The Changing Role of Government Research Institutes in Innovation Systems

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ABSTRACT

Recent years have seen an intensified discussion in many OECD countries about the role and mission of public research in the innovation system. This discussion takes place in quite specific national contexts, but should benefit from international experience. However, whereas voluminous literatures address the changing governance methods, organizational forms and missions of universities[1], much less attention has been devoted to developing a common understanding of the challenges faced by non-university public research institutions.[2]

The main goals of this paper is to contribute to clarifying the nature of these challenges, outlines possible policy answers and draws some implications for Korea. In the first section, the paper uses available internationally comparable indicators to review trends in the contribution of government research institutes (GRIs) to R&D and innovation activities. In the second section, the paper identifies the current major changes in the dynamics of innovation that may call for further adjustments in the positioning, organization and steering of public research institutes. Finally, the paper outlines some strategic objectives and orientations for the reform of public research institutes as part of the broader agenda of the Korean innovation strategy.

KEYWORDS: public(government) research institutes, reform, R&D, innovation, Korea

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[1] For example, see the OECD Thematic Review of Tertiary Education, 2008.

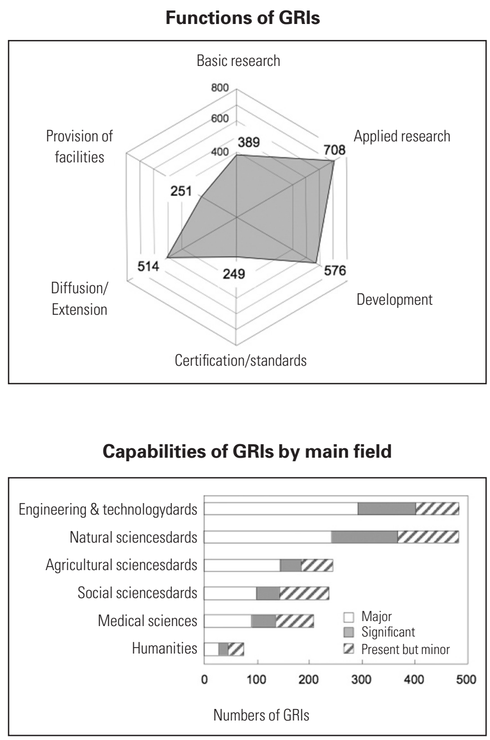
[2] Efforts to study GRIs have been and remain mainly undertaken at the national or institutional level (e.g. Gulbrandsen and Nerdrum, 2007; Hyytinen et al 2009). Cross-country analyses of GRIs using the same methodology are sparser. One example is the Eurolab project which was carried out in 2002 by an international consortium led by PREST at the University of Manchester (PREST, 2002). In 2003, the OECD published a report on the Governance of Public Research: Toward Better Practices (OECD, 2003) which reviewed the changes in the governance of OECD countries' science systems.

1. GRIS IN NATIONAL INNOVATION SYSTEMS – A HISTORICAL AND CROSS-COUNTRY PERSPECTIVE [3]

Public research institutions have always been important actors in innovation systems and have been the source of important technological and innovation breakthroughs. From a historical point of view, GRIs were set up to compensate for market or systemic failures of their respective innovation systems, by performing a wide range of functions, with variable disciplinary focus. These functions include conducting "strategic", pre-competitive research, providing technological support to business, supporting public policy, creating and establishing technical norms and standards and constructing, operating and maintaining key facilities (Figure 1).

Following World War II, the number and variety of GRIs established for civil and military applications expanded rapidly in many OECD countries. This growth largely continued in the 1960s but began to slowdown and fade in the 1970s. By the 1980s, the relative role of GRIs, in terms of their contribution to innovation and technological development, started to decline in most countries for several reasons. Among them were the reinforcement of the R&D capacities of the business enterprise sector, reductions in the defense budgets of many larger OECD members, the restructuring of national science systems in response to changing priorities for mission-oriented research and the rise of university research.

FIGURE 1
THE VARIETY OF EUROPEAN GRIS



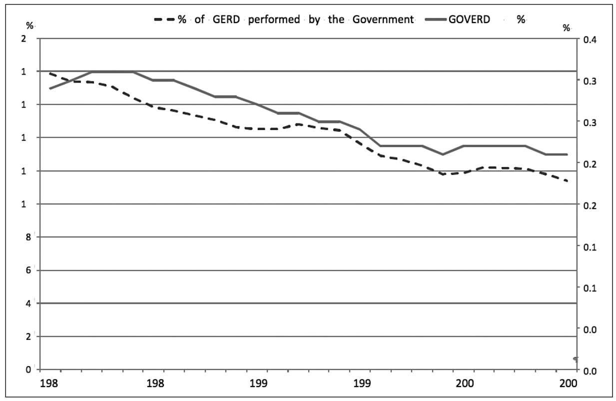
Source: PREST(2002)

[3] This section draws heavily on the interim results of the ongoing work by the OECD Working Party on Research Institutions and Human Resources (RIHR) led by Ester Basri (OECD, DSTI Science and Technology Division).

In the OECD region, the share of gross domestic expenditure on research and development (GERD) performed by the government sector was 17.9% in 1981 and 11.4% in 2006. As a share of GDP, government intramural expenditure on R&D (GOVERD, which is a proxy for R&D spending in GRIs) was between 0.34 and 0.36% in the early 1980s and had fallen to 0.26% of GDP by 2006 (Figure 2).

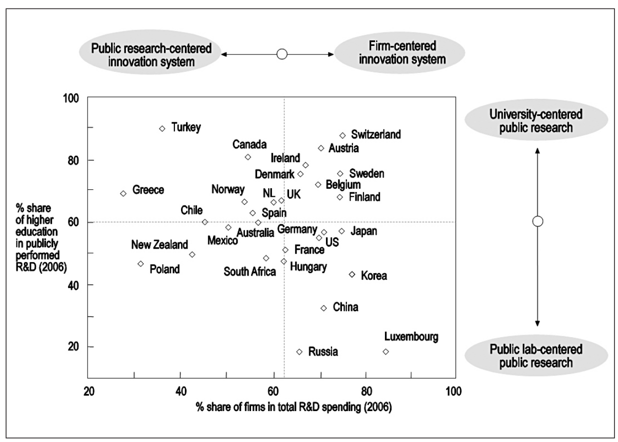
These overall trends have attenuated—but only to a limited extent—the considerable cross-country variability of the role of GRIs in the innovation system, relative to firms and universities, the two other main actors (Figure 3). This variety reflects enduring differences in the levels of economic and technological development, the emphasis placed on military research and the historical legacies of institutional arrangements in the public sector. Additionally, this variety reflects R&D funding, orientations and performance, as measured by existing indicators largely according to the Frascati definition (OECD, 2002) of the government research sector at the aggregate national level.

FIGURE 2.
R&D IN THE GOVERNMENT SECTOR, TOTAL OECD, 1981-2006



Source: OECD, Research and Development Statistics Database.

FIGURE 3
ARCHETYPES OF NATIONAL INNOVATION SYSTEMS



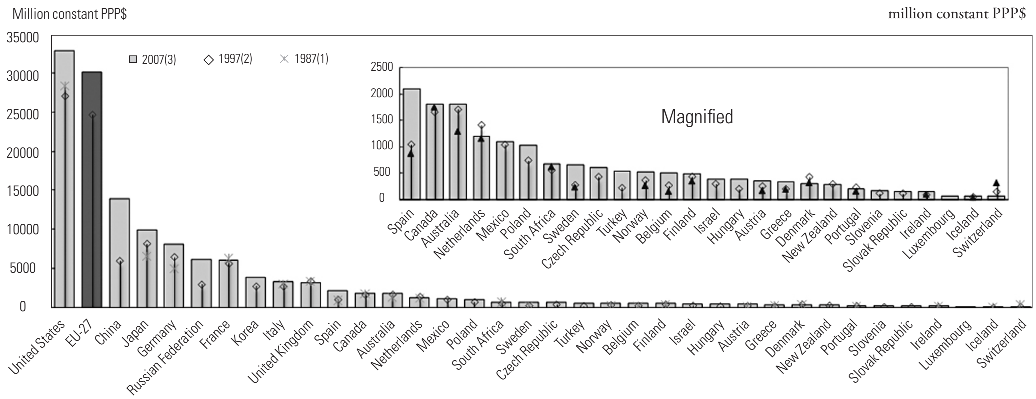
Source: The author, based on OECD data.

Rising Levels but Decreasing Share of R&D Spending in GRIs

Absolute real expenditure on R&D in the government sector has increased over the past decade in most countries (Figure 4). From around 1997 to 2007, Denmark, the Netherlands, Portugal, Switzerland and the United Kingdom were the only countries in which spending fell. OECD investment in GOVERD climbed to USD 81.2 billion in 2006, up from USD 59.7 in 1987 and USD 67.4 billion in 1997, representing an annual growth rate (in real terms) of 1.2% from 1987 to 1997 and 2.1% between 1997 and 2006.

GOVERD as a share of GDP reveals even more diversity across countries (Figure 5). OECD-area expenditure on R&D in the government sector fell from 0.35% of GDP in 1987 to 0.26% in 2006. Over the period 1987 to 2007, the largest falls were in France, the Netherlands, Switzerland and the United States. From 1997 to 2007, expenditure fell in 16 OECD countries as well as Israel and South Africa. In contrast, the largest growth of GOVERD as a share of GDP occurred in Iceland, Sweden, Belgium and Turkey.

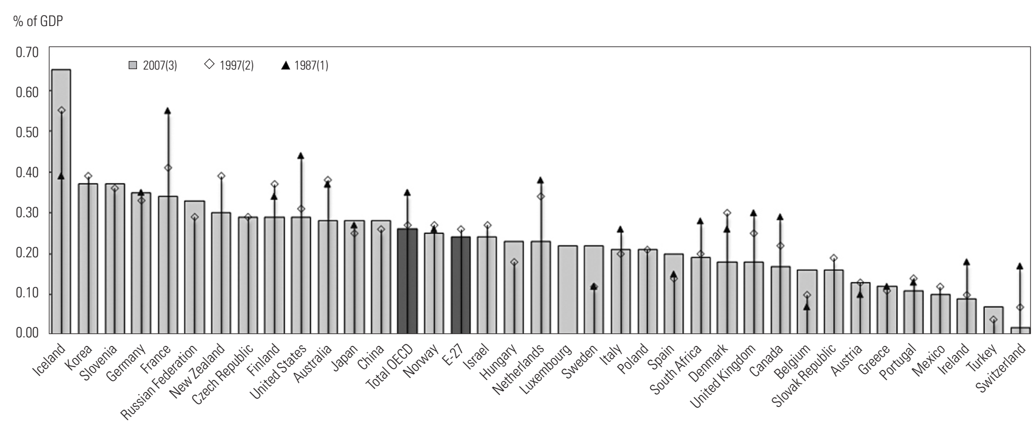
FIGURE 4. Government Expenditure on R&D (GOVERD)



1. 1985 instead of 1987 for Austria. 1986 for Greece and Switzerland
2. 1996 instead of 1997 for Australia and Switzerland. 1993 for Austria.
3. 2005 instead of 2007 for Iceland, Mexico, New Zealand and South Africa. 2006 for Australia, Japan, Korea, Poland, Spain, Switzerland, Turkey, the United Kingdom, Total OECD and China.

Source: OECD, Main Science and Technology Indicators

FIGURE 5. GOVERNMENT EXPENDITURE ON R&D AS % OF GDP



Notes: 1985 instead of 1987 for Austria. 1986 for Greece and Switzerland. 1996 instead of 1997 for Australia and Switzerland. 1993 for Austria. 2005 instead of 2007 for Iceland, Mexico, New Zealand and South Africa. 2006 for Australia, Japan, Korea, Poland, Spain, Switzerland, Turkey, the United Kingdom, Total OECD and China.

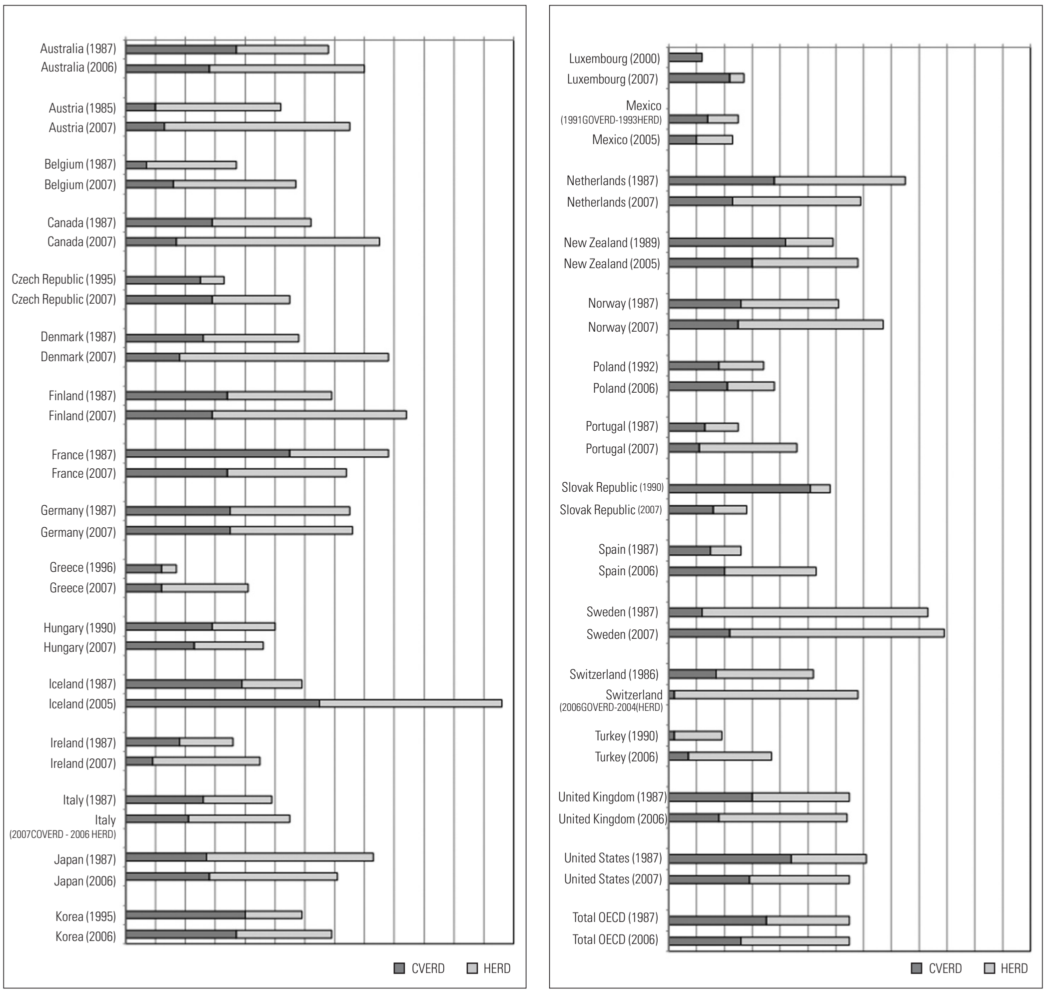
Source: OECD, Main Science and Technology Indicators

Figure 6 shows that, over the past two decades, public sector R&D has shifted away from the government sector and towards the higher education sector in almost all countries, Germany being a notable exception. As a share of GDP, GOVERD fell in more than half of OECD countries, and growth was mostly negligible in the remainder of countries, yet higher education expenditure on R&D (HERD) as a share of GDP expanded in 27 OECD countries.

FIGURE 6

TOTAL FUNDING OF R&D PERFORMED IN THE PUBLIC SECTOR 1987 AND 2007

As a percentage of GDP



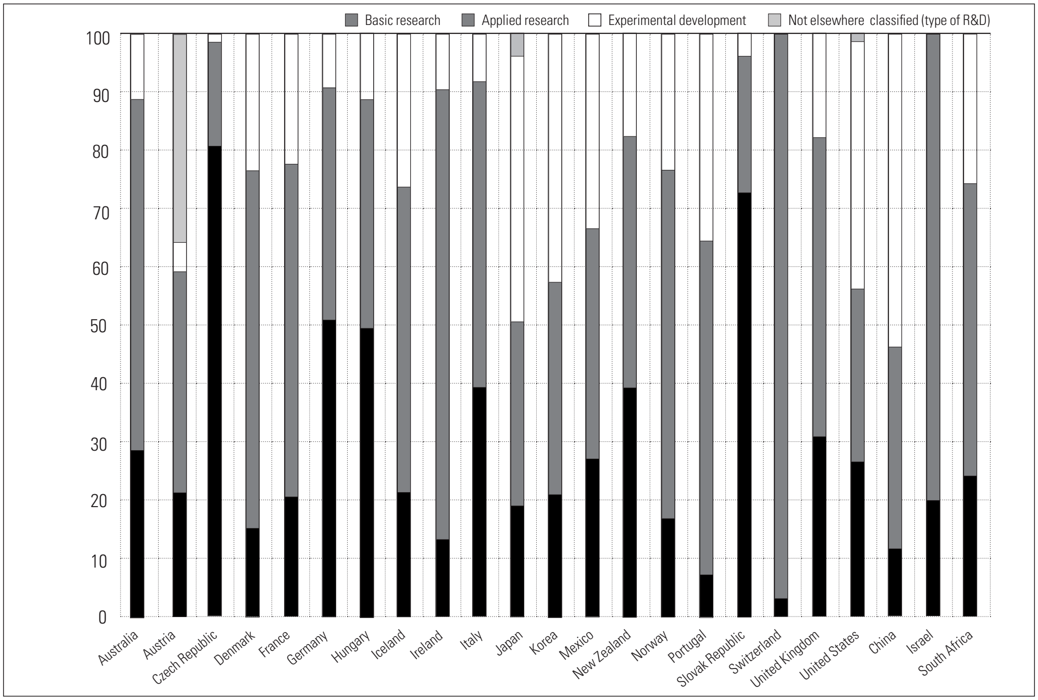
Source: OECD, Main Science and Technology Indicators.

Country-Specific Type and Orientation of Research in GRIs

Regarding the type of research, although the statistical categories differ slightly across countries R&D data are usually presented in terms of three main types, namely basic research, applied re-

FIGURE 7. GOVERD BY TYPE OF R&D, 2007

As % of total GOVERD



Source: OECD, Research and Development Statistics database

1.1986 instead of 1987 for Australia

2.1988 instead of 1997 for Greece; 1993 for Austria; 1995 for the Netherlands (1991 for Basic Research/Applied Research/ Experimental Development); 1996 for Australia, Portugal, Switzerland and Turkey.

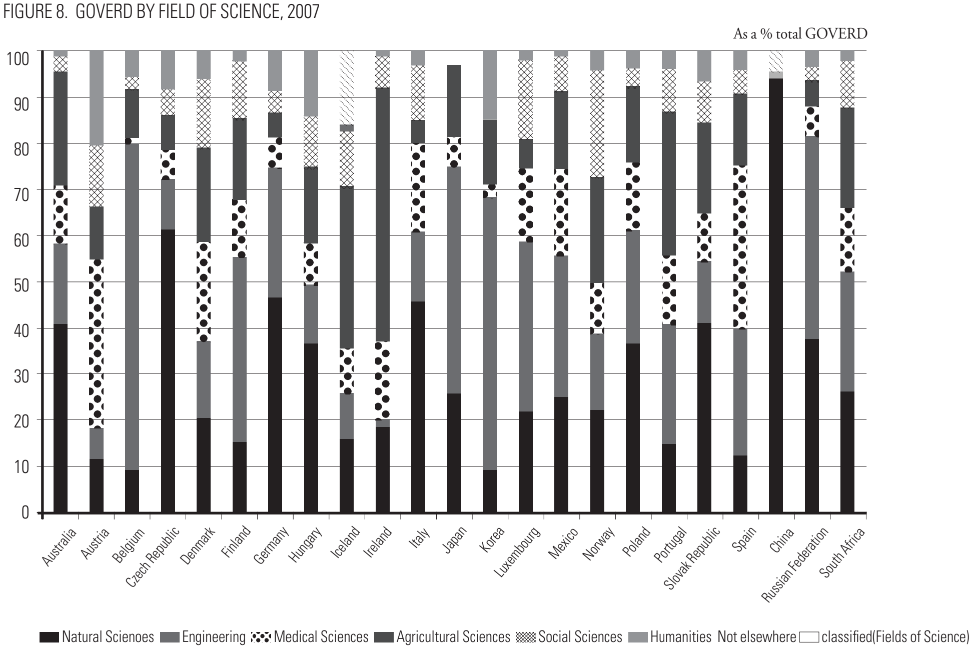
3.2003 instead of 2007 for Mexico; 2005 for Greece, Iceland, New Zealand, Norway and Portugal; 2006 for Austria, Australia, Denmark, France, Germany, Hungary, Italy, Japan, Korea, Switzerland, Turkey (1994 for Basic Research/Applied Research/Experimental Development), the United Kingdom and China. 2005 for South Africa for the following types of R&D Basic Research/Applied Research/Experimental Development and 1999 for Israel for the type of R&D Not elsewhere classified.

search and experimental development.[4] Figure 7 shows that in 2007 the share of basic research performed within GRIs ranged from 76% in the Czech Republic, a country with the legacy of a centrally-planned economy, to 4% in Switzerland, a country in which very strong universities traditionally dominate the public research sector. The bulk of GRI research in most countries is directed towards applied research or acquiring new knowledge directed primarily towards a specific practical aim or objective. In the countries for which adequate information exists to measure the changing focus in GRIs over time, for example in Australia, France, Italy and Japan, the share of basic R&D in GRIs increased over the last 20 years, while the share of experimental development fell.

[4] It is important to note that the Frascati Manual (OECD, 2002) acknowledges there are many conceptual and operational problems associated with these categories because they seem to imply a sequence and a separation which rarely exist in reality.

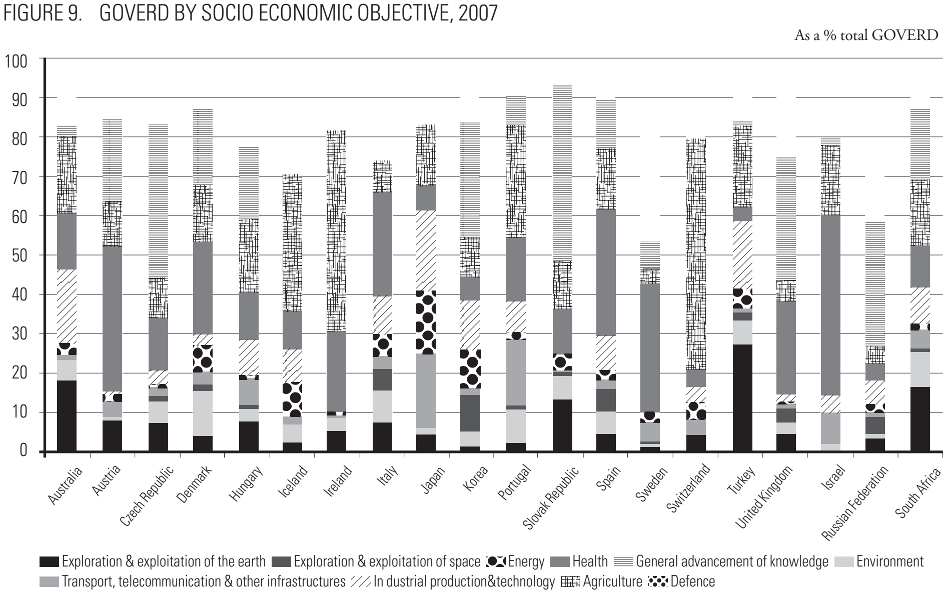
Regarding the orientation of research there are large differences among countries in the fields of study (Figure 8), as well as in socio-economic objectives pursued by GRIs (Figure 9). These differences not only reflect the specialization of national innovation systems, but also the division of labor between GRIs and universities in each of these systems.

FIGURE 8. GOVERD BY FIELD OF SCIENCE, 2007



Source: OECD, Research and Development Statistics database.

FIGURE 9. GOVERD BY SOCIO ECONOMIC OBJECTIVE, 2007

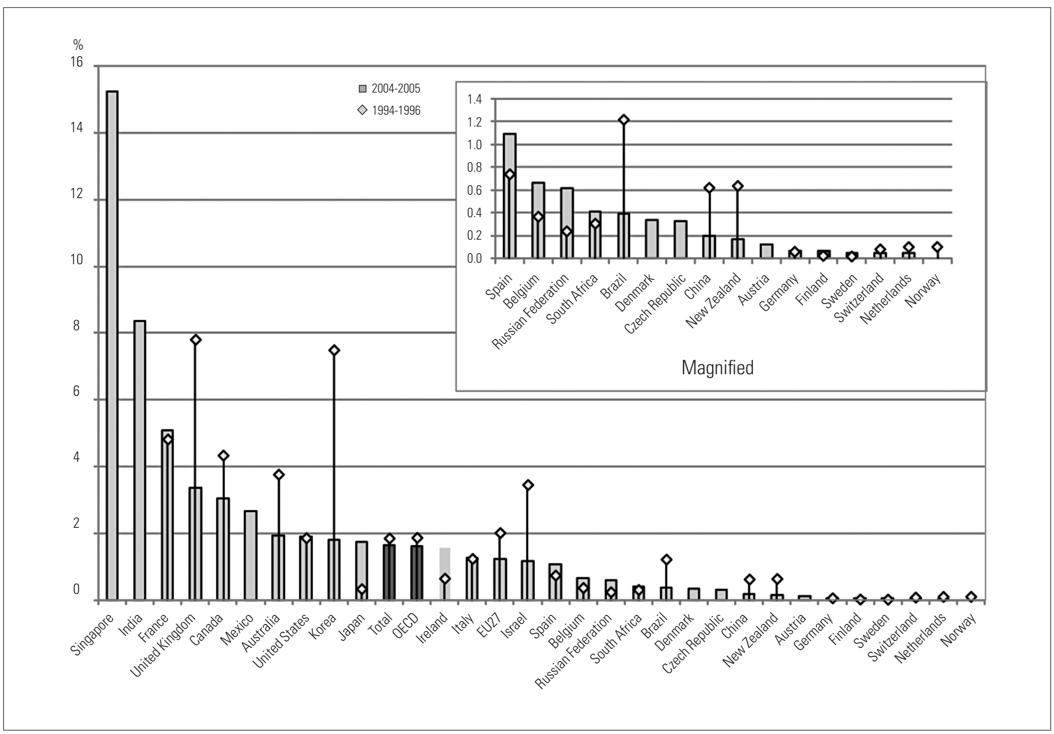


Source: OECD, Research and Development Statistics database.

Significant but Uneven Contribution of GRIs to Innovation Outputs

Statistics on patenting activity are the main internationally comparable indicators of inventive outputs. Nearly 80% of world patents are owned by private sector businesses, and government institutions (excluding universities) owned only 1.64% of all international patents filed under the Patent Cooperation Treaty (PCT) between 2004 and 2006, a fall from 1.85% between 1994 and 1996. This drop is noteworthy in the context of the rapid growth of patenting in other institutional sectors (OECD 2008a) and the increased emphasis on patenting, licensing and commercializing public research results. As shown in Figure 10, Singapore, India and France had the highest share of patents owned by government institutions. In more than half the countries, the share owned by government was less than 1%. Japan reported the largest increase in the share of patents owned by government over the period 1994-96 to 2004-06 whereas in Korea and the United Kingdom the share fell considerably. Table 1 shows government patents by technology field as a share of countries patents in that field. It reveals considerable diversity across countries and technology fields reflecting specialisation patterns within countries.

FIGURE 10. SHARE OF PATENTS OWNED BY GOVERNMENT INSTITUTIONS



Source: OECD, Patent Database

TABLE 1 Government Patents by Technology Field, 2004-06

% share of countries patents in that field

	Biotechnology	ICT	Nanotechnology	Renewable
Australia	4.41	2.33	1.84	1.30
Canada	11.15	2.45	11.86	0.65
France	16.97	7.07	35.13	3.66
Germany	0.21	0.11	-	0.36
Italy	4.50	2.68	14.10	-
Japan	8.88	1.81	13.80	0.30
Korea	5.62	0.90	9.71	2.08
United Kingdom	5.88	7.64	3.18	-
United States	6.32	1.37	4.86	0.46
EU27	3.58	2.13	6.49	0.57
OECD	5.80	1.68	7.15	0.55
World total	5.88	1.69	7.41	0.58

2. GRIS WITHIN CHANGING INNOVATION PROCESSES – PRESSURES FOR CHANGE AND EMERGING RESPONSES

The Innovation Imperative and Changing Innovation Processes

Most of the rise in living standards since the Industrial Revolution has been the result of new and improved products, processes and services. However, innovation has now become even more important for a wider spectrum of economic and social activities, including those required to respond to pressing challenges for the world community, such as global warming, entrenched and widespread poverty, food security and emerging infectious diseases. Only through increased innovation will economies be able to generate more wealth while reducing the environmental costs of the production, transportation and use of an increased variety of quality goods and services.

[BOX 1] INNOVATION HAS BECOME THE KEY DRIVER OF ECONOMIC GROWTH

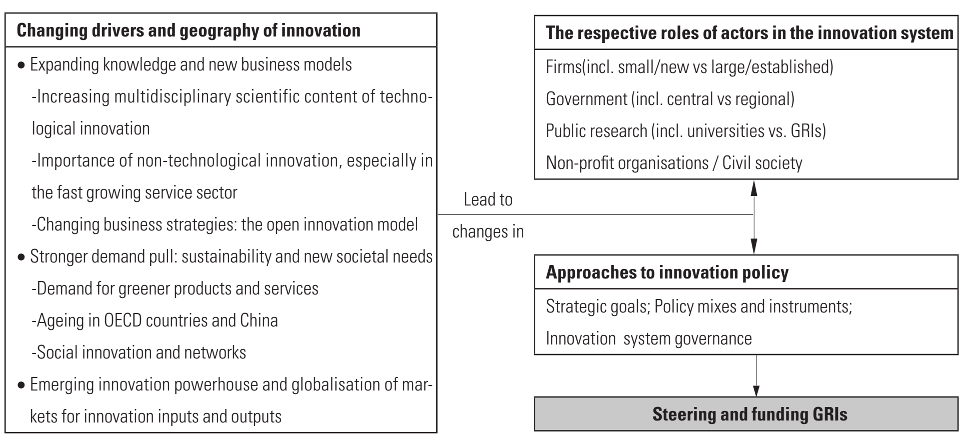
At the macro level, about half of the cross-country differences in per capita income and growth is due to differences in total factor productivity (TFP), which, in turn, is mainly driven by technological development and innovation, with a strong influence of R&D. Recent empirical research (Coe et al., 2008) confirms the role of both domestic and foreign R&D capital as significant determinants of TFP. Human capital and institutional factors, notably those that condition the efficiency of national innovation systems (NIS), also have a significant impact on TFP. Moreover, countries where doing business is facilitated and quality of tertiary education is high tend to derive more benefits from domestic R&D, from foreign R&D spillovers and from human capital formation.

At the micro level, it has been demonstrated that in all sectors of activity, from high-technology to the more traditional resource-based industries, innovative firms exhibit better performance and create more and better jobs. For example, recent OECD analysis of innovation at the firm level (OECD, 2008b) shows that product innovation increases business firms' labor productivity. For business innovation to translate into better macroeconomic performance, structural change is required to shift resources from non-innovative towards innovative firms, irrespective of the industry. In successful countries, the government facilitates such processes by providing favorable framework conditions, giving specific support to induce more companies to enter the "innovation game" in the first place and rewarding the efforts of already innovative companies. The OECD study shows that firms that receive financial support from government or engage in co-operation (with other firms and/or public research institutes) invest more in innovation (OECD, 2008b).

This happens when globalisation is forcing all countries to move their economic activity further up the value chain to ensure that they can continue to compete and prosper. Continued leadership, but also the capability to catch up, will therefore come from staying a step ahead of the competition in higher value-added elements of the economic process. Economic research provides new empirical evidence of this tightening relationship between innovation capability and economic success at both the macro (aggregate) and micro (firm) level (Box 1).

While innovation becomes more important for achieving national and global socio-economic objectives, the processes through which innovation happens and impacts on consumption and production patterns are also changing. These changes come with significant implications for the respective role of actors, as well as for innovation policy, including the steering and funding of public research (Figure 11).

FIGURE 11. NEW TRENDS IN INNOVATION PROCESSES AND POLICIES



Source: The author

Some of these changes require policy makers to broaden their conceptualization of innovation and extend the scope of their action accordingly, recognizing the importance of looking beyond the S&T sphere. An important consideration concerns the types of innovation that dominate the national innovation system. Common distinctions in characterizing types of innovation include the following (Edquist, 2008):

- New to the world innovations versus absorption of existing innovations
- Radical versus incremental innovations
- High-tech versus low-tech innovations
- Product versus process innovations
- Technical versus organizational/managerial innovations

Much of innovation policy tends to favor the first type of innovation in each of these bullet points, viewing the second type as less interesting. Yet, empirical evidence suggests that the second types are more common and possibly more significant for socio-economic development in some settings.

However, adopting a broader approach to innovation should not lead to an underestimation of the continued importance of public research. In fact, public research retains a key, though evolving, role, due to changes in the demand and supply of knowledge, in a context where the central actors in innovation systems, firms, adopt more open R&D strategies.

On the supply side, the direct or indirect contribution of science to innovation is increasing for two main reasons: the growing importance of many science-based technologies (electronics, new materials, biotechnology, nanotechnology, advanced analytical and measurement methods); and the fact that ICTs have enhanced the role of codified knowledge, enabling a move away from craft-based technology to technology based on more formal bodies of knowledge (including science) in many traditional engineering sectors.

The demand for long term, "public good" and mission-oriented research is expanding in several areas, such as environment, health and security. In addition, economically relevant research requires more effective pre-competitive platforms, as firms adopt more open innovation models.

Changing Principles, Scope and Strategic Tasks of Innovation Policy

Taken together, the changes that have just been outlined have some profound implications for the principles, scope and strategic tasks of innovation policy (Figure 12). Some of the practical consequences vary between countries, reflecting different histories and states of development. But many are more general, as for example the following:

- During several decades a more market-oriented rationale for policy intervention gradually reduced the potential space for technology and innovation policy. But, more recently, and in light of the comparative success of the East Asian developmental state model, the so-called "Washington Consensus" has been challenged and new rationales for "smart" public policy intervention have emerged.

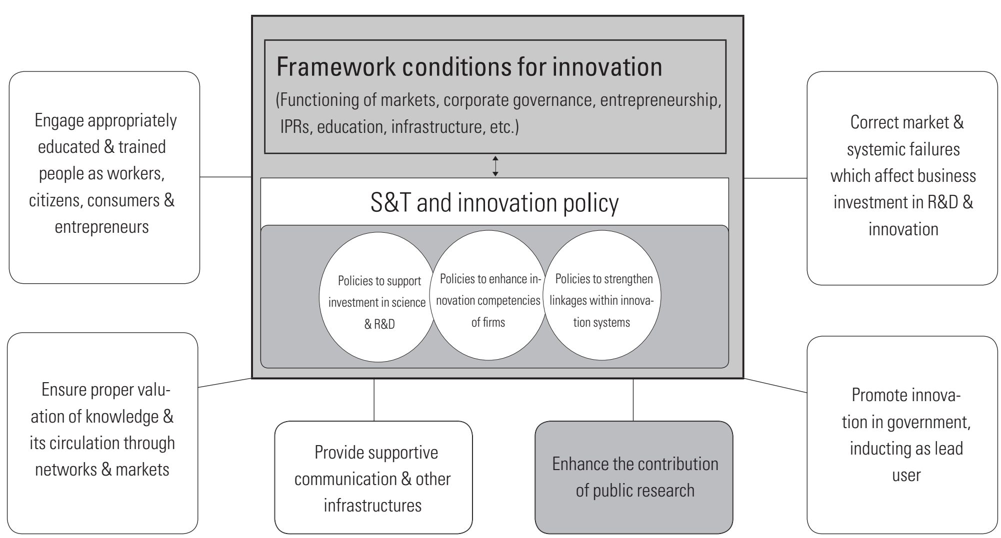
- The principles and methods of New Public Management (NPM) have inspired public sector reforms in many countries. These include the separation of government functions and the creation of operating agencies pursuing well-defined missions in the framework of a customer-contracto relationship. These relationships are linked to their “principal” institution (customer) by quasi-contractual relations, which are typically underpinned by sets of performance measures.

- Globalization has seen national policy increasingly framed in global terms, reflecting a growing sense of global identity, the global nature of many problems and issues and the globalization of markets and production. At the same time, a growing ‘regionalism’ has seen more control over policy and resources devolved to sub-national authorities.

- The practice of Public-Private Partnership (P/PPs) has grown in importance across many areas of government. P/PPs offer a framework for the public and the private sectors to join forces in areas in which they have complementary interests but cannot act as efficiently alone.

- Accountability regimes have been strengthened in most countries requiring policymakers to publicly account for the ways resources have been used and to demonstrate outputs and outcomes from the policies and programmes they fund.

FIGURE 12. THE SCOPE AND STRATEGIC TASKS OF INNOVATION POLICY



Source: The author

Adapting Public Research

Among the strategic tasks of innovation policy, one of the most important in all countries is to ensure that the public research system is adaptive to the new dynamics of innovation. To enhance the contribution of public research to innovation, governments have to clarify the division of labor between the main actors, while accepting some convergence of their respective activities, since "fruitful overlaps" are required by the emerging open innovation model.

In fact, over time, more actors have been expected to play multiple roles. For instance, part of the process of creating scientific and technological human capital for innovation systems is carried out by specialized education and training organizations. But, a very important part is also carried out by business enterprises via large expenditures on education and training and by active management of the process of experience accumulation. Within public research organizations, universities have extended their traditional function of basic research into technology development, and even further downstream to design, engineering and entrepreneurship.

Broadly speaking, regarding public research the main concern of governments should be to ensure, through appropriate organizational arrangements and steering and funding mechanisms, that they can combine excellence, relevance and critical mass in accomplishing their public missions and in complementing firms within knowledge markets and innovation networks. This means that in the efforts of many countries to "populate the Pasteur's quadrant" (Stokes, 1997) by promoting more use-inspired, fundamental research, they use a combination of tools to counteract the trend of some research organizations towards too much purely curiosity-driven research, as well as that of others towards too much applied research (Figure 13).

Implications for GRIs

In most OECD countries the repositioning of GRIs is the most important, often long-delayed, and tricky task. Their diversity, in terms of their main function, their research orientations and their linkages with other innovation actors and the education system, has contributed to a 'fuzziness' and lack of clarity around a clear and distinctive role for this sector. This places many institutes under considerable pressure to continually justify not just their performance, but also, at times, their very existence (Box 2).

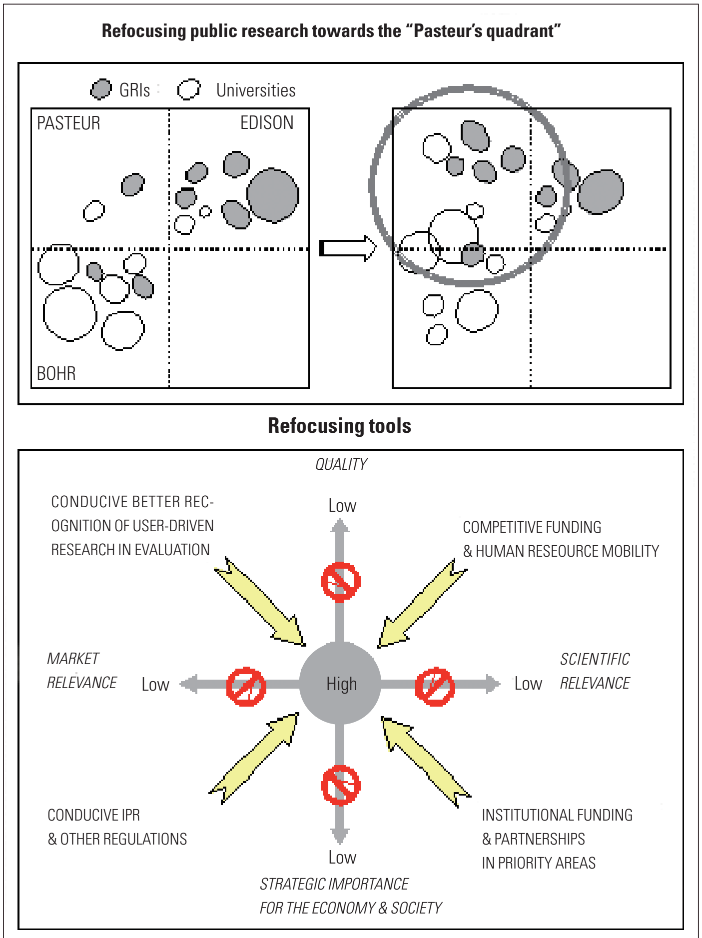
Several OECD members have undertaken reforms of their GRIs, but this restructuring is far from complete in most countries. Questions remain regarding the organizational and institutional changes that are needed to improve their ability to respond flexibly to evolving societal objectives over the long term and the respective roles of government laboratories and universities in the public research system. The critical questions that have to be addressed by reforms are the following:

- How to ensure economic relevance but not at the expense of research depth or public missions? The risk of encouraging an indiscriminate rush towards market for contract research and technological services must be particularly considered when changing funding mechanisms. The international experience points to the need to secure a sufficient level of institutional funding.

- How to ensure quality following a different model than academic research? Appropriate evaluation of projects, teams and researchers, as well attractiveness for young talents, in terms of salaries and access to exclusive research infrastructures and networks, are key.

- How to ensure critical mass in areas where domestic demand is limited or still nascent (e.g. new

FIGURE 13.
ENHANCING THE CONTRIBUTION OF PUBLIC RESEARCH TO INNOVATION



Source: The author

fields of multidisciplinary research)? GRIs must implement their own "open innovation model", through collaboration with universities and firms, including those located beyond national borders.

- As compared to universities or market-based (private) service providers, what are the distinctive missions for GRIs? GRIs must specialize in: the advancement of science in areas where academic excellence is not a driver (e.g. where publication opportunities are fewer, and/or where research requires intensive advanced specialized engineering); the provision platforms for fundamental, pre-competitive technological development; the maintenance of specialized applied research capabilities; and the provision of technical facilities and instrument for diffusion of technology in areas of market or system failure.

[BOX 2] PUBLIC RESEARCH ORGANIZATIONS UNDER PRESSURE

While government laboratories have made numerous contributions to industrial innovation and economic growth, econometric analysis suggests that the effects of publicly funded R&D on productivity growth are larger in countries that devote more of their public research budget to universities than to government labs (Guellec and van Pottelsberghe de la Potterie, 2001). This reflects the fact that in some countries the very nature of the R&D missions entrusted to government labs limits the generation of economic spillovers, but additional structural impediments also appear to be in place. Although their size and research portfolios are diverse, public labs in a number of countries face common problems relating to aging staff, blurred missions and relative isolation from the mainstream of knowledge exchange and the education system. Government labs do not generally participate in training students who can transfer knowledge to industry, and the disciplinary nature of many labs can impede their attempts to conduct research in emerging interdisciplinary areas. They may nevertheless play a critical role in providing government ministries with impartial, long-term, in-depth and interdisciplinary expertise which is important to their mission and which cannot be suitably obtained from the university system.

Source: OECD (2003).

4. GRIS IN KOREA: SPECIFIC FEATURES AND OUTLOOK [5]

A recent OECD report has analyzed the strengths and weaknesses of the Korean innovation system, and has addressed some of the opportunities and threats that are likely to arise in the coming years (OECD, 2009). These are summarized in Table 2. The positioning, organization and research orientations of public research are among problematic areas identified in this SWOT analysis.

By budget expenditure, the GRIs in Korea are the largest performers of research in the public sector, though their leading position is increasingly challenged by universities. They have played a significant part in the technological upgrade of Korean industry over the last four decades, and have shown themselves, in most cases, able to adapt to fast-changing conditions. However, further reform and adaptation of GRIs is on the political agenda and necessitates understanding of their current and potential contribution to the Korean innovation system.

This section starts by describing the different public research organizations operating in Korea, their historical development and their funding. Next, the performance of GRIs is reviewed and the continuing debate over their appropriate role in the wider innovation system is discussed. Finally, some directions for policies to enhance the contribution of GRIs to the transition of the Korean economy towards a more innovation-driven sustainable growth path are suggested.

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[5] This section draws heavily on the results of the OECD Review of Innovation Policy (OECD, 2009) which was drafted by Michael Keenan (Country Review Unit, DSTI, OECD) and Ron Johnston (consultant to the OECD, Professor at the University of Sydney), with contributions from and under the supervision of the author, and benefitted from the support of the Korean government and contributions by STEPI researchers, particularly Kong-Rae Lee.

TABLE 2 SWOT analysis of the Korean innovation system

Strengths •Strong, mobilizing national vision •High growth rates in GDP •Strong government support for innovation and R&D •Good and improving framework conditions for innovation •High ratio of gross domestic expenditure on R&D (GERD) to business enterprise expenditure on R&D (BERD) •Highly educated workforce •Good supply of human resources for science and technology (HRST) •Ready early adopters of new technologies •Strong ICT infrastructure •Exceptionally fast followers •Strong and internationally competitive firms •Learning society with a capacity to learn from failures and international good practices •Capability to produce world-class talents	**Opportunities** •Geopolitical positioning in one of the most dynamic regions of the world •Free trade agreements •Globalization, including of R&D •Growing Korean S&T diaspora •Developments in S&T (technological change), particularly information technology, nanotechnology, biotechnology and environmental technology – and their possible fusion •Growth of China and other newly industrializing economies, both in the region and worldwide, offering new markets for Korean exports
Weaknesses •Under-developed fundamental research capabilities and weak research capacity in universities •Weak linkages between GRIs and institutions of higher education •In education, rote learning, overemphasis of university entrance exam, and crippling cost of private education •Under-utilization of female labour •Low productivity in the services sector •Relatively weak SME sector •Legacy of dirigisme which hampers the development of a diffusion-oriented innovation policy •Unbalanced international linkages •Uneven development across regions and sectors •Small domestic market (compared to China, Japan, United States) •Policy co-ordination problems between ministries	**Threats** •Low fertility rates and an aging society •Arrival of strong new competitors in fields in which Korea excels, e.g. ICTs, particularly from China •Geopolitical developments in the region •Disruption in the supply of imported natural resources and energy, upon which the Korean economy is highly dependent •Global economic outlook and its consequences for export-oriented economies

Types and Regional Distribution of Korean GRIs

GRIs are classified into four categories in Korea, according to their governance and financing arrangements:

- Government-sponsored research institutes (GRIs sticto sensu) – these are semi-autonomous research centres established by the Korean government. There are 100 GRIs in all, 52 of which are associated with the humanities and social sciences. They operate under the provisions of the Law for the Creation and Promotion of the Government Research Institutes (1999). Employees do not have the public servant status. The largest GRIs fall directly or indirectly (through two research councils) under the Ministry of Education, Science and Technology (MEST) and the Ministry of Knowledge Economy (MKE). This section focuses on them.

- National labs – these are fully financed by the central government, which employs the research staff directly. There are currently 53 national labs, many of which are operated by the Ministry for Food, Agriculture, Forestry and Fisheries.

- Local government-sponsored research institutes – these are autonomous organizations financially supported by local governments. The majority are involved in planning and linking local innovation actors to boost technological innovation in regions, and as such do not do scientific research themselves. There are 38 such organizations across Korea.

- Local government labs – these were mostly established several years ago to support local agriculture and fishing, though in recent years, some have been established to support manufacturing or to cultivate emerging industries. They are governed by local governments, and their research staffs are local government officials. Korea has 118 such organizations.

TABLE 3 Distribution of public research organizations in Korea (2004)

Types of organization	Natural science & technology	Agriculture and fishery	Humanities and social science	Total
Total number (%)	79 (25.6)	131 (42.4)	99 (32.0)	309
- Central govt. sponsored	46 (46.0)	2 (2.0)	52 (52.0)	100
- National labs	7 (13.2)	34 (64.2)	12 (22.6)	53
- Local govt. sponsored	5 (13.2)	0 (0.0)	33 (86.8)	38
- Local govt. labs	21 (17.8)	95 (80.5)	2 (1.7)	118

Table 4 shows the R&D expenditure of GRIs, universities (public and private) and companies in each region as of 2006. As the data shows, the Seoul metropolitan area accounts for around 30% of GRIs' R&D expenditures. Although the government has launched initiatives in other parts of the country, such as the construction of a new government administrative city and "innovation cities" and "enterprise cities", in order to boost development, the lack of innovation resources or assets across Korea, especially in universities and companies, is seen as the greatest barrier to more effective regional economic development through innovation.

TABLE 4 R&D expenditure and ratio by sector of performance and region (2006)

KRW millions and percentages

Region \ Sector of performance	Research institutes	Universities and colleges	Companies	Total
Seoul Metropolitan Area	1 098 449	1 495 569	14 746 266	17 340 284
	(31.40)	(54.94)	(69.80)	(63.42)
Busan	68 057	149 764	373 474	591 295
	(1.95)	(5.50)	(1.77)	(2.16)
Daegu	30 278	98 756	183 023	312 057
	(0.87)	(3.63)	(0.87)	(1.13)
Gwangju	30 900	162 473	188 239	381 612
	(0.88)	(5.97)	(0.89)	(1.40)
Daejeon	1 760 100	183 610	1 118 321	3 062 031
	(50.33)	(6.75)	(5.29)	(11.20)
Ulsan	1 975	29 661	507 545	539 181
	(0.06)	(1.09)	(2.40)	(1.97)
Gangwon	31 075	75 278	75 561	181 914
	(0.89)	(2.77)	(0.36)	(0.67)
Chungbuk	75 022	56 498	331 671	463 191
	(2.15)	(2.08)	(1.57)	(1.69)
Chungnam	87 128	74 856	1 003 312	1 165 296
	(2.49)	(2.75)	(4.75)	(4.26)
Chonbuk	50 926	81 728	134 944	267 598
	(1.46)	(3.00)	(0.64)	(0.98)
Chonnam	22 472	39 588	168 352	230 412
	(0.64)	(1.45)	(0.80)	(0.84)
Gyeongbuk	72 380	172 801	1 308 523	1 533 704
	(2.07)	(6.35)	(6.19)	(5.68)
Gyeongnam	154 984	84 719	967 750	1 207 453
	(4.43)	(3.11)	(4.58)	(4.42)
Jeju	13 305	16 573	19 799	49 677
	(0.38)	(0.61)	(0.09)	(0.18)
R&D expenditure by sector	3 497 05	2 721 874	21 126 780	27 345 704

Source: MoST and KISTEP (2007).

Historical Development

A short historical account of the development and evolution of GRIs provides insight into many of the challenges that these institutions still face today. In the 1960s, Korea lacked technological capabilities for industrialization and imports of foreign technologies were the immediate solution. The more fundamental solution, however, was the establishment of an industrial R&D institute that would build up endogenous technological capabilities. Accordingly, the Korea Institute of Science and Technology (KIST) was founded in 1966 as an integrated technical centre to meet the country's industrial needs. At that time, KIST relied on recruiting overseas-trained Korean scientists and engineers, and its main purpose was to support industry in its efforts to adopt and adapt foreign technologies. By 1970, the few GRIs that had been established accounted for 84% of the nation's total R&D expenditures and 44% of the nation's pool of researchers (Kim, 2001).

In the 1970s, a number of specialised research institutes were established to keep pace with the rise in industrial sophistication and diversity. Each institute aimed to develop capabilities in strategic areas such as shipbuilding, geo-science, electronics, telecommunications, energy, machinery, chemicals, etc., in order to serve the growing needs of the private sector.

However, by the 1980s, Korean firms were criticizing the research support being provided by GRIs as failing to meet their needs. At the same time, the government believed that many "specialized satellite institutes" under related ministries were too small to achieve economies of scale and that this resulted in overlap and frequent duplication of research efforts (Yim and Kim, 2005). The government therefore consolidated 15 GRIs under various ministries into nine large research institutes under MoST.

The Korean government was also keen for industry to perform a greater share of R&D so as to develop its own technological capacity. Thus, in addition to consolidating the number of GRIs, the government initiated national R&D programs (NRDP) in 1982 to provide funding for GRIs to collaborate with industry on areas of strategic research and technological development. This extra funding helped GRIs to increase their research activities, but throughout the 1980s and 1990s, their performance continued to be criticized by government and business alike. Criticisms centred upon apparent duplication of research domains, poor R&D project management, and perceived low R&D productivity levels. To boost research efficacy and productivity, from 1991, GRIs were subject to regular evaluations of their performance, and in 1996 a contractual project-based management system (PBS) was introduced to replace the lump-sum system then in operation.

During the 1980s and 1990s, the number of GRIs continued to grow and there was further reorganization through mergers and break-ups. Nevertheless, GRIs began to lose their once-dominant role, with industry quickly becoming the largest R&D funder and performer by the mid-1980s, and with the universities also gradually catching up over time.

In 1998-99, a committee drew up proposals for the most fundamental reform of GRIs in almost two decades. It proposed separating GRIs from their host ministries (several ministries besides MoST had again acquired their own research institutes after the move to consolidate GRIs in the early 1980s) and placing them under five newly established research councils located in the Office of the Prime Minister. The intention was to improve their performance by giving them greater autonomy from ministerial interference – in a sense, to separate bureaucratic and research cultures. The suggested reform was carried out, but only in part, as the research councils had no budgets of their own to distribute to the GRIs and the latter were therefore still dependent upon the ministries for their funding.

The system underwent further change in 2004, when the then new government moved the three science and technology-based research councils from the Office of the Prime Minister to MoST. This move was part of a broader set of measures to strengthen a revamped MoST and saw the biggest GRIs come under MoST's jurisdiction. In mid-2008 the number of research councils was reduced from five to three, with two remaining in the S&T area: the Research Council for Fundamental S&T under the supervision of MEST and the Research Council for Industrial S&T under the supervision of MKE. Both research councils supervise 13 GRIs each.

Funding of GRIs

The proportion of government support in total R&D expenditure differs by type of research field, research institute and historical dependency. Roughly speaking, around half of the GRIs' budget comes from a government core grant (Table 5), while the other half comes from contract research for various organizations, including a range of central government ministries (the main purchasers of research), local governments and private companies. GRIs have benefited from the smallest increases in R&D spending over the last decade or so, with universities and firms accounting for an ever-increasing share of Korean R&D.

TABLE 5 Government core grant to GRIs under the three1 S&T research councils

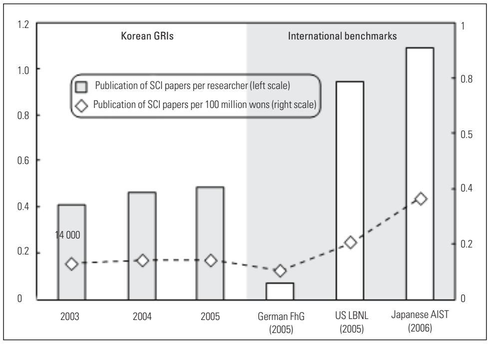
KRW millions

Name of councils and their member institutes	2006	2007	Growth rate (%)
Korea Research Council of Fundamental Science & Technology(KRCF)	8 229	13 761	67.2
Korea Institute of Science and Technology (KIST)	84 134	85 908	2.1
Korea research Institute of Bioscience and Biotechnology (KRIBB)	45 458	50 832	11.8
Korea Basic Science Institute (KBSI)	35 417	39 647	11.9
Korea Astronomy and Space Science Institute (KASI)	16 323	18 357	12.5
Korea Institute of Oriental Medicine (KIOM)	12 875	17 316	34.5
National Fusion Research Centre (NFRC)	11 114	20 371	83.3
National Institute for Mathematical Sciences (NIMS)	1 000	2 105	110.5
Korea University of Science & Technology (UST)	2 059	2 949	43.2
Subtotal	216 606	251 246	16.0
Korea Research Council of Industrial Science & Technology (KOCI)	10 509	10 478	- 0.3
Korea Institute of Industrial Technology (KITECH)	59 363	56 147	- 5.4
Electronics and Telecommunications Research Institute (ETRI)	20 204	21 246	5.2
Korea Food Research Institute (KFRI)	15 354	16 654	8.5
Korea Institute of Machinery and Materials (KIMM)	39 830	45 780	14.9
Korea Electrotechnology Research Institute (KERI)	32 657	35 124	7.6
Korea Research Institute of Chemical Technology (KRICT)	35 152	39 463	12.3
National Security Research Institute (NSRI)	31 788	35 182	10.7
Korea Institute of Toxicology (KITOX)	13 341	26 342	97.5
Subtotal	258 198	284 416	10.9
Korea Research Council of Public Science & Technology (KORP)	11 245	11 334	0.8
Korea Institute of Science and Technology (KISTI)	55 038	63 843	16.0
Korea Institute of Construction Technology (KICT)	24 609	23 622	- 4.0
Korea Railroad Research Institute (KRRI)	16 238	20 053	23.5
Korea Research Institute of Standards and Science (KRISS)	53 748	56 030	4.2
Korea Ocean Research & Development Institute (KORDI)	39 929	47 119	18.0
Korea Institute of Geoscience and Mineral Resources (KIGAM)	35 557	39 056	9.8
Korea Aerospace Research Institute (KARI)	25 769	26 791	4.0
Korea Institute of Energy Research (KIER)	31 092	38 779	24.7
Korea Atomic Energy Research Institute (KAERI)	52 567	58 340	11.0
Subtotal	345 792	384 967	11.6

1. In mid-2008, the number of research councils was reduced from three to two.

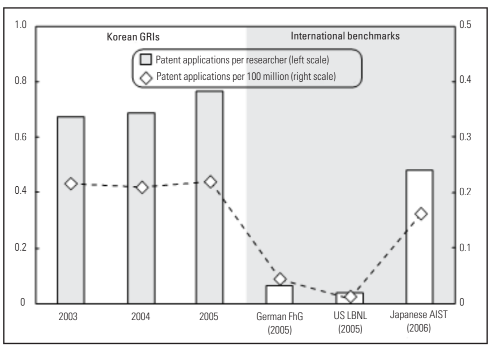
Source: MoST.

FIGURE 14. SCI PUBLICATIONS BY GRIS (2003-2005) AND INTERNATIONAL BENCHMARKS



Source: Lee (2007).

FIGURE 15. PATENT APPLICATIONS OF GRIS (2003-2005) AND INTERNATIONAL BENCHMARKS



Source: Lee (2007).

GRIs Performance

Under the research councils, GRIs have recently improved their performance in terms of publications and patent applications (Lee, Chul-Won, 2007). For example, SCI publications per researcher increased from 0.407 in 2003 to 0.465 in 2004 and to 0.489 in 2005, a significant rise in a short space of time. As Figure 14 shows, these numbers are higher than those of the Fraunhofer Society's institutes in Germany (although the latter conduct more applied research and may be less active in academic publishing than institutes engaged in more fundamental research), though considerably lower than those of the Lawrence Berkeley National Laboratory (LBNL) in the United States and the National Institute of Advanced Industrial Science and Technology (AIST) in Japan. The results are similar when using SCI publications per KRW 100 million spent.

In terms of patent applications, the performance of Korean GRIs appears very good by international standards. As shown in Figure 15, patent applications per researcher increased from 0.6754 in 2003 to 0.765 in 2005, figures that are much higher than those of the Fraunhofer institutes, the LBNL or AIST (as the LBNL undertakes largely fundamental research, its relatively low performance on this measure is not unexpected). A comparison based on patent applications per KRW 100 million shows a similar trend. Furthermore, GRIs made 3 158 patent applications in 2006 (Table 6), significantly more than US GRIs and Canadian government research institutes including universities.

In terms of technology transfer rates, Table 6 shows that Korea underperforms the United States and Canada but seems to do better than Japan. Around 30% of Korean GRI patents were transferred in 2006, compared to 37.5% in US GRIs. Korean GRIs performed considerably better than Korean universities, which saw only 13.6% of their technologies transferred. Overall, these figures indicate that Korean GRIs have more difficulty commercializing their R&D than their counterparts in North America.

Royalty income figures provide one indicator of the "quality" of technology transfer. As Table 6 shows, Korea again underperforms the United States and Canada (figures for Japan are not available). The picture is even worse for Korean universities.

Figure 16 shows that the Korean situation is gradually improving. The royalty ratio as a percentage

TABLE 6 International comparison of technology transfer among public sector research performers (2006)

Performance indicators	Korea			United States			Japan (Univ. + GRIs)	Canada (Univ. + GRIs)
	Univ	GRIs	Total	Univ.	GRIs	Total		
Number of technologies patented (2006)	4,616	3,158	7,774	15,002	1,790	16,792	8,725	1,307
Number of technologies patented (2006)	629	951	1,580	4,087	671	4,758	1,171	544
Ratio of technology transfers (%)	13.6	30.1	20.3	27.2	37.5	28.3	13.4	41.6
Yearly royalty income (USD millions)	3.2	53.3	56.5	1088	346	1435	n/a	43.3
Yearly R&D expenditure (USD millions)	2200	2964	5164	37162	4082	41244	47200	3127
Number of employees per commercialisation unit	4.8	3.6	4.2	8.65	6.1	8.2	14.3	8.3

Source: Lee (2007).

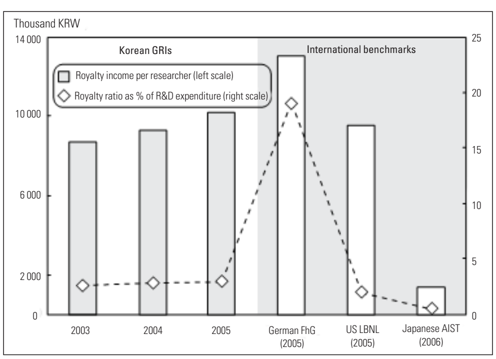
of R&D expenditure has shown a similar trend over the same period. This performance is comparable to that of the LBNL in the United and far exceeds the performance of AIST in Japan. But GRIs have some way to go to catch up with the German Fraunhofer institutes, which earn the equivalent of almost 20% of their total R&D expenditure in royalty income (on the basis of a fraction of the patent applications made by Korean institutes).

To summarize, Korean GRIs have improved their performance in recent years, in terms both of number of publications and returns from commercialization of their R&D efforts. However, given the level of patenting activity, they should be doing much better. There are several possible explanations for this relatively disappointing performance:

- First, technology markets are less developed in Korea than in North America, owing to their relatively weak institutionalization.

- Second, compared to North America, there is relatively weak interest on the part of local firms in adopting new technologies from GRIs, particularly among SMEs. Even among larger firms, there appears to be a growing preference to conduct research in house and to reduce reliance on the GRIs for fear of "knowledge leakage".

FIGURE 16 . ROYALTY INCOME OF GRIS (2003-2005) AND INTERNATIONAL BENCHMARKS



Source: Lee, Chul-Won (2007).

•A third explanation may lie in the GRIs and universities themselves, as they may be insufficiently geared to offer their R&D for exploitation. However, the Korean government has placed much emphasis on the commercialization of R&D and the channels for transferring public research results are various, such as technology transfer agreements, direct creation of venture firms, technical consulting and training of engineers and technicians. Most GRIs have set up commercialization units, but these remain comparatively small. As Table 6 indicates they employ on average 3.6 persons, fewer than Korean universities (4.8) and considerably fewer than in Japan, Canada and the United States.

•Finally, it seems certain that Korean GRIs and universities are patenting excessively, as evidenced by the very rapid rise of Korea in the patent rankings over the last decade. The government has set very ambitious performance targets, including publication and patenting, for the public sector research base. As researchers have struggled to meet these targets, they have tended to patent discoveries that might not otherwise have been patented. As a result, Korean institutes hold a large body of patents, many of which are unlikely ever to be exploited.

What Role for GRIs?

In spite of successive reforms of recent decades, the role GRIs should play in the Korean innovation system is still widely discussed. There remains a sense that they are not as effective and efficient as they could be. Indeed, according to the opening lines of the page devoted to GRIs on the MoST/MEST website,[6] "there have been grave concerns regarding research effectiveness and operational efficiency of the GRIs' R&D activities". It is clear that for many, these concerns remain, but the extent to which they are justified is open to question.

The main problem – stretching back perhaps 30 years – has been a lack of consensus on the role-that the GRIs should play in the innovation system. Korea is hardly alone in this uncertainty, as the role of GRIs has been called into question across the OECD area in recent decades. Yet, GRIs remain extremely important players in national research systems, and especially in Korea where university research still remains relatively weak. Because they have been poorly studied, GRIs have often been victims of stereotypes and of policy fashions (Laredo, 2008). In fact, GRIs vary widely, with different types of organizations facing different issues that require different policy responses. This observation also applies to Korean GRIs, and due attention should be paid to this sort of differentiation.

Thus, in the context of a rapidly evolving innovation system and industry's development of its own R&D capabilities, the purpose of Korean GRIs is not as clear-cut as it once was. At the same time, the Korean government has begun to favor the strengthening of R&D capabilities in universities, which are considered the "natural" sites of skills development and knowledge transfer. Pressure to reform GRIs has resulted in a succession of changes in their governance systems, creating a near-permanent sense of uncertainty and even crisis in many institutes. This has served to undermine the stability required for conducting long-term fundamental research, something that governments have often failed to take into account (Lee, Kong-Rae, 2007).

Clearly, GRIs are in a difficult position. They were the main recipients of public R&D funding when universities conducted relatively little R&D. However, as the R&D capabilities of universities and firms have increased, some convergence has begun, with all actors conducting similar sorts of research. Accordingly, many in industry argue that the GRIs should now focus primarily on funda-

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[6] MEST website (http://english.mest.go.kr), accessed August 2008

mental research. Yet, many university researchers argue that the GRIs should return to their original purpose of supporting technology adoption and adaptation by Korean firms. Whether GRIs face such a stark choice is an open question, and there are few reasons to believe that they should focus on just one type of activity at the expense of others. Moreover, as highlighted above, the GRIs are not identical and each institute has its own history and accumulated competencies. Sensitivity to these is required in any future reforms.

Nevertheless, the GRIs would appear to be squeezed between two constituencies with a strong sense of their identity. Before exploring the positioning issue further, however, it is worth reviewing the direction in types of research performed by the GRIs. As Table 7 shows, the trend has been away from basic research towards more experimental development, while the proportion of R&D expenditures for applied research has remained largely unchanged, at approximately one third. Most of this shift occurred in the first few years after the Asian financial crisis and the current picture stabilized in 2003 (in fact, the current proportion of basic research stabilised in 2001). These figures seem to suggest that GRIs are primarily positioning themselves to develop new technologies. Although GRIs seem to have greater potential than universities to contribute to the diversification of the economy away from the ICT sector (Table 8), there are questions concerning whether GRIs are best placed to bring technologies to the market; it is widely believed that this is best done by the private sector.

Another issue to take into account is the fact that GRIs conduct much of the "big science" carried out by the public sector and universities cannot match their facilities. This is not unusual, and international experience suggests that GRIs often carry out fundamental research that would be impossible to conduct in universities. However, if GRIs are to conduct more fundamental research, it is

TABLE 7 R&D expenditure by research stage in research institutes

KRW millions and %

	Total R&D expenditure	Basic research		Applied research		Experimental development	
1998	2 099 470	561 521	26.7	741 199	35.3	796 750	38.0
1999	1 979 174	494 138	25.0	756 409	38.2	728 627	36.8
2000	2 031 981	454 443	22.4	672 213	33.1	905 325	44.6
2001	2 160 166	438 260	20.3	894 403	41.4	827 503	38.3
2002	2 552 632	526 182	20.6	1 015 664	39.8	1 010 786	39.6
2003	2 626 356	525 515	20.0	972 984	37.0	1 127 856	42.9
2004	2 964 646	616 140	20.8	1 151 992	38.9	1 196 514	40.4
2005	3 192 887	684 540	21.4	1 158 356	36.3	1 349 991	42.3
2006	3 497 050	716 725	20.5	1 252 430	35.8	1 527 896	43.7

Source: MoST and KISTEP (2007).

TABLE 8 Association of R&D expenditure's to "6T" (2006)

(in %)

	GRIs	Universities	Companies	Total
ICT (Information technology)	19.4	25.7	39.5	35.6
BT (Biotechnology)	12.7	24.2	3.3	6.6
NT (Nanotechnology)	4.8	9.7	15.3	13.4
ST (Space technology)	9.2	2.0	0.6	1.8
ET (Environment technology)	13.1	8.6	5.0	6.4
CT (Culture technology)	0.0	2.7	1.2	1.2
Other	40.8	27.2	35.1	35.0
Total	100.0	100.0	100.0	100.0

Source: MoST and KISTEP (2007).

likely that the current project-based system will need to be revised. Originally introduced in 1996 to improve the efficiency and performance of GRIs, the project-based management system (PBS) has improved R&D management through the use of competitive tendering. However, there have also been some less desirable effects:

- First, PBS has been detrimental to the stability needed to foster more fundamental research (since many projects are more mission-oriented and relatively short-term).[7]

- Second, it has encouraged GRIs to apply for a wide spectrum of projects as they compete for funding. The loss of focus has contributed in part to the identity crisis in many GRIs.

- Finally, it has seen a vast expansion in the use of temporary contract labour (for example, at the Korean Research Institute for Bioscience and Biotechnology [KRIBB], special service interns outnumbered regular employees by almost 2:1 in 2006). Although the use of temporary contracts gives GRIs some flexibility, it also makes them less attractive destinations for researchers (see below).

Although some research collaboration occurs already (see Box 3), there is no doubt that there is much greater scope for such co-operation between GRIs and universities. This is hampered by the mutual distrust of the two sectors: the universities view themselves as more academically valid and the GRIs see themselves as the public sector's main source of research with the necessary experience, competencies, equipment and relevance. This distrust and lack of understanding and respect creates problems for developing closer and mutually beneficial linkages.

In a further twist to the trend towards convergence between research performers, GRIs have also come together to found a university – the University of Science and Technology (UST) – which focuses upon hands-on multidisciplinary training, a missing gap in much Korean higher education (see Box 4).

The capability to attract young talents to combat aging of their staff and boost creativity is vital for GRIs. A common complaint among GRI researchers is their relatively poor employment conditions. Although they tend to be paid more than their counterparts in universities, they have been forced to retire at 61 (the retirement age in universities is 65) without a pension. Because of this and the lack of institutional stability, many GRI researchers tend to seek alternative appointments in universities and the private sector before they reach their mid-40s.

In the last three or four years, however, the GRIs have enjoyed a modicum of stability as they have focused their attention on a set of core research areas (for example, through the Top Brand Project initiative, in which GRIs identify a small number of fields in which they aim to achieve leadership positions in the short to medium term). The PBS continues to be improved and it has recently been announced that GRIs will benefit from more core funding in the future, with as much as 70% of staff costs being met in this way by 2012, as compared to 40% or so in 2007. Finally, the new government has also announced that it intends to set aside KRW 200 billion by 2013 to cover the pen-

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[7] On the other hand, GRIs are major players in some of the government's more long-term, strategic research programmes, including the 21st Century Frontiers programme.

[BOX 3] THE KIST-ACADEMIA COLLABORATIVE EDUCATION PROGRAM

KIST has set up graduate collaboration programs with nine Korean universities in which students complete a basic curriculum at the university in which they are enrolled and then participate in a KIST research project. While they are working on KIST research, students write the thesis required for their degree, and KIST and university faculty members act as co-advisors. Collaboration is seen as beneficial for all: students gain a combination of theoretical and practical knowledge that should stand them in good stead in future employment in industry and KIST can employ the graduates directly after they complete their studies. More indirectly, it is claimed that students act as conduits for the transfer and distribution of KIST's research products to industry.

Source: KIST (2007)

[BOX 4] THE UNIVERSITY OF SCIENCE AND TECHNOLOGY

Inaugurated in 2004, the University of Science and Technology (UST) operates as a graduate school affiliated with 22 GRIs and specializes in the training of research students in interdisciplinary R&D fields (in contrast to most national and private universities, which have a strong disciplinary academic culture). The UST aims to exploit the synergy effects of conducting education and research together and seeks to capitalize on the facilities, equipment, manpower and experience available in GRIs. Students learn through participation in research projects in GRIs, with minimal lecture-based education.

GRIs cover all major fields and the UST's interdisciplinary approach allows it to offer a differentiated curriculum that meets the growing need for training and education in multidisciplinary fusion technologies. This differentiation is achieved, in part, through a system of lab rotation, whereby students participate in the projects of other research institutes and private corporations, in addition to their advisors' research projects, thereby gaining experience in various research environments. It is also mandatory for students to study a selection of general courses, covering topics such as technology management, research management and planning, venture business studies, and technical writing. Taken together, the training and hands-on practical experience that students gain meets the needs of research and industry and reduces the need for re-education.

Current annual admissions rates are rising though still modest, with 115 admissions divided among masters and doctoral programs in 2007. However, the government has significantly increased UST's budget since its inauguration and there are plans to continue the university's expansion.

Source: UST website.

sions of GRI researchers.[8] In parallel to these developments in GRIs, the universities are becoming less comfortable places to work, as professors are increasingly expected to meet performance targets and in some institutions (*e.g.* KAIST) to teach in English. Therefore, some convergence in working conditions between GRIs and universities appears likely, which could make the GRIs, once again, relatively attractive places in which to work.

The Future Role and Governance of GRIs – Policy Options

To better contribute to the overall coherence and the adaptive efficiency of the Korean innovation system GRIs may have to adjust their missions. This has implications for the way they are institutionalized and governed. Missions on which more emphasis should be put in the future include the following (somewhat overlapping):

- *Servicing SMEs*. Korea is often compared to Chinese Taipei, where GRIs have played important roles in the development of technologically strong and innovative SMEs. A similar role is often proposed for Korean GRIs. But the situation in Korea is very different, with relatively weak SMEs that are mostly unfit for the sorts of research collaboration that would interest most GRIs. Although this picture might now be changing owing to the recent growth of high-technology start-ups.

- *Moving away from industrially oriented R&D towards public and welfare research*. With the chaebol largely self-sufficient in terms of R&D, and doubts about whether GRIs should be involved in developing commercial technologies or collaborating with SMEs, GRIs might be better off leading a shift towards more public and welfare-oriented R&D around important national challenges. In fact, several institutes already have an explicit public-welfare focus, but others might seek to reorient their research portfolios in similar directions.

- *Concentrating on platform technologies*. If GRIs are still to contribute to industrial innovation, they should focus upon pre-competitive, so-called platform technologies. Several institutes are already working on such technologies, often in co-operation with industry, but this could be further expanded and become the main rationale for several institutes.

- *Leading Korea's shift to more fundamental research*. GRIs have facilities superior to those of universities and greater research experience, which makes them obvious candidates to lead Korea's shift towards more fundamental research. However, recent relative declines in basic research, together with the government's intent to strengthen research in universities, are likely to undermine GRIs' claim to this role. Moreover, if GRIs were to conduct more fundamental research, the current project-based system (PBS) would need to be revised, since it has been detrimental to the stability necessary for fundamental research.

- *Working in areas of interdisciplinary and "fusion" research*. Disciplinary structures in universities are known to inhibit interdisciplinary work, while the scale requirements of "fusion" research of-

[8] As reported in The Korea Times, 20th March 2008

ten require dedicated research centres and research infrastructures that are not commonly found in Korean universities. GRIs could occupy this territory, but would themselves need to break down cultural and epistemic barriers between institutions.

Different options for the institutionalisation of GRIs are also regularly discussed. These range from merging and breaking up institutes to revising their ministerial location – options that have been used many times in the past. More radical proposals are also sometimes discussed, including privatization and mergers with universities. Of course, GRIs vary widely; they have different types of organization and face different issues that require different policy responses. The government should be sensitive to this differentiation when formulating policy and should consider the future of each institute on a case-by-case basis. Furthermore, GRIs should be expected to play a number of roles and no institute should be pigeonholed into performing a single function, even if this gives the appearance of administrative untidiness.

As for the governance of GRIs, an additional institutional layer, in the shape of five research councils, was established in the late 1990s between the ministries and their funding agencies and GRIs. Inspired by similar structures in the United Kingdom and Germany, the rationale for the research councils was to give GRIs a certain degree of autonomy from political interference by supervisory ministries, in the hope that this would enhance their R&D performance and efficiency. However, in contrast to their European counterparts, Korean research councils have no funding power and have only an administrative relationship with GRIs.

The research councils were originally placed under the Prime Minister's Office, but those specifically dedicated to S&T, i.e. the Korea Research Council of Fundamental Sciences & Technology (KRCF), the Korea Research Council for Industrial Science & Technology (KOCI), and the Korea Research Council of Public Science & Technology (KORP), were transferred to MoST as part of the 2004 reform package to enhance the latter's co-ordinating position. The other two research councils, which were dedicated to the social sciences and humanities, were merged into the single National Research Council for Economics, Humanities and Social Science (NRCS) and remained under the supervision of the Prime Minister's Office.

The research councils are quite similar in terms of function, internal governance and number of staff. Each has a Board of Trustees composed of vice ministers from relevant ministries, and experts invited from universities, private firms, GRIs and the mass media. Research councils appoint the presidents of the GRIs and operate planning and evaluation committees. They also operate management advisory committees and have small secretariats that carry out policy research, planning and evaluation. Each function has few administrative staff. The GRIs report their research and management plans to their research councils annually. In recent years, the results of the evaluation by an appointed expert committee have exerted significant influence on the budget allocation to GRIs by the Ministry of Planning and Budget.

On the positive side, the research council system has secured a more autonomous research environment for GRIs, as intended. The research councils have also been able to carry much of the bureaucratic load associated with liaising with ministries and the National Assembly, thereby allowing GRIs to get on with their R&D work. Furthermore, the evaluation committees of each research council have included an examination of the organizational structure of GRIs and their operations every year. This has allowed them to guide GRIs in their management reform activities.

However, some issues need to be resolved:

- First, since the research councils lack the financial capacity to support GRIs, regular evaluations and requests to provide management information are often regarded by GRIs as interference by a higher administration body. Some GRIs also find yearly evaluations unnecessary and the source of a heavy burden of administrative work. They also criticize the standardized evaluation criteria used as failing to take sufficient account of the differences between institutes.

- Second, the names of the research councils – referring to fundamental, industrial and public S&T – do not necessarily reflect the orientation of GRIs assigned to them, as GRIs typically conduct a broad array of R&D. Indeed, to an outsider, the allocation of GRIs to the research councils seems somewhat arbitrary. By contrast, in other countries, structures like the research councils are often discipline-based.

- Third, even though the research councils are not discipline-based, a certain rigidity acts as a barrier to interdisciplinary research co-operation by GRIs located in different research councils.

- Finally, each research council has a very small administrative staff. If the roles of the research councils do not increase markedly, it might be better to amalgamate them to create a single organization with greater critical mass. In fact, given that standardized evaluation arrangements are used – and evaluation is perhaps the research councils' main role at present – such amalgamation would create relatively little disruption for GRIs and would achieve scale efficiencies. It could also promote greater interdisciplinary research co-operation.

Some reforms of the research councils have been introduced by the new administration. The main change is a reduction in number of research councils from five to three, with two remaining in the S&T area: the Research Council for Fundamental S&T under the supervision of MEST and the Research Council for Industrial S&T under the supervision of MKE. Both research councils supervise 13 GRIs each. Whether these new institutions will play an enhanced role in steering the GRIs remain to be seen.

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