

Success and Challenges in Managing R&D Policy Performance in South Korea

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Abstract

The strenuous R&D investments of the government have helped Korea to transform the country, which previously acquired and imitated foreign technologies, towards a more technologically advanced economy. Analyses of S&T journal publications and patents in conjunction with R&D inputs show that Korea's R&D activities in which the government is thought to be a major actor seemed to have been successful in terms of the increasing rate and cost-effectiveness when compared with the U.S. and Japan. Among others, key driving forces of this success include the strong leadership of presidents who have envisioned national S&T policies; clear-cut policy goals, planning and programs set out by ministries and agencies; increasing capabilities of corporate R&D institutes; and a newly launched R&D performance management system. Yet there are some challenges that the current R&D performance management system has to grapple with to make the system more effective—strengthening the NSTC's strategic planning function; shifting from an output- to outcome-oriented R&D review, analysis and evaluation system; and playing a *de facto* policy coordination and program adjustment role of the NSTC.

Keywords: research and development (R&D), Korea, performance management, R&D performance evaluation system

1. Introduction

Research and development (R&D) within a science and technology (S&T) policy frame is a crucial determinant to strengthen domestic economic growth and international competitiveness of a nation, given that much technological innovation can be initiated by R&D activities (Griliches and Mairesse, 1984; Grossman, 1991; Kim, 1998).¹⁾ R&D is especially important to countries such as South Korea (hereafter

“Korea”) which lacks endowed natural resources. As a major source of adding value to products, most governments have a keen interest in enhancing the R&D capabilities of the industry. Arguably, the government has a decisive impact not only on the direct provision of new technologies but also on the facilitation of a R&D-breeding environment in the market (Kim, 1998). Having said this, the role of the government in the R&D area is essential because R&D generates positive externalities. Government

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1) In some cases, R&D and S&T policies are used interchangeably. In fact, they are conceptually and practically distinctive. Conventionally, S&T policy is inclusive to embrace R&D policy. UNESCO (1978) conceptualizes S&T policy as “systematic [policy] activities which are closely concerned with the generation, advancement, dissemination and application of scientific and technical knowledge in all fields of science and technology.” R&D policy, thus, is one ingredient of S&T policy. The Korean government also regards R&D activities—financing, personnel, incubators and science parks, and facilities and equipment management—as one component of national S&T policy (MOST, 2005).

R&D activities work as the seed with which the industry commercializes innovative products and creates new markets (Sheehan and Wyckoff, 2003). Several empirical studies have found significant effects of social rate of return to R&D spending that exceeds private rate of return (e.g., Griliches, 1991; Hall, 1996). In addition, many analyses have proved that results of R&D activities enhance intra-industry, inter-industry, and firm-to-firm international R&D spillovers.

Had it not been for government interference, technologies and innovations would have produced less than the socially optimum level because of the public good characteristic of R&D activities together with effects of positive externality (Arrow, 1962). Yet a substantial amount of resources that might have been alternatively used for other purposes involves in the course of nurturing R&D activities by the government. Because one of the principal ideas of effectively managing government activities is to allocate and prioritize scarce resources in a way to meet agreed-upon policy goals (Gore, 1993), the notion of performance management needs to be paid attention to in the nation's R&D sector.

The Korean government has also played a certain role in stimulating and incubating national R&D activities. Unlike the rapid economic development during the last 50 years or so, the Korean government did not consider R&D policy a top priority until the 1980s (Sakakibara and Cho, 2002). Recognizing the endogenous limits of economic growth without product innovation and facing external environmental changes in the 1980s, the Korean government attempted to restructure the nation's industrial sector into a more technologically intensive one. Coalesced with the private sector's effort to innovate technology activities, the government has put more effort in R&D investment as a crucial means of sustainable economic growth since the 1980s. Leading the world in several high-technology product markets such as telecommunications, semiconductor memory chips, petrochemicals, steel, and automobiles, the overall performance of Korea's R&D policy has been regarded a success (Kim, 1998; Sheehan and Wyckoff, 2003). Supported by a rapidly growing R&D expenditure,

achievements such as the increasing number of patents and Science Citation Index (SCI) journal publications are also in line with this evaluation (Amsden and Mourshed, 1997). Yet there is still much room for the Korean government to improve managing performance in the R&D policy area. The government-initiated policy is somewhat deficient in the ultimate attainment of R&D outcomes without proper support of universities and industrial actors. While a supply-pushing strategy led by the government has played the significant role of a "seed" to promote industrial technologies, a demand-pulling orientation driven by the market should be emphasized on the basis of entrepreneurship to actively participate in and collaborate with governmental R&D policy.

Assuming the crucial role of the government in stimulating technological innovations, this paper aims at analyzing the extent to which the Korean government has managed national R&D activities. In so doing, the next section summarizes the central ideas and principles of performance management and evaluation of public sector within which this paper is theoretically framed. In the third section, we attempt to evaluate the outputs of R&D activities in conjunction with R&D inputs. Whereas R&D expenditure, R&D personnel, and R&D institutes and centers are used as proxies for inputs, S&T journal publications and patents registered in the U.S. are employed as output indicators. The fourth section addresses several key sources of success in the R&D performance management system of the Korean government. The last section identifies challenges in terms of performance management for which the Korean government must meet to enhance the effectiveness of national R&D policy.

2. Managing Performance

As the nature of organization and its surrounding environments change, the virtues of a Weberian bureaucracy diminish. Nowadays the bureaucracy as observed in reality, not in an ideal form, conveys an unfavorable meaning of organizational behaviors and operations. It reflects red tape, unnecessary delays, a waste of resources, inflexibility and avoidance of

accountability and responsibility. Transformation from a mass production society to a knowledge-based one requires new types of organizational structures and processes different from traditional bureaucracy. In the public sector, efficiency, efficacy and productivity were emphasized together with the values of responsibility, accountability and equity in the early 20th century. Yet the relative importance of the former values was not the same as the latter values. What makes value identification different since the 1980s is that efficiency, efficacy and productivity cannot be further sacrificed to restore public trust in government. As the public management literature acknowledges, the notion of performance management has developed from narrowly defined objectives such as the 3Es—efficiency, effectiveness and economy—to all-encompassing definitions to improve present and future organizational performance and development.

An orthodox view of performance management in the public sector is to improve services with less cost to the citizens. Yet this understanding does not suffice to meet another criterion, which is the gains of public activities, even if cost-effective, must exceed the gains when those activities are left and managed by the market mechanism (Moore, 1995). The importance of performance management can be understood in this context. Scholars in public sector management have proposed and tested the relationship between quality management and performance of public policies (Meier and O'Toole, 2002). They suggest that constructing a performance management system is a necessary, if not a sufficient, condition for the organization to improve efficiency and productivity. The necessity of performance management can be justified not only by formal requirements, which demand organizations to document and report program details.²⁾ At the same time, performance management helps managers identify program activities and associated problems, meet the needs and concerns of stakeholders, and garner support from the public. Whereas the former aspect represents

a Weberian feature of formal bureaucracy, the latter aspects are more closely related to the emphasis on the relatively recent ideas of new public management (NPM). For example, the advancement of statistical techniques supplemented by traditional qualitative methods renders performance evaluation easier, providing quantitative information on performance (Heinrich, 2002). Information on performance management is regarded valuable for the organization to make a better informed decision (Moynihan, 2005).

A simple but clear goal of performance management is to align organizational goals with program outcomes rather than process (Blalock, 1999).³⁾ Rather than casting a fundamental doubt on the potential benefits from the improvement of performance management, researchers and practitioners have been concerned more about how to develop quality management which can be, directly or indirectly, linked to organizational performance. Depending on the scope and focus of analysis, while some view individual attributes such as leadership and entrepreneurship of managers as critical success factors (e.g., Hennessey, 1998), others stress the structural and systemic features of organization such as budgeting and planning, human resources management, incentives, performance appraisal system, and supervision and monitoring (e.g., Brewer and Selden, 2000).

3. Assessing R&D Activities in Korea

Measurement is one of the difficult problems faced by researchers. Part of this problem arises from the inadequacy of accurate information. And the other part, particularly associated with R&D policy, is caused by the multi-dimensional characteristics of government programs which require evaluators to use an integrated and comprehensive indicator. In fact, some dimensions of policy are not easy to measure and quantify. Furthermore, if the effects of a policy are shown over a longer time period, it becomes more difficult to determine to what extent the actual outcomes can be

2) In the R&D policy sector in Korea, for example, the government mandated the “National R&D Program Review, Analysis and Evaluation System,” in which program evaluation is conducted across almost all ministries and agencies that carry out R&D programs.

3) As generally accepted, an outcome, which can be understood as the impacts of policy activities on the welfare of stakeholders, signifies broader contexts such as clients' satisfaction. An output whose definition is narrower than an outcome indicates the result of activities.

exclusively attributable to the policy adopted while controlling other confounding factors (Blalock, 1999). Inherently, R&D policies possess these characteristics.

Among diverse evaluation tools, exploring an input-output link is one method of measuring the R&D policy performance of a government (e.g., Guellec and van Pottelsberghe de la Potterie, 2003). On the input side, the government can deploy diverse policy tools to promote the nation's R&D activities—institutionalizing intellectual property rights protection, expanding government funding on R&D, building R&D infrastructure such as research institutes/centers and science parks, encouraging university-firm and public-private partnerships, providing R&D information to the industry, subsidizing private R&D expenses (see Jaffe, 2002, Hall, 2002 and Kauko, 1996 for a skeptical view), and/or providing tax incentives (Hall and Van Reenen, 2000) and preferential loans. Concerning the effects of these policy tools, conventional wisdom is that these policy tools can foster innovation of the firms, and produce positive social and economic outputs (see, however, Goolsbee, 1998 for an opposite view).

As for the output side, it needs to consider a variety of factors to evaluate the results of R&D policies. It is expected that government-funded R&D activities can be a source of stimulation for firms' innovations and, ultimately, increase the productivity and competitiveness of firms. Assuming that private investment in R&D tends to be provided below the socially optimum level due to a market failure characteristic (Arrow, 1962), government-funded R&D also has positive externality or knowledge spillover effects on related firms and industries. Although, in theory, an input-output linkage in all dimensions should be incorporated for precise performance measurement, most research facing the constraints of data availability

only considers a few of these factors.

The efforts of Korea to pour more inputs on R&D can be illustrated by R&D expenditures, the number of R&D personnel, and the creation of research institutes and centers. As displayed in Table 1, the growth of inputs on R&D is never trivial in terms of sheer magnitude and growth rate. When compared with the market growth rate, the growth rate of R&D investment is faster. During the period of 1981-2006, while Korea's GDP had grown by 17.4 times from K₩48.6 trillion in 1981 to K₩846.6 trillion in 2006, the total R&D investment, which combines government investment with the public sector investment, increased more than 74.1 times from about K₩37 trillion in 1981 to K₩27.3 trillion in 2006. A similar pattern can be found in the government spending. In other words, the Korean government's R&D spending rate grew faster than the growth rate of government expenditure. These points reflect the concerns of the Korean government in R&D.⁴⁾ For example, whereas the government expenditure expanded by about 19.9 times during the period of 1981-2006, the R&D investment by the Korean government increased by about 32.6 times from 1981 to 2006. The size of human resources in the R&D sector became larger by 10.2 times during 1981 and 2006. The number of research institutes and centers increased by about 8.3 times from 1,143 in 1984 to 9,443 in 2006.⁵⁾

When examined from the perspective of journal publications and patents, what Korea has achieved in output aspects over the last decade or so is also remarkable. Although journal publications and patents are never complete proxies to evaluate outputs from R&D activities, more R&D expenditure as an input factor is highly correlated with increasing journal publications and patents as output factors (Amsden and Mourshed, 1997). Therefore, an examination of

4) Although the Korean government's R&D expenditure in absolute monetary terms still lags behind other developed countries, the rate of expenditure vis-à-vis government expenditures and GDP has grown much faster than many developed countries (Sakakibara and Cho, 2002; Sheehan and Wyckoff, 2003). During the period of 1991 to 2001, the average growth rate of R&D expenditure in Korea in terms of percent of GDP is 4.83, which is higher than most OECD countries including the U.S. and Japan.

5) Figures in the last column in Table 1 include research centers and institutes in the public as well as the private sector. The Korean government's stance towards R&D is to encourage the establishment of more research institutes and centers in the private sector. As a result, the number of corporate-affiliated research institutes and centers exponentially grew from 53 in 1981 to 500 in 1988 to 1,000 in 1991 (Kim and Lee, 2003).

Table 1 Major indicators of inputs of R&D activities in Korea (1981-2006)

Year	GDP (A) ^a	Gov't Expenditure (B) ^a	Total R&D Investment (C) ^a	Gov't R&D Expenditure (D) ^{a, b}	Ratio of (C) over (A) ^c	Ratio of (D) over (B) ^c	Total # R&D Personnel	Total # R&D Institutes and Centers
1981	48,627.7	6,078.9	368.8	203.6	.76	3.35	35,805	n.a.
1982	55,721.7	6,904.8	533.1	264.3	.95	3.83	46,390	n.a.
1983	65,559.0	7,750.9	682.2	231.2	1.04	2.98	58,720	n.a.
1984	75,126.3	8,355.9	907.2	251.5	1.21	3.01	70,524	1,143
1985	84,061.0	9,425.6	1,237.1	306.8	1.47	3.25	73,516	1,291
1986	98,110.2	10,769.1	1,606.9	374.3	1.64	3.48	87,430	1,682
1987	115,164.3	12,334.4	1,985.2	490.2	1.72	3.97	96,288	1,864
1988	137,111.5	14,743.9	2,454.2	522.9	1.79	3.55	104,737	2,821
1989	154,753.4	17,818.5	2,817.3	575.0	1.82	3.23	119,357	2,077
1990	186,690.9	22,053.7	3,349.9	651.0	1.79	2.95	125,521	2,106
1991	226,007.6	26,303.3	4,158.4	808.5	1.84	3.07	131,983	2,352
1992	257,525.4	31,021.9	4,989.0	856.9	1.94	2.76	148,947	3,106
1993	290,675.6	34,413.2	6,153.0	1,026.6	2.12	2.98	156,073	3,318
1994	340,208.3	38,941.5	7,894.7	1,880.2	2.32	4.83	190,298	2,640
1995	398,837.7	44,686.9	9,440.6	2,289.1	2.37	5.12	201,661	2,587
1996	448,596.4	52,138.5	10,878.1	2,850.6	2.42	5.47	202,347	2,856
1997	491,134.8	56,748.7	12,186.4	3,344.8	2.48	5.89	212,117	2,962
1998	484,102.8	61,980.6	11,336.6	3,491.1	2.34	5.63	199,191	2,896
1999	529,499.7	65,173.6	11,921.8	3,574.3	2.25	5.48	212,510	3,059
2000	578,664.5	70,097.7	13,848.5	3,816.9	2.39	5.45	237,232	4,635
2001	622,122.6	80,298.2	16,110.5	4,316.5	2.59	5.38	261,802	6,801
2002	684,263.5	88,512.2	17,325.1	4,740.0	2.53	5.36	279,806	7,210
2003	724,675.0	96,203.2	19,068.7	4,876.2	2.63	5.07	297,060	7,127
2004	778,435.09	103,899.46	22,185.40	5,446.10	2.85	5.24	312,314	7,254
2005	810,583.89	112,211.41	24,155.40	5,877.20	2.98	5.24	335,428	9,961
2006	846,616.10	121,188.33	27,345.70	6,632.10	3.23	5.47	365,794	9,443

Notes: ^a Korean won in billions; ^b R&D expenditure by the national and public universities, government-funded research institutes, and government-affiliated non-profit research foundations (R&D expenditure in the private sector = C - D); ^c %

Sources: KOITA (2004); MOST (2002b; 2004; 2007); NSO (2005); OECD (2007)

those output factors provides some, albeit limited, information to evaluate the impact of the government on the nation's technological development. As indicated in Table 2, the total number of articles published in science and technology (S&T) journals jumped from 1,227 in 1988 to 23,286 in 2006, which shows about a 19-fold increase. This process is even more noteworthy when compared with the U.S. and Japan. In 1988, the number of published S&T journal articles in Korea was merely .5% and 2.7% of that in the U.S. and Japan, respectively. This ratio grew to 7.9% of the U.S. and 32.7% of Japan in 2006. What is more astonishing is the cost-effectiveness, which measures the number of articles published per US\$1 million of R&D expenditure. During 1988 and 2006, this number

in Korea increased from .36 to .81. By contrast, this number decreased sharply in the U.S. and slightly in Japan during the same period of time. At least from the perspective of cost-effectiveness of journal publications, Korea outperformed the U.S. and Japan. The cost-effectiveness of Korea can be also found in the area of patents registration. While the number of patents registered increased by more than 33.8 times in Korea from 1988 to 2005, in the U.S. and Japan it increased only 3.6 and 2.2 times, respectively, during the same period. In a cross-sectional comparison, the number of patents in Korea consisted only 5.4% and 4.0% of that in the U.S. and Japan in 1988. Yet it comprised 51.1% of the U.S. and 59.8% of Japan in 2005. As per \$1 million of R&D expenditure, the

Table 2 Outputs of science and technology (S&T) activities in Korea, U.S., and Japan (1988-2006)

Year	Total # Published S&T Journal Articles			Total # Published S&T Journal Articles per US\$ in Millions of R&D Expenditures			Total # Patents Registered (Applied)			Total # Patents Applied per US\$ in Millions of R&D Expenditures		
	Korea	U.S.	Japan	Korea	U.S.	Japan	Korea	U.S.	Japan	Korea	U.S.	Japan
1988	1,227	250,358	46,252	.36	1.99	.61	2,174 (20,015)	40,497 (147,344)	55,300 (345,418)	5.84	1.17	4.53
1989	1,567	231,332	46,737	.38	1.75	.59	3,972 (23,315)	95,539 (161,660)	63,301 (357,461)	5.62	1.22	4.52
1990	1,780	248,562	48,710	.38	1.63	.58	7,762 (25,820)	90,366 (176,100)	59,401 (376,792)	5.52	1.16	4.51
1991	1,818	224,955	44,521	.33	1.40	.47	8,690 (28,132)	96,519 (177,388)	36,100 (380,453)	5.15	1.10	4.03
1992	2,461	254,373	51,772	.39	1.54	.51	11,446 (36,491)	97,443 (187,291)	92,100 (384,456)	5.77	1.13	3.81
1993	2,997	258,776	51,199	.39	1.56	.45	11,446 (47,344)	98,344 (191,386)	88,400 (380,035)	6.22	1.16	3.37
1994	3,910	267,125	55,142	.39	1.58	.45	11,683 (60,594)	101,676 (209,691)	82,400 (370,652)	6.05	1.24	3.05
1995	5,814	277,902	59,611	.48	1.52	.43	12,512 (96,557)	101,419 (235,440)	109,100 (388,957)	7.92	1.28	2.77
1996	6,449	253,044	61,445	.50	1.29	.48	16,516 (113,994)	109,646 (223,419)	215,100 (401,251)	8.85	1.14	3.15
1997	7,841	251,096	61,986	.91	1.19	.52	24,579 (129,982)	111,984 (236,692)	147,686 (417,974)	15.10	1.12	3.49
1998	9,555	252,623	67,004	1.02	1.11	.59	52,900 (75,188)	147,520 (262,787)	141,448 (437,375)	8.01	1.16	3.86
1999	11,066	253,325	68,896	1.05	1.03	.52	34,956 (80,642)	153,487 (294,706)	150,059 (442,245)	8.06	1.21	3.35
2000	12,232	251,023	68,134	1.00	.95	.48	45,298 (102,010)	157,496 (331,773)	125,880 (486,204)	8.36	1.25	3.42
2001	14,733	257,668	70,711	1.18	.94	.55	34,675 (104,612)	166,038 (375,657)	121,742 (496,621)	8.37	1.37	3.88
2002	15,705	253,215	69,290	1.09	.91	.56	45,298 (106,136)	163,518 (334,445)	119,192 (421,805)	7.37	1.21	3.40
2003	18,830	254,260	75,731	1.18	.95	.56	44,178 (118,651)	169,035 (342,441)	122,522 (413,093)	7.41	1.18	3.05
2004	19,328	265,205	68,752	1.00	.88	.47	49,068 (140,115)	164,291 (356,943)	124,192 (423,081)	7.23	1.19	2.90
2005	23,089	299,898	75,502	.98	.92	.50	73,512 (160,912)	143,860 (390,733)	122,944 (427,078)	6.82	1.20	2.82
2006	23,286	293,254	71,143	.81	.85	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Sources: KISTEP (2010); OECD (2007); Yeom et. al. (2004)

number of patents in Korea steadily increased from 5.84 in 1988 to 6.82 in 2005. This number marginally increased in the U.S. and declined in Japan.

One of the cruxes of performance management is to choose a less expensive and easy-to-administer policy measure in the course of achieving organizational goals (Heinrich, 2002). According to this criterion, the R&D activities of the Korean government can be positively evaluated. Despite this fact, however, further exploration is required to discern whether such output

growth contributed to the productivity and economic growth of Korea.

4. Korean Government's Management of R&D Activities

As the scale and scope of R&D expanded in the 1990s, the overall, although incomplete, R&D performance evaluation system in Korea has improved as well. This does not mean that there is no room

for further improvement in the R&D efforts of the Korean government. Nor does it mean that the Korean government accomplished this success in a drastic manner. R&D policy in Korea has undergone a series of evolutionary stages—gestation stage in the 1960s, R&D system formation stage in the 1970s, early maturity stage in the 1980s, and substantial maturity stage in the 1990s (Kim and Lee, 2003). Despite the establishment of the Ministry of Science and Technology (MOST) in 1967 and the introduction of “*Gwahak Kisul Jinheung Bup* (the Science and Technology Promotion Law)” of 1972, the role of the government in promoting R&D was limited until the 1980s (Sakakibara and Cho, 2002). This is largely due to the fact that S&T policy played a supplementary role for industrial policy. The Korean government’s reposition in the 1990s when dealing with R&D may be its recognition that economic growth could not be sustained solely by an injection of more physical capital without improving R&D capabilities.

Since the 1980s, the Korean government has employed diverse policy measures to promote R&D activities. Those efforts of the government gained tangible outcomes in the mid 1990s. Because the R&D activity adopted the government-led supply policy strategy for several decades rather than market-based demand pulling, it is always an overstatement to attribute the achievement to solely market initiation. It is more natural to seek the success factors in the government in managing R&D performance by combining several key factors as follows.

4.1 Leadership-backed Prioritization

Strong political and/or administrative leadership is one of the essential values in managing performance (Mintzberg, 1996). In the process of technological innovation, the good leadership of project managers is a decisive factor for success or failure of the project (Cleland, 1995; Hennessey, 1998). In a similar vein, the strong leadership of the president in charge of directing the nation’s critical decisions is needed to furnish a clear and unwavering strategic direction for S&T policy.

In Korea, S&T has always been one of the nation’s important policy agendas in every administration. Although the degree to which each administration prioritizes S&T policy somewhat varies (i.e., status as a supplementary policy until the 1980s or a primary national agenda after the 1990s), most presidents regarded S&T as a key to the nation’s competitiveness. As pointed out earlier, it is indisputable that their awareness arises from realization of the lack of sufficient natural resources in Korea under which S&T, particularly R&D, is one of the push factors for economic growth. For example, in a commemoration speech for the opening of the Korea Institute of Science and Technology (KIST) on October 6, 1966, President Park Chung Hee addressed that “Economic growth and modernization cannot be achieved without the development of S&T (Office of the President, 1968).” The importance of S&T policy and R&D investment has been recurrently emphasized by presidents in Korea. President Roh Tae Woo in the 1990 State of Union Address expressed his aspiration for Korea’s S&T to reach the level of the world’s top 7 countries in 10 years (Office of the President, 1990). President Kim Young Sam in an address to Korean scientists in the U.S. stated that “the government is executing proactive S&T promotion policy, acknowledging that S&T is a determining element to become a world-class nation (MOST, 1995).”

Even during times of political turbulence and economic difficulties, the government attempted to manage those circumstances by accentuating the role of S&T. In his inauguration address immediately following the outbreak of the 1997 financial crisis, President Kim Dae-jung proposed a blueprint to lead Korea to become one of the technology superpowers of the world (Kim, 1998). The government’s prioritization of S&T policy indicates not only a practical gist to seed economic development but also a symbolic significance to the Korean people to justify their regime.

4.2 Clear-cut Policy Goals, Planning and Programs

From the 1960s, the Korean government has set up relevant S&T policy goals that embrace environmental

changes and established mid- and long-term R&D plans as one means to accomplish S&T policy goals. Principal policy goals and specific plans according to S&T-related environmental settings are summarized in Table 3.

In order to meet these policy goals and plans, the Korean government has developed a series of R&D programs. In 1982, the MOST implemented the “Specific R&D Development Program (SRDDP)” based on the S&T Development Promotion Law.⁶⁾ In 1983, the government created the “Purposeful Basic Research Program” that aimed to support research capability, and scientists and engineers at universities. The SRDDP was further pushed in 1990 in a way that the government reconfigured its implementation methods and performance management system. Accordingly, the SRDDP was classified into 10 major technology areas and 42 large government-funded programs. The “G7 Program” in 1992 set up the basic science research program as a separate program. In 1996, government-funded programs branched out into the “Program for Creating a Base of International Cooperation,” the “Grand Sciences,” and the “Shared Laboratory Facilities.” The “Creative Research Promotion Program” was run in 1997 to provide a seed for new technologies and associated industries. In 1999, the “21st Century

Frontier Research Promotion Program” was launched to strategically and selectively develop leading-edge technologies.⁷⁾

As those diverse programs articulate, the government’s R&D programs have diverged in the course of the implementation processes. In addition, more ministries and agencies have engaged in carrying out R&D programs, which require inter-ministerial cooperation. Those R&D programs can be characterized as a “diverse, continuous, and sustainable” effort of the Korean government.

4.3 Triggering Private Sector R&D Institutes

Other than self-initiations, the Korean government has provided various support to the private sector to vitalize market-based R&D activities. For this purpose, the government has utilized technology development funds, subsidies, tax incentives, and military exemption for research professionals (MOST, 2002a). As a corollary, corporate-affiliated research institutes have grown by leaps and bounds from 46 in 1981 to 235 in 1991 to 1,960 in 2001. R&D expenditure by private research institutes also increased sharply by 7.6 times from KW3.3. trillion in 1990 to KW25.1 trillion in 2008. In 2008, R&D investments by the private sector

Table 3 Principal science and technology (S&T) policy goals and R&D plans

Time	Environments	S&T Policy Goals	Major R&D Plans
1960s	Absence of ST infrastructure	Import and improve foreign technology	5-year Plan for Technology Promotion
1970s	Underdeveloped industry	Promote heavy industry for industrial restructuring	STPI Project
1980s	Nationalistic technology	Strengthen ST capacity at a national level	Long-term Plan for 2000
First half of 1990s	Technology protectionism	Reconstruct the nation’s innovation system	G7 Comprehensive Plan
Second half of 1990s	Financial crisis and contraction of R&D investment	Allocate R&D resources efficiently	Long-term Vision for 2025

Source: Adopted from Park et. al. (2001)

6) The SDDRP targeted technological innovations in the areas of information, bioengineering, new materials and energy, medicine, and environment. In doing this, the “industries-universities-research institutes” triangular collaboration is particularly stressed. During 1982-1992, about US\$.88 billion was funded by the government for 2,415 research projects (Lee et. al., 1996).

7) Managed largely by the MOST, the 21st Century Frontier Research Promotion Program is a large-scale R&D program in the basic and applied research areas including information communications technology, biotechnology, nanotechnology, life sciences, environmental technology and new materials.

account for almost 73% of the nation's aggregated R&D spending (MOST, 2010). Although it is certain that a large part of private R&D activities is based on the needs of the corporate sector, it is difficult to deny that such growth of private R&D capabilities results from the effort of the government in managing the nation's S&T policy.

4.4 Performance Management System

Despite that how to manage performance of R&D programs is as important as what R&D programs had been implemented, the performance management system was not well equipped before the 1990s, largely due to a lack of understanding of the significance of performance management by the ministries concerned (Lee et. al., 1996; Schindler, 2004). However, as R&D investments expanded rapidly and more ministries and agencies became engaged in R&D programs since the 1990s, the government had to craft a more effective performance management system that could streamline the "review-analysis-evaluation" processes of the nation's R&D programs. This system was designed to minimize overlapping R&D investments and to maximize efficient R&D resources allocation. There are several distinctive features of the performance management system.

First, as a means to improve the efficiency of R&D investments administered by the many ministries, the review and coordination system underwent three major structural changes (Hwang, 1999). The Overall Science and Technology Review Council (OSTRC) chaired by the Prime Minister was set up in 1973. The Council's function was to review and coordinate S&T policy and R&D programs. The OSTRC was reformed into the Ministerial Council on Science and Technology (MCST) in 1996 which was comprised of S&T-related ministers as members. Except for the fact that more ministries participated, the function of the MCST did not differ much from that of the OSTRC. In 1999, the MCST was expanded and framed into the National Science and Technology Council (NSTC), for which the president serves as chairman. The NSTC as the highest decision making body concerning national

S&T policies is responsible for the planning and coordination of major S&T policies and budgets, and review and finalization of R&D programs for efficient operation.

Second, the "National R&D Program Review, Analysis and Evaluation (RAE) System" was introduced in 1998. Grounded on the "Special Act for Scientific and Technological Innovation of 1998," this System is designed to evaluate the progress of national R&D projects spread out across diverse ministries and agencies. The primary goals of this System are (1) to increase the productivity and efficiency of national R&D programs and structures by reviewing and evaluating the contents and performance of national R&D projects, (2) to derive from (1) a developmental plan based on the principle of "selection and concentration," and (3) utilize the RAE results to foster inter-ministerial competition for advancing national R&D activities. Using multiple criteria such as the relevancy of project goals, efficiency of project implementation methods, and project outcomes and performance, each project is classified into 5 grades from A (outstanding) to E (needs improvement). A project graded either D or E is adversely affected in budget allocation in the next fiscal year (NSTC, 2002). In a 2004 evaluation which was conducted by the Korea Institute of Science and Technology Evaluation and Planning (KISTEP), an assisting arm of the NSTC, 266 programs with a total R&D budget of ₩4.9 trillion carried out by 20 ministries and agencies were selected. Of the 266 programs, the KISTEP evaluated 201 programs among which 116 programs were graded. In the final evaluation, 24.1% (28 programs) received a grade of E or D (MOST, 2005). In a 2009 evaluation, 78.6% (55 programs) were assessed as "More than Average," while the remaining 21.4% (15 programs) received a grade of "Insufficiency." (MOST, 2010).

Third, the government has been reengineering the S&T information system to integrate R&D-related data and manage R&D activities. Integrating multiple databases into a single one makes it easier not only for users (ministries and agencies, universities, and industries) to access recent government-led R&D

activities and outcomes, but also for evaluators to monitor and oversee R&D programs (Saunders and Heflinger, 2004). The information system was initially proposed in 1998 when the National R&D Program RAE System required ministries and agencies to submit their R&D program data. Previously, R&D information and databases were individually managed at the ministry/agency level. Yet an initial attempt to construct a full-scale information system only created a limited database that contained the evaluation results of the National R&D RAE. In 2002, the system was upgraded to the “Comprehensive Management System” that aimed to link the R&D databases of 20 ministries (MOST, 2002a). Recently, the most current “National S&T Information System (NTIS)” was adopted in 2005 to consolidate previously scattered R&D-related data and information into one system. The NTIS now serves as an information and data gateway of R&D programs, personnel, and performance management among others. Furthermore, this system will allow ministries and agencies to connect and share their R&D database with one another through database standardization and compatible systemization protocols (MOST, 2010).

5. Conclusions: Policy Implications and Challenges

The strenuous R&D investments of the government have helped Korea to transform the country, which previously acquired and imitated foreign technologies, towards a more technologically advanced economy. As exemplified by the increasing number of S&T journal publications and patents, R&D activities in Korea in which the government is thought to be a major actor seems to have been successful. Among others, the key driving forces of this success include the strong leadership of presidents who have envisioned national S&T policies along with the efforts of ministries and agencies that translate the S&T visions of presidents into policy goals and action programs. In addition, as the private sector has gained competitiveness, corporate-affiliated research institutes also played an important role to secure national R&D capabilities.

To streamline those endeavors, especially of the government, a new system of managing projects and evaluating programs is being utilized. As national R&D programs become more complicated because of their scope and scale and more actors take part in R&D activities, an effective performance management system is a vital element to sustain and further what Korea has achieved in the R&D sector. Nonetheless, there are several challenges to make the current R&D performance management system more effective.

First, the NSTC as the highest decision making body for S&T policy has to broaden its activities beyond reactive budget allocation, program monitoring and policy coordination. Future technology is evolving very rapidly through the convergence of technologies, which in nature is hard to predict. In this regard, the NSTC should respond proactively to this environmental change by strengthening the strategic planning functions of the prediction of future technology and technology impact analysis. In addition, the current “National R&D Program Review, Analysis and Evaluation (RAE) System” carried out by the KISTEP places its evaluation focus on the “output” rather than the “outcome” of R&D programs (Schindler, 2004). In other words, the System is concerned more about planning mid- and long-term financing of large-scale R&D programs and setting R&D investment priorities. Yet its performance management does not seriously pursue the social and economic implications of the R&D programs.

Second, the NTSC has to be a *de facto* policy coordinator. Despite that formally the NTSC is granted to carry out this coordination function by law, there has been criticism concerning the waste of R&D resources because of duplicate R&D investments among ministries and agencies. The NSTC has become a conflict-manifest arena for competing ministries and agencies who wish to preempt leading-edge research programs rather than the policy-coordination and program-adjustment sphere (Yeom, 2004). In the midst of inter-ministerial conflicts and pressures, it seems that the NTSC places more emphasis on budget allocations rather than comprehensively coordinating the details of key R&D policies and programs.

Third, the government should consider R&D resource allocations to bridge the technology gap between a few large *chaebols* (conglomerates) and a large number of small- and medium-sized enterprises (SMEs). Although the principle of selection and concentration warrants the distribution of more R&D resources to high technology-oriented industries, a large portion of which is already dominated by *chaebols*, it will only intensify the present disparity between *chaebols* and SMEs. For example, the top five *chaebol* companies—Samsung Electronics, LG Electronics, Hyundai Motors, Hynix Semiconductors, and GM Daewoo Auto & Technology—hold a lion's share in terms of R&D investments and outputs: 37% of business R&D spending, 28% of employment of researchers, 57% of U.S.-registered Korean patents in 2003 (Baek and Jones, 2005). The fact that the private sector R&D investments largely led by *chaebols* accounts for almost three quarters of the nation's R&D spending indicates that *chaebols* may have enough resources without support from the government. By contrast, SMEs have difficulty in engaging actively in R&D investment because of their limited capacity to mobilize needed capital and because of a fear that their investment may fail. Contrary to the common notion of "high-risk-and-high-return," R&D is occasionally a high-risk activity with low returns SMEs incur. *Chaebols* are tempted to merge SMEs or purchase SMEs' innovative ideas and technologies at an unfairly low price. When such predatory practices continue, the ecosystem in the technology market can be destroyed in the long run. These circumstances provide a rationale for why the government has to adopt a policy to strategically support the SMEs' R&D activities and diffuse innovations throughout the economy. Moreover, to maintain a healthy economic ecosystem, the government needs to construct a productive partnership between *chaebols* and SMEs.

Considering the public good characteristic and the positive spillover effect of R&D, the competitiveness of Korea is largely determined by the extent to which the government is able to manage effectively the nation's R&D activities through further consolidation of success factors and the overcoming of challenges.

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