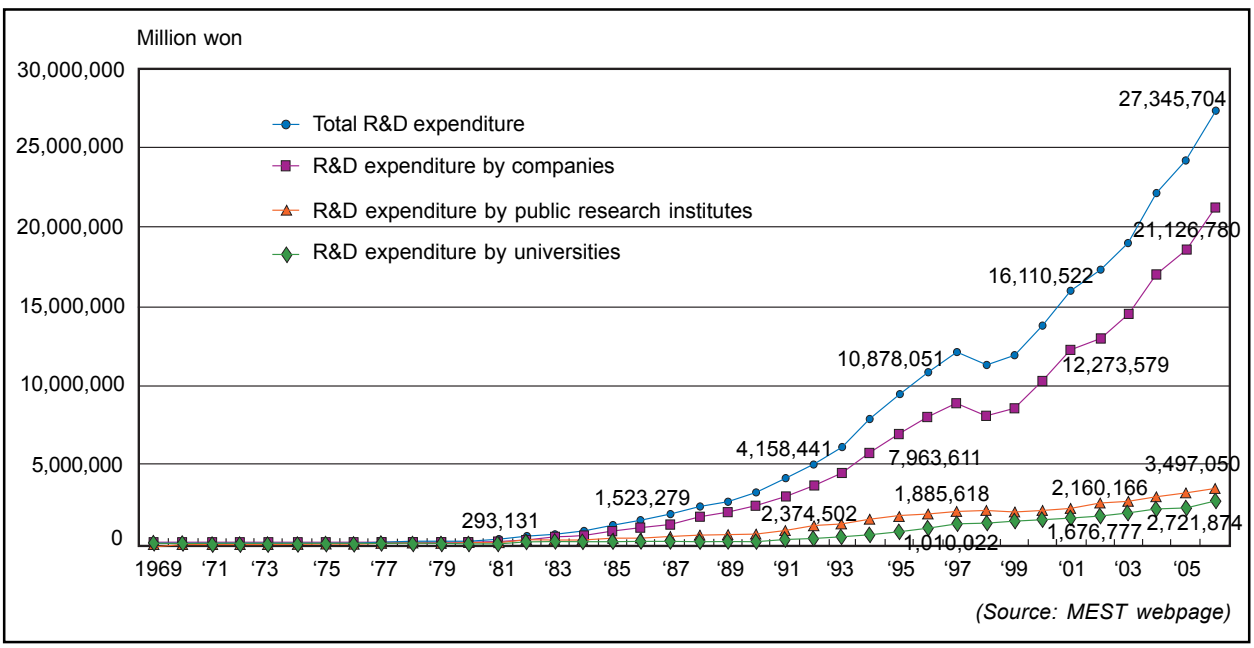
However, in 2009, the government-private sector ratio was 29:71, indicating that the government is increasing its R&D investments to encourage more R&D expenditure. In 2009, the R&D expenditure was 3.37 per cent of the GDP, up from 3.23 per cent in 2006.

Figure 10: Trend of number of researchers by R&D performers



The pattern of increase in the number of researchers is quite similar to the pattern of the R&D expenditure; continuous increase except for the financial crisis period (Figure 10). In 2009, the number of researchers was more than 300,000, increasing by about 50,000 in three years.

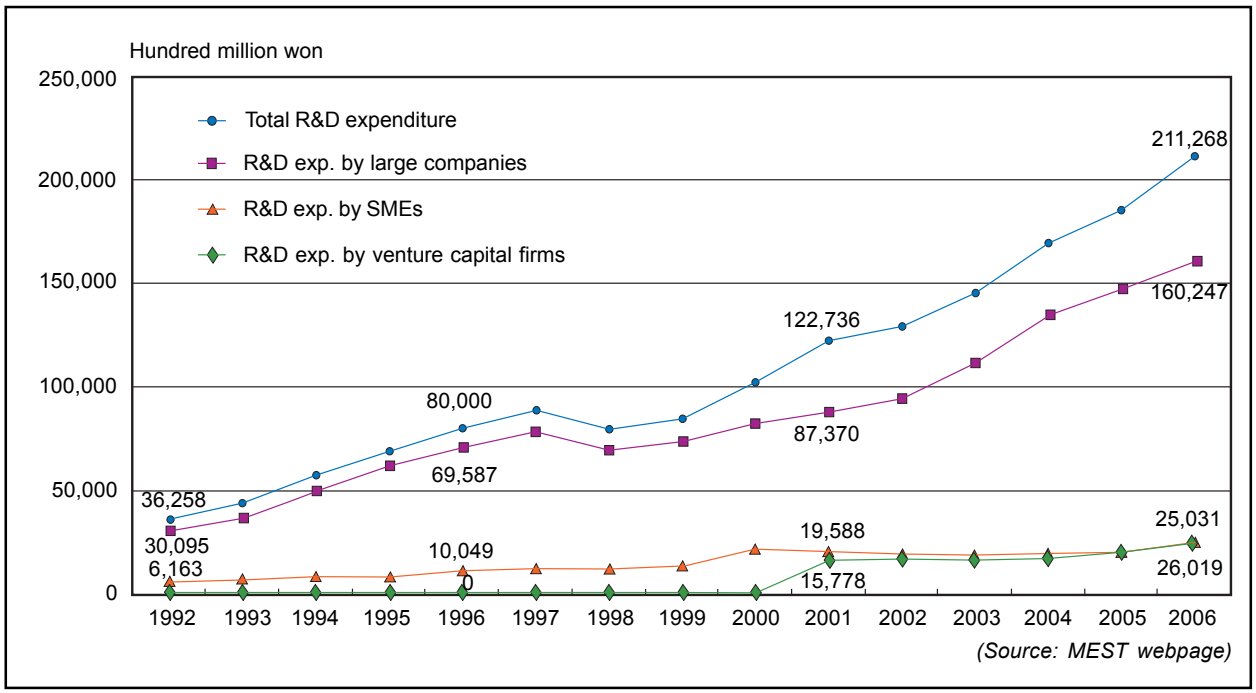
Figure 11: Trend of R&D expenditure by R&D performers



Public research institutes had the largest number of researchers before the mid-1970s, universities until the early 1980s and private sector has been the dominating holder of researchers in the Republic of Korea since then. In 2006, the total number of researchers was 256,598 and the private sector employed 67.8 per cent of them, universities 25.7 per cent and the public sector 6.5 per cent.

B. R&D execution

Figure 12: Trend of R&D expenditure by company type



Of the total R&D expenditure, companies spent 77.3 per cent, public research institutes 12.7 per cent and universities 10.0 per cent. Public research institutes were a dominant user of R&D fund before 1980, but the share of companies' R&D expenditure dramatically increased thereafter (Figure 11). Universities' share almost caught up with the share of public research institutes in 2000.

Large companies are always leading the R&D investment in the private sector, while SMEs' R&D investment has slightly increased since 1990 (Figure 12). Venture companies invested almost the same amount as SMEs in R&D in the 2000s.

In 2006, 65.0 per cent of the total R&D expenditure was invested in development, 19.8 per cent in applied research and 15.2 per cent in basic research (Figure 13). In the 2000s, basic research has shown higher growth rate than that of development, but the dominant position of development has not changed.

Government R&D investment has also increased in the 2000s, to almost US$9 billion in 2006. Public research institutes have spent more than 50 per cent, universities 21.7 per cent and companies 17.2 per cent (Figure 14).

Figure 13: Trend of R&D expenditure by R&D stage

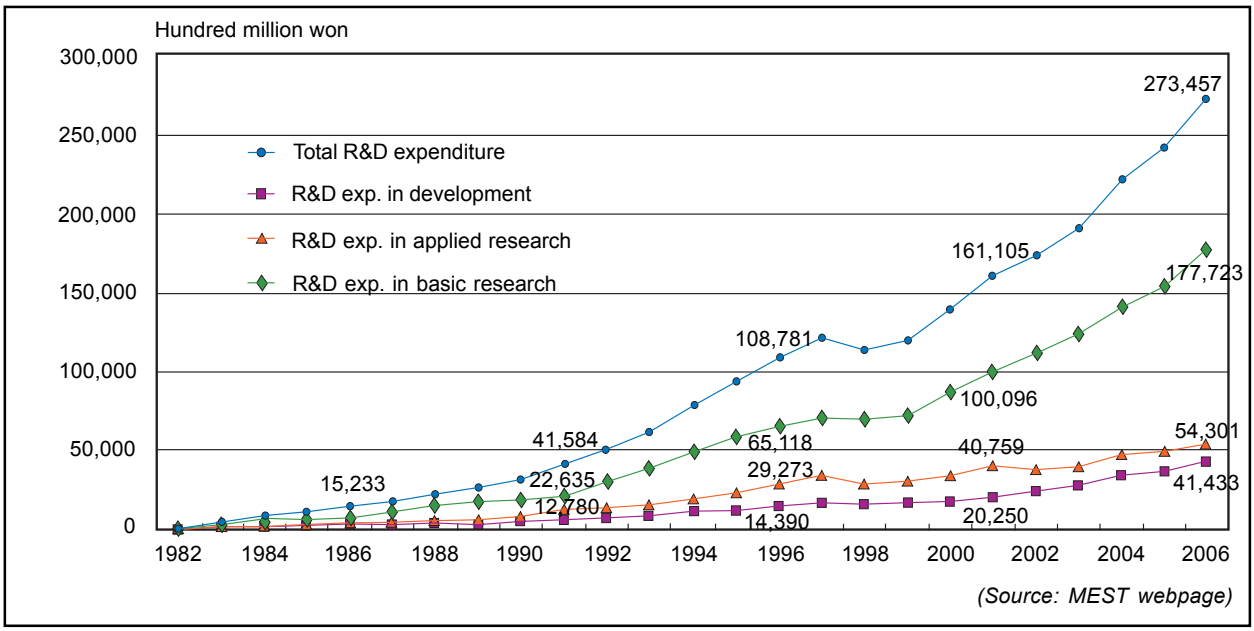
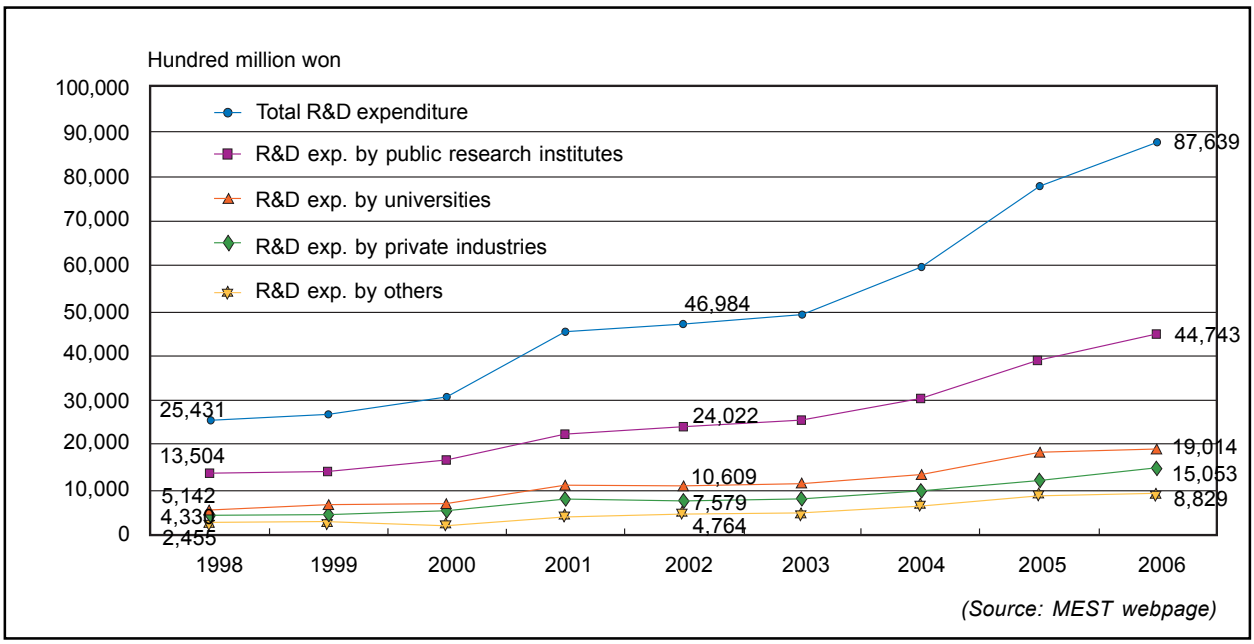


Figure 14: Trend of R&D expenditure by public R&D performers



C. R&D system output/outcome

It is not easy to find out the direct effect of the R&D system but the following statistics reveal roughly the sufficiency of the system.

The population of the Republic of Korea had doubled from 25 million in 1960 to almost 50 million in 2006. The GDP was almost US$900 billion in 2006, which was only US$2

billion in 1996 and per capita GDP was over US$20,000 in 2007 (Table 4). The GDP growth rate was around 20 per cent in 1970, 1980 and 1990, but has decreased now to around 5 per cent as the national economy has stabilized.

Table 4: Rapid growth of economy of the Republic of Korea since 1960

	1960	1970	1980	1990	2000	2006
Population (1,000 persons)	25,012	32,241	38,124	42,869	45,985	48,497
GDP (billion US$)	2	8	62	253	512	887
Growth rate (%)	2.2	17.2	21.8	20.6	8.5	5.0
GDP per capita (US$)	80	248	1,632	5,900	11,134	18,873
Trade balance (million US$)	-65	-597	-4,834	-2,004	11,787	16,082
Exports (million US$)	32	660	17,214	63,124	172,268	325,465
Imports (million US$)	97	1,256	21,598	65,127	160,481	309,383

The Republic of Korea exported US$325 billion worth and imported US$309 billion worth, with the trade balance being US$16 billion in 2006.

Patent applications in the Republic of Korea and the United States, articles in Science Citation Index (SCI) journals and company research institutes have also increased rapidly since the early 1960s (Table 5). From around 162,000 in 2006, the number of patent applications in the Republic of Korea went up to more than 170,000 in 2008. During the same period, the number of Korean patent applications in the United States went up from around 6,000 to around 8,000. Similarly, the number of articles had exceeded 35,000 in 2008. The number of company research institutes had risen from 13,300 in 2006 to 16,700 in 2008.

Table 5: Expansion of R&D output/outcome since the early 1960s

	1963	1970	1980	1990	2000	2006
Patent applications in the Republic of Korea	771	1,846	5,070	25,820	102,136	162,618
Patent applications in the United States	3*	3	8	225	3,786	5,908
No. of articles in SCI journals	n.a.	n.a.	236**	1,587	12,472	23,286
No. of company research institutes	n.a.	n.a.	46**	966	7,110	13,324
* 1964 data ** 1964 data						

The statistics cited above indicate that the R&D system in the Republic of Korea is still in an expansion mode. This continuous expansion with increasing investments in R&D has helped the country survive the economic crisis of the 1990s and the recent one, helping the Republic of Korea to be one of the top 10 economies. The R&D system has quantitatively and qualitatively evolved to adapt to the changes in global economy.

II DIAGNOSIS OF THE R&D SYSTEM BY PHASES

Following statistical analysis, the R&D system in the Republic of Korea can be divided into three phases as follows.[15] During the first phase before 1980, government research institutes (GRIs) played major roles in the R&D system. Then, industrial R&D began to dominate the R&D system during the second phase from the early 1980s to the financial crisis of the late 1990s. After the financial crisis, the R&D system in the country began to diversify, with more active R&D activities by universities and technology ventures, and increased government R&D investment with more focus on basic R&D.

In this section, the three stages are qualitatively diagnosed based on critical review of the related policy reports and presentation materials (Hwang, 2003, 2007a and b; Cho et al, 2007; Kum, 2007; Choi, 2007).

In the 1960s, the Republic of Korea was one of the poorest countries following the three years of the Korean War. Only about 25 per cent of the population of the Korean peninsula was in the southern part. Given these conditions, what the country could do was to optimize the utilization of its human resources in areas such as textiles, garments, furniture, assembly of some electronic goods like radios and television sets, etc. As those labour-intensive industries were expanding, the decision-makers decided that certain heavy industries and chemical industries need to be established to provide materials and components for them.

Thus, the key concern of the economy during the period was manufacturing technologies for industrialization. The Korea Institute of Science and Technology (KIST) was established in 1966 for technology assimilation and development of industrialization. At that time, there was no active R&D in universities, and R&D investments by company research institutes were miniscule despite the need for production technologies and machinery-embedded technologies.

In the 1970s, the Republic of Korea expanded into strategic industries such as shipbuilding, machinery, industrial chemicals, electronics, automobiles, etc. As KIST could not cover all these areas, specialized GRIs were created as technology windows for diversified technological needs of strategic industries. These GRIs were nurtured by contract research emanating from the government and the industry. Thus, in the 1970s, GRIs were major players for technology acquisition and assimilation by the country's industries.

In the second phase during the 1980s and 1990s, the socio-economic R&D demands were for critical and essential technologies to overcome technology protectionism and secure competitive advantages in the international market. As R&D in the private sector started picking up in response to these demands, the 15 GRIs were restructured into nine large institutes for enhancing efficiency. University participation in government-sponsored research was still very little in the 1980s, but limited contribution to the

[15] Technological trajectories of advanced countries usually pass through fluid, transition and specific phases while those of developing countries show vice versa pattern. Kim (1997) used this framework to divide the Republic of Korea's innovation system into three stages: specific phase in 1960s and 1970s, transition phase in 1980s and fluid phase in 1990s. This transition might influence the change of the Republic of Korea's R&D system in the 2000s to be more focused on the basic/original technologies.

industrial needs was realized in the 1990s. More company research institutes began to emerge to create technology-intensive industries, and in-house R&D emphasized technology indigenization for creation of new information technology industries.

It was during this phase that the government launched national R&D projects and the Industrial Technology Development Programme. In the 1990s, these projects were broken down and reconstituted to suit new demands and directions, forming new projects such as Highly Advanced National (HAN) Projects, Leading Technology Development Programme and Basic Research Programme. Large companies internalized imported technologies and the joint efforts of GRIs and universities were able to provide complex technologies needed for the industry. During this time, an increasing number of imported parts and components began to get indigenized. Thus, the 1990s saw an increase in the country's industrial value chain.

In the third phase, after the financial crisis of the late 1990s, emphasis was placed on fundamental technologies to lead the global technology market for continuous growth in knowledge economy and public technologies (such as technologies for environmental protection) to meet various social demands. GRIs began preparing future industries and public needs under the regime of three Research Councils established by the GRI law of 1999. GRIs with specific missions began operating on specific R&D programmes under various ministries. The government R&D programme thus adjusted its focus towards frontier programmes for the 21st century and next-generation growth engine technologies.

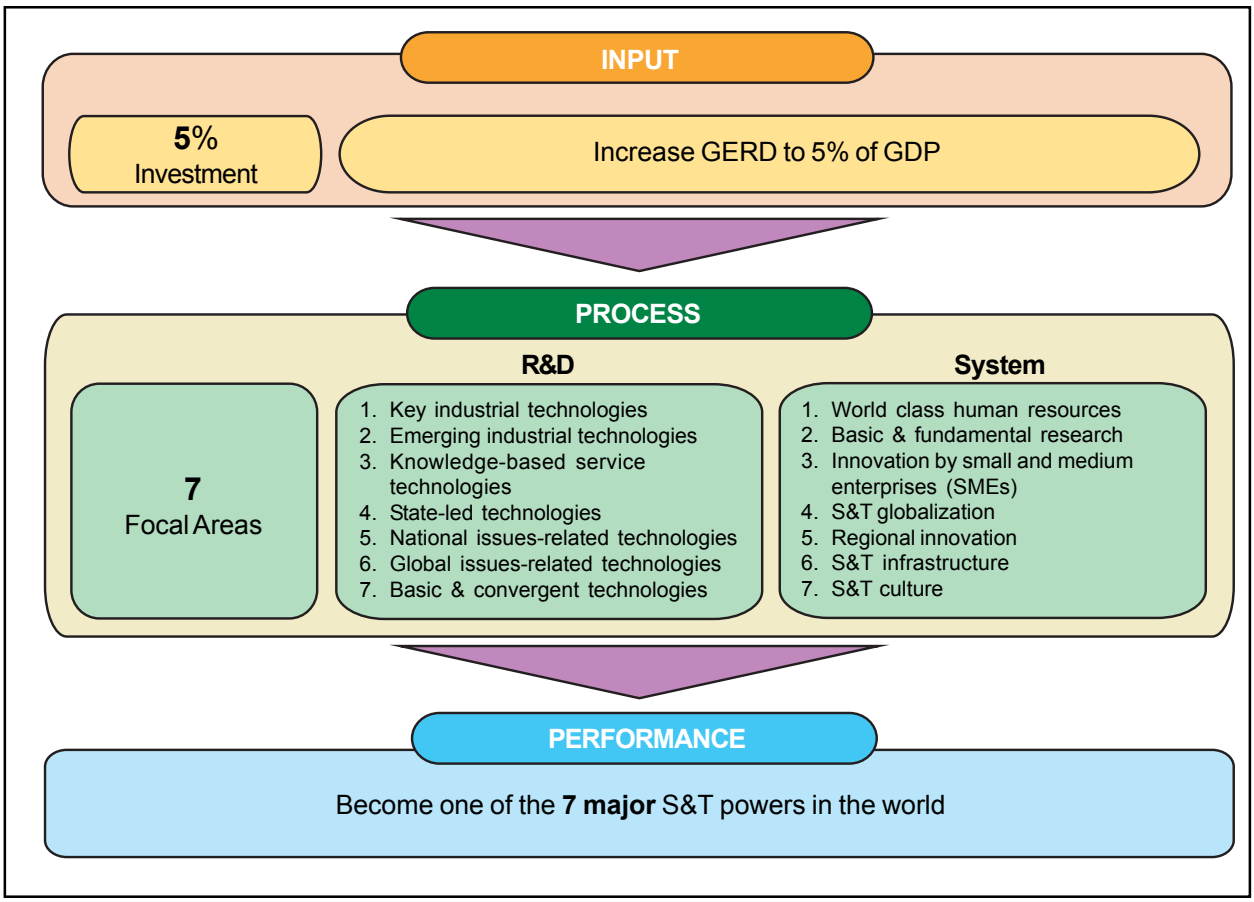
The role of universities in basic research became more important and industry-academic linkages were encouraged. The private sector realized the necessity to develop technologies needed for future knowledge-intensive industries and directed the work of their research institutes towards this. It also began working with GRIs and universities in strategic partnership to develop a domestic technology base and join the National Innovation System (NIS).

III FUTURE DIRECTION IN SCIENCE, TECHNOLOGY AND INNOVATION

The government of the Republic of Korea has embarked on its 577 Programme that aims to increase its R&D expenditure to 5 per cent of the GDP, and become one of the top 7 S&T countries in the world by focusing on seven key areas (Figure 15). The direction that the government has charted for the future of science, technology and innovation (STI) is outlined below:

- Expand public & basic R&D investment
  - Increase government's R&D funding from W11.1 trillion in 2008 to W16.6 trillion by 2012; and
  - Raise the share of basic research in public R&D investment from 25.6 per cent in 2008 to 35 per cent by 2012.
- Encourage private R&D investment
  - Provide quick response to industrial needs (e.g., tax credit, job support, public procurement);
  - Deregulate labour market, legal system, etc.; and

Figure 15: The 577 initiative in science, technology and innovation policy direction



- Strengthen the mid- and long-term R&D capabilities of companies (e.g., research collaboration among the triple helix – i.e., GRIs, universities and the industry)

- Promote new growth engines (17 major technologies in 3 key areas)
  - Green technology industry: new and renewable energies, etc.;
  - Cutting-edge fusion industry: information and communication technologies, biotechnology, nanotechnology-based fusion technologies, etc.; and
  - High-technology service industry: healthcare, education, etc.
- Promote green growth
  - Develop a National Strategy and the first Five-Year Plan for green growth;
  - Increase government's R&D funding on green technologies;
  - Select 27 major green technologies to foster (e.g., forecasting technology, new and renewable energy technology, high-efficiency and low-pollution energy technology); and
  - Create green jobs.
- Develop mega sciences
  - Nuclear energy (e.g., export of nuclear power plants); and
  - Space exploration (e.g., space satellite).

- Develop high-quality human resources
  - Gifted and talented education;
  - College and graduate education;
  - Post-doctoral researchers; and
  - Star scientists and scholars.
- Strengthen S&T policy governance
  - Establish National Science and Technology Council (NTSC) as the central, autonomous coordinating body;
  - Set up S&T Policy Sub-committee;
  - Set up R&D Budget Review and Coordinating Sub-committee; and
  - Set up Knowledge Diffusion Sub-committee.
- Increase R&D efficiency
  - Conduct creative and transformative research;
  - Allow for R&D failure, if sincere;
  - Promote technological originality; and
  - Promote cooperation among triple helix (GRI, university and industry).
- Establish International Science Business Belt
  - Establish Belt Core; C and K Belts;
  - Link science to business; and
  - Establish International Basic Science Institute.

IV TRANSITION OF S&T ADMINISTRATIVE FRAMEWORK

Figure 16: Transition of S&T administrative framework in the Republic of Korea

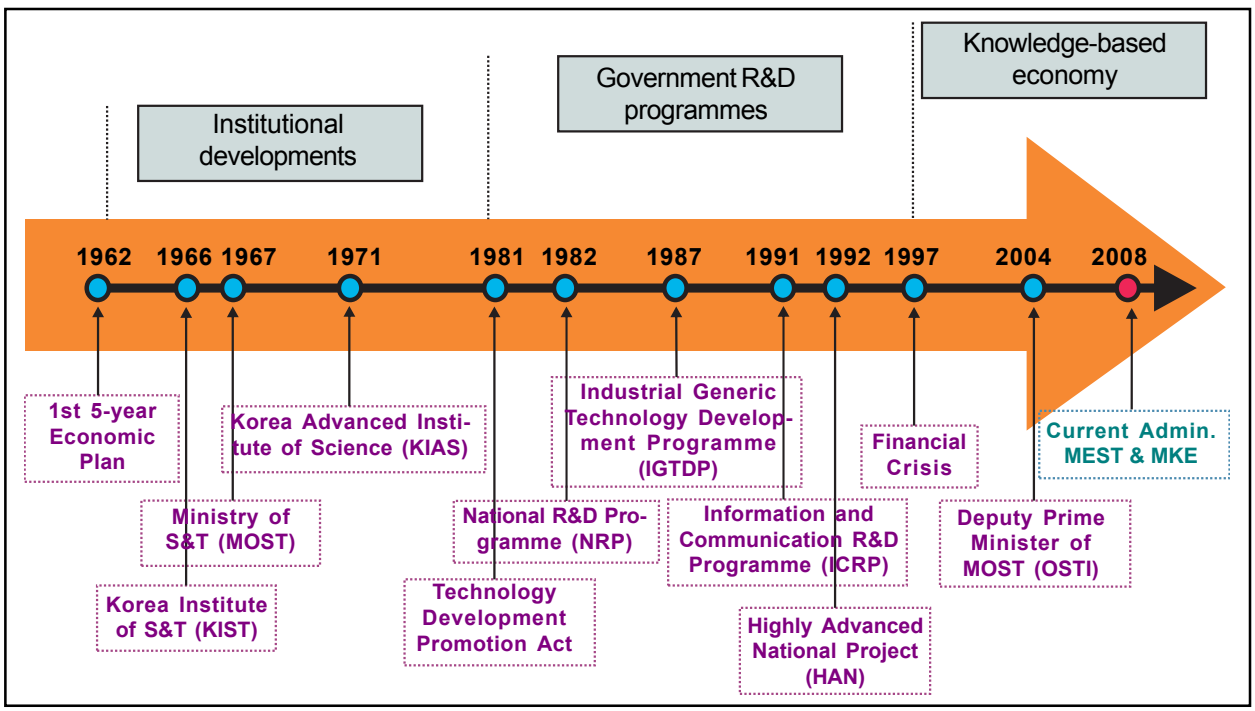
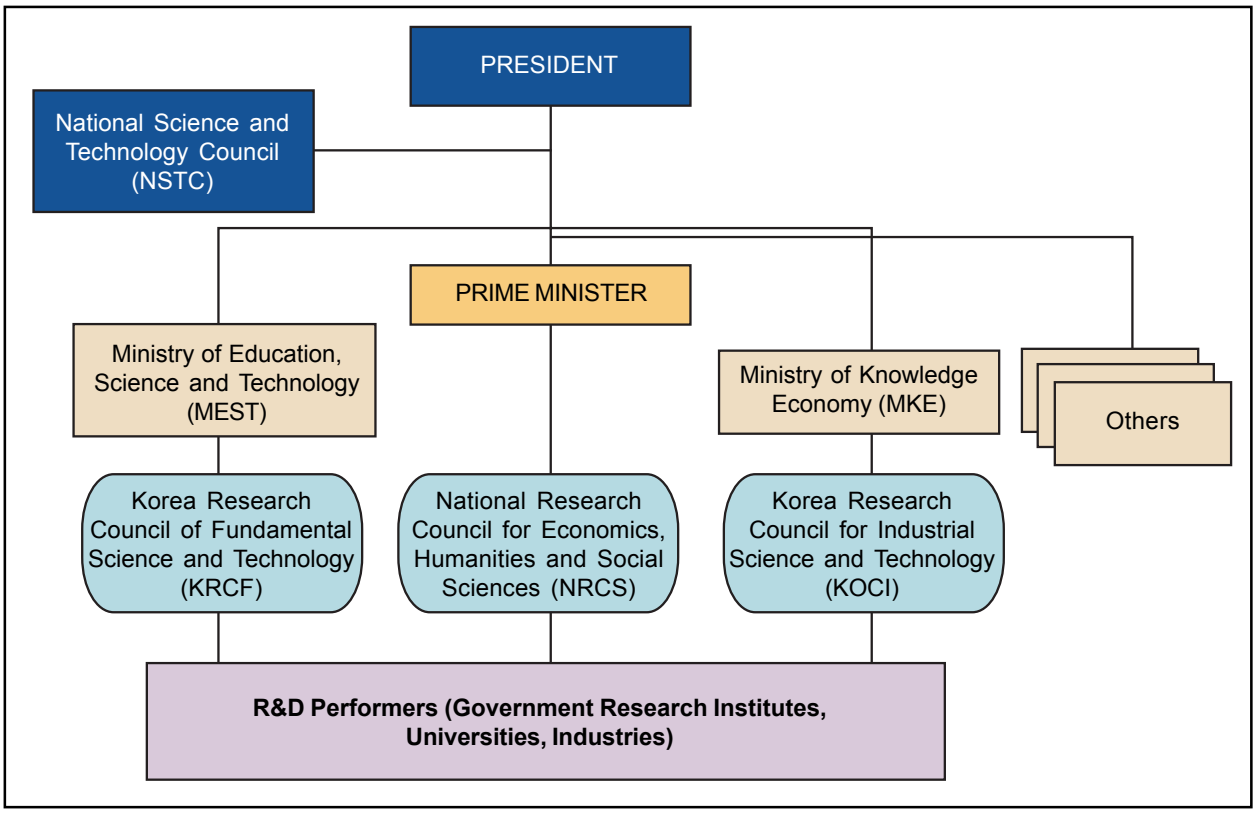


Figure 17: Current S&T administrative framework in the Republic of Korea



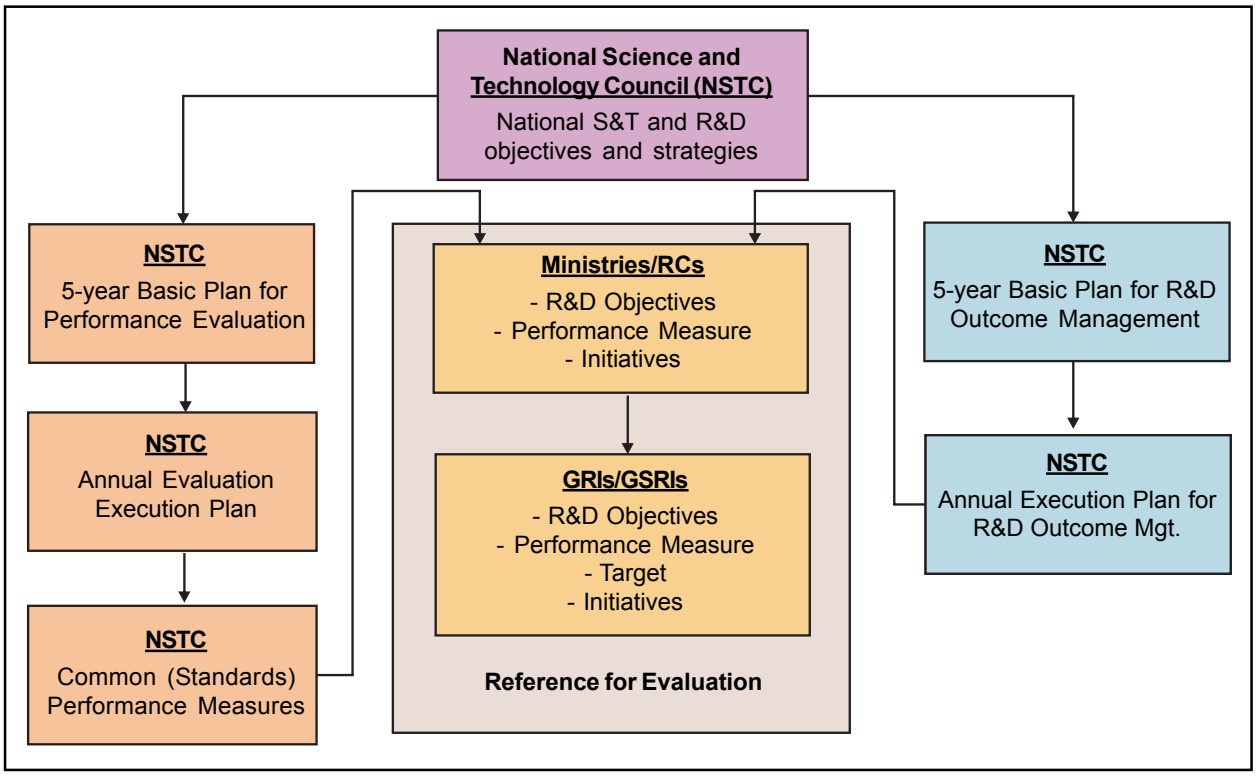
In the Republic of Korea, the S&T administrative framework has transformed from Ministry-centred administration in the 1970s and 1980s, through decentralized administration in the 1990s, to a coordinated one in the 2000s (Choi, 2007). This transformation was triggered by the rapid expansion of government expenditure in R&D.

Coordination among the various R&D ministries became essential after the number of ministries rapidly increased since the mid-1990s (from 9 in 1994 to 19 in 2008). Currently, the role of S&T is not limited to achieving economic development, but extends to addressing various social demands such as quality of life, sustainable development and national security. These have led to the formation of a coordinated S&T administrative framework in the country (Figure 16).

Currently, the National Science and Technology Council (NSTC) is the strong candidate for the central S&T coordinating body. The Ministry of Education, Science and Technology (MEST) and the Ministry of Knowledge Economy (MKE) are the two ministries that have the maximum spending on R&D in the Republic of Korea. Under these two ministries, there are two research councils and a national research foundation. The R&D performers – GRIs, university research and joint industry research – come under these mechanisms (Figure 17).

In the coming months, NSTC may emerge as the supervising body for all R&D activities (Figure 18).

Figure 18: Proposed S&T administrative framework in the Republic of Korea



V CONCLUSION

From the statistical review and qualitative diagnosis by phases, the evolution pattern of the R&D system in the Republic of Korea can be characterized as having shown a phenomenal output/outcome, based on the continuous expansion of investment of R&D fund and human resources and diversification of R&D performers, such as company research institutes (of large companies and SMEs), GRIs and universities.

The R&D system has successfully adapted and transformed, responding to the changes in socio-economic conditions and demands during the rapid growth of the country's economy and provided appropriate technologies for industrial development. The strategic intervention of government was also an important trigger for the successful R&D system transformation through the last five decades. The government S&T administrative framework also continued to evolve to ensure successful coordination among the various R&D ministries responsible for the continuous expansion of R&D investment and R&D performers.

The continuous expansion of Chaebol (large conglomerate)-based and export-oriented economy, which enjoyed the favourable global market conditions during the economic growth, has been the source of the R&D system dynamics in the Republic of Korea.

The evolution of the Republic of Korea's R&D system is now a well-known successful model of S&T system for industrialization of developing countries. This model has also

been introduced as a benchmark case of the most sophisticated STI governance systems among the OECD countries (Guinet, 2008).

The future of the Republic of Korea's R&D system is not certain and is currently under review for restructuring/minor adjustment to make it more efficient and contribute to the socio-economic development. The current issues of the system include coordination of R&D ministries and actors, expansion of strategic basic research, R&D human resource enhancement, specialization of GRIs, research capacity building of company research institutes and triggering public-private partnerships among GRIs, universities and company research institutes.

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