LOOK OUT TO THE WORLD

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[2], much less attention has been devoted to developing a common understanding of the challenges faced by non-university public research institutions[3].

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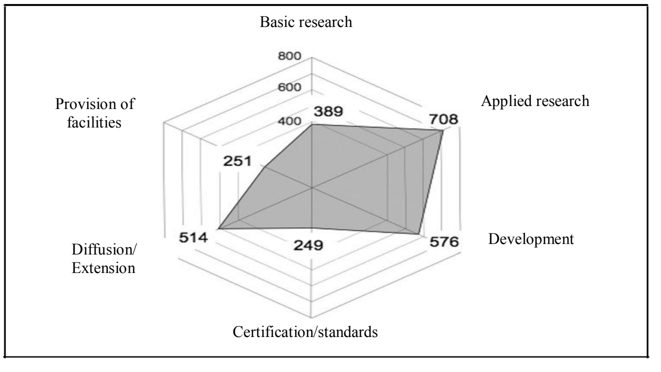
[2] For example, see the OECD Thematic Review of Tertiary Education, 2008.

[3] 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.

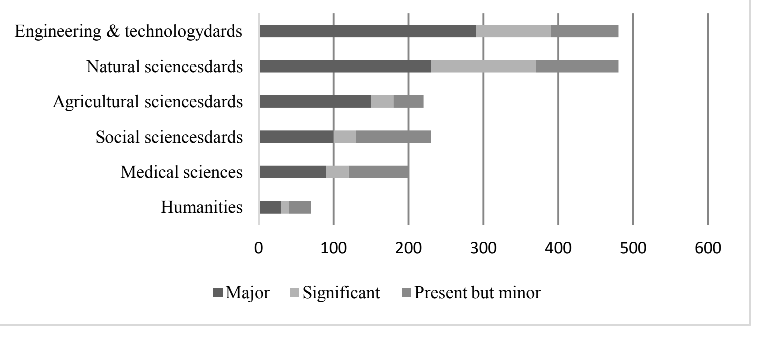
1. GRIs in national innovation systems - a historical and cross-country perspective[4]

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).

Functions of GRIs



Capabilities of GRIs by main field



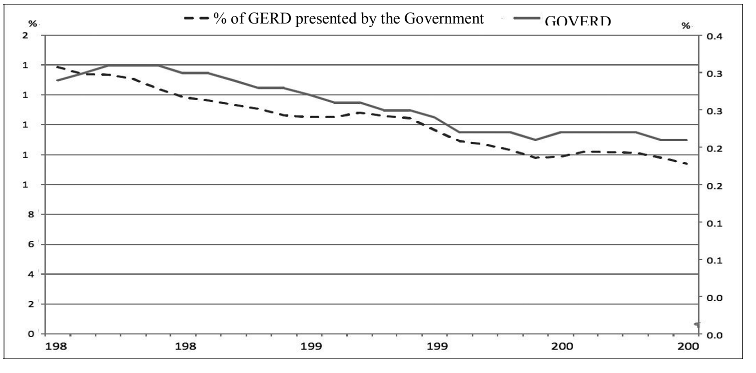
Source: PREST, 2002

Figure 1. The variety of european GRIs

[4] 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).

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.

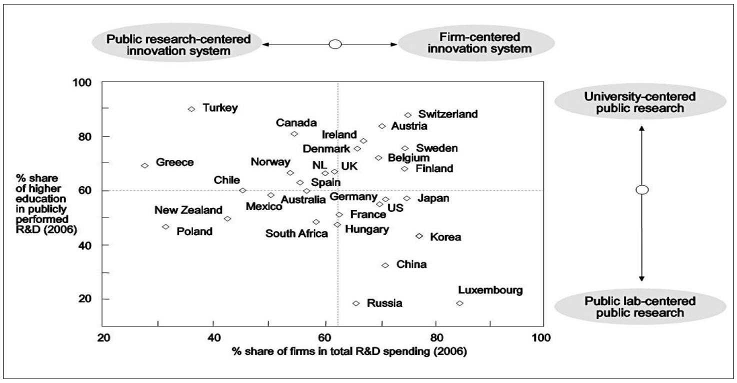
In the OECD region, the share of gross domestic expenditure on research and development (GERD) performed by the government sector was 17.9% in 1981 and 11.4% in 2006. As a share of GDP, government intramural expenditure on R&D (GOVERD, which is a proxy for R&D spending in GRIs) was between 0.34 and 0.36%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



Source: OECD, Research and Development Statistics Database.

Figure 2. R&D in the government sector, total OECD, 1981-2006

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.



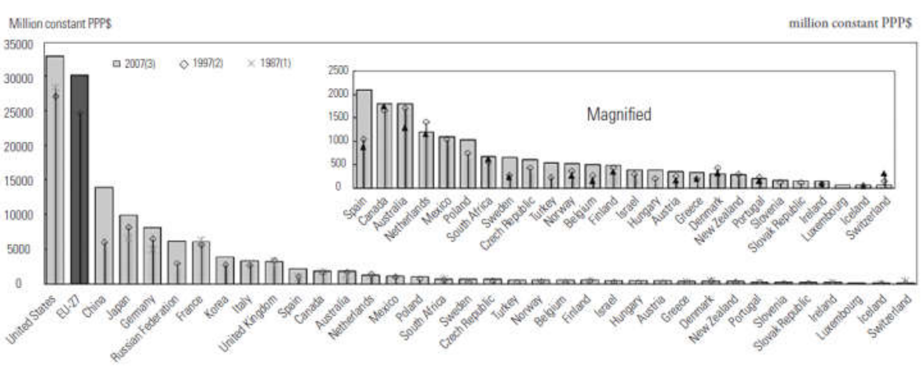
Source: The author, based on OECD data.

Figure 3. Archetypes of national innovation systems

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.

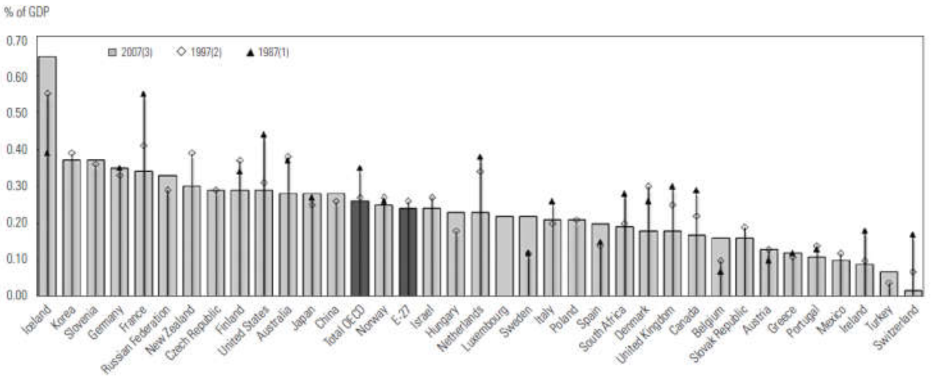
GOVERD as a share of GDP reveals even more diversity across countries (Figure 5). OECD-area expenditure on R&D in the government sector fell from 0.35% of GDP in 1987 to 0.26% in 2006. Over the period 1987 to 2007, the largest falls were in France, the Netherlands, Switzerland and the United States. 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.



Source: OECD, Main Science and Technology Indicators

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.*

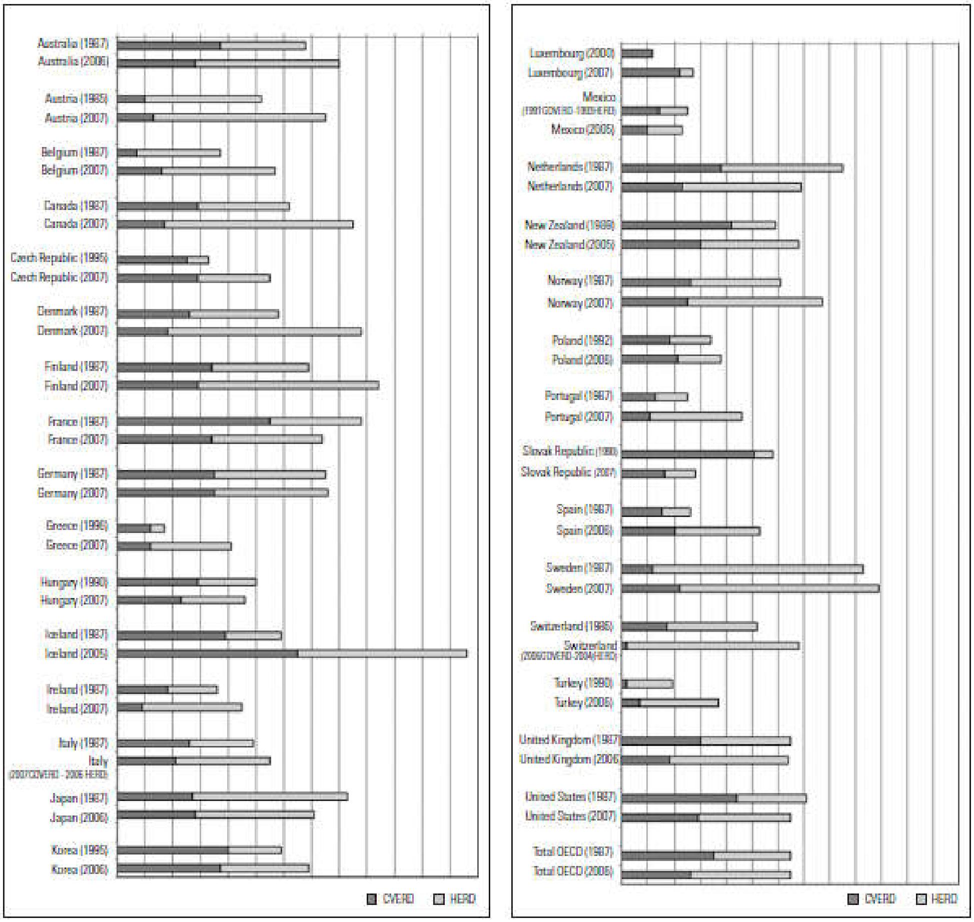


Source: OECD, Main Science and Technology Indicators

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.

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.



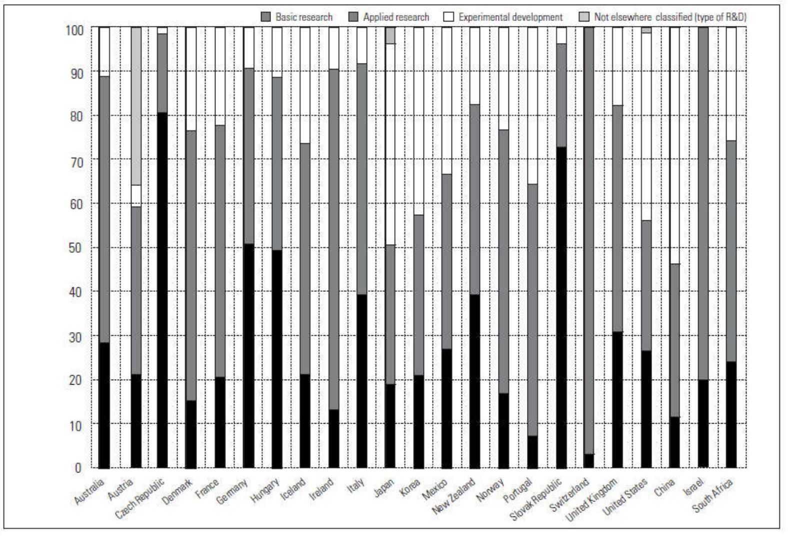
Source: OECD, Main Science and Technology Indicators.

Figure 6. Total funding of R&D performed in the public sector 1987 & 2007

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 research and experimental development.[5] 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.

[5] 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.



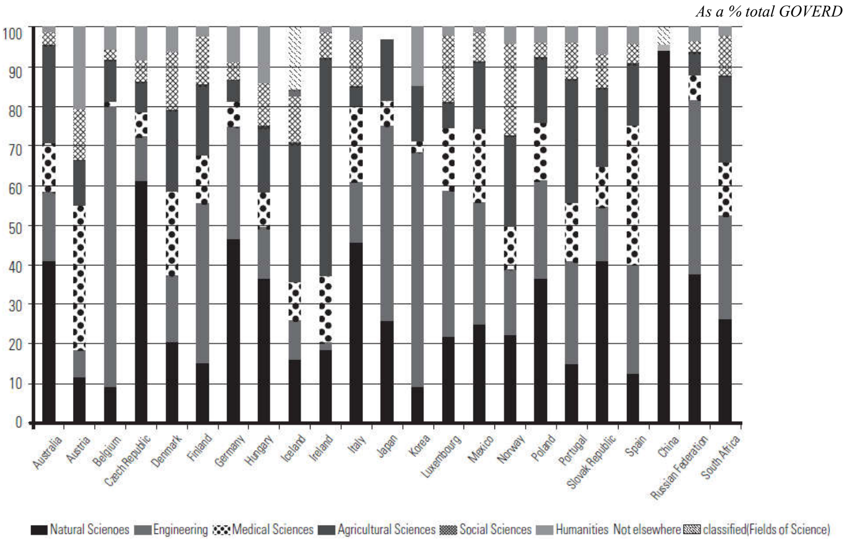
Source: OECD, Research and Development Statistics database.

Figure 7. Goverd by type of R&D, 2007

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.*

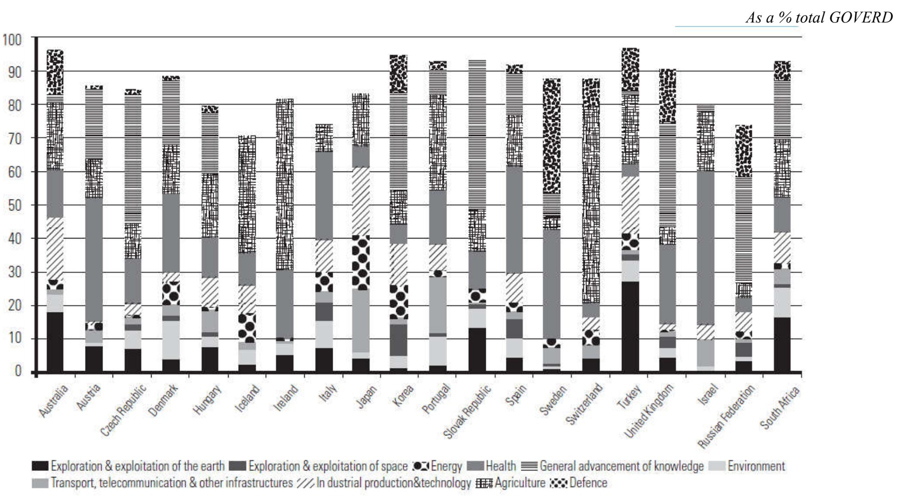
The bulk of GRI research in most countries is directed towards applied research or acquiring new knowledge directed primarily towards a specific practical aim or objective. In the countries for which adequate information exists to measure the changing focus in GRIs over time, for example in Australia, 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.

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.



Source: OECD, Research and Development Statistics database.

Figure 8. Goverd by field of science, 2007

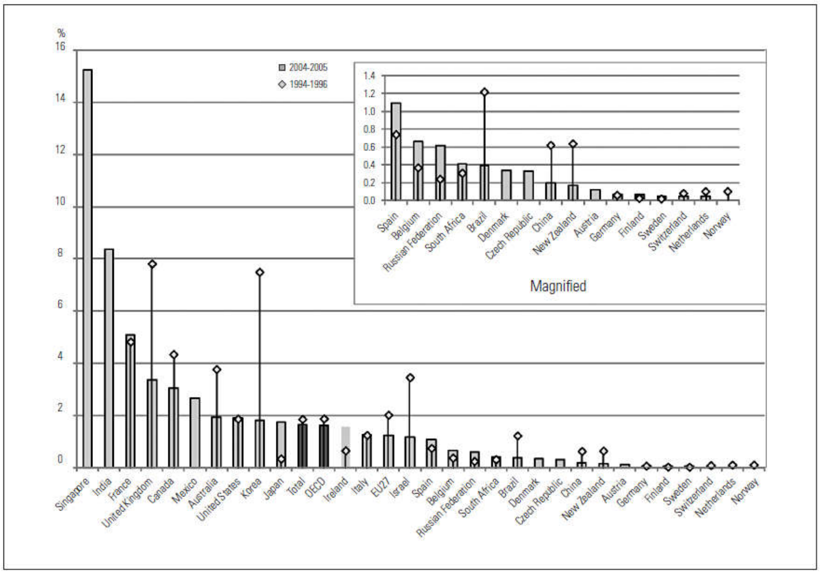


Source: OECD, Research and Development Statistics database.

Figure 9. Goverd by socio economic objective, 2007

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.



Source: OECD, Patent Database

Figure 10. Share of patents owned by government institutions

Table 1. Government patents by technology field, 2004-2006

% share of countries patents in that field

	Biotechnology	IC	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

	Biotechnology	IC	Nanotechnology	Renewable
German	0,21	0,11	-	0,36
Italia	4,50	2,68	14,10	-
Japan	8,88	1,81	13,80	0,30
Korea	5,62	0,90	9,71	2,08
UK	5,88	7,64	3,18	-
America	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.

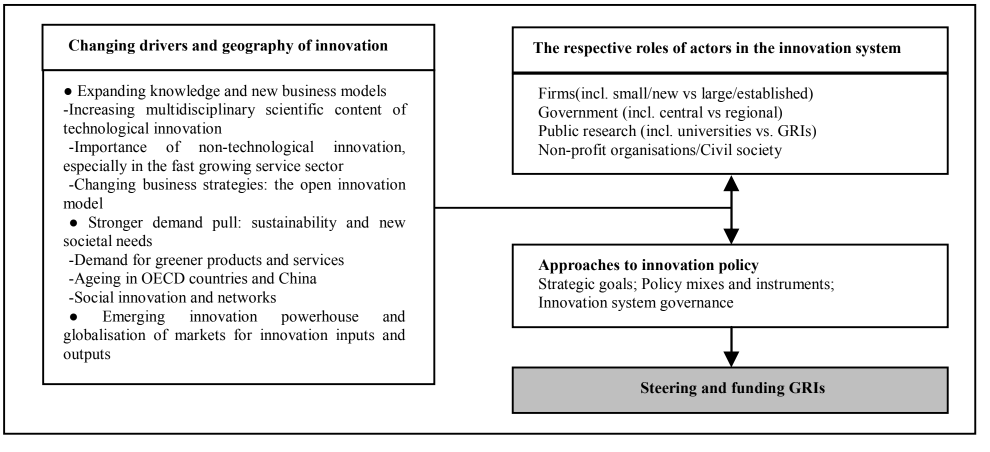
Box 1. Innovation has become the key driver of economic growth

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 noninnovative 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).



Source: The author

Figure 11. New trends in innovation processes and policies

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.

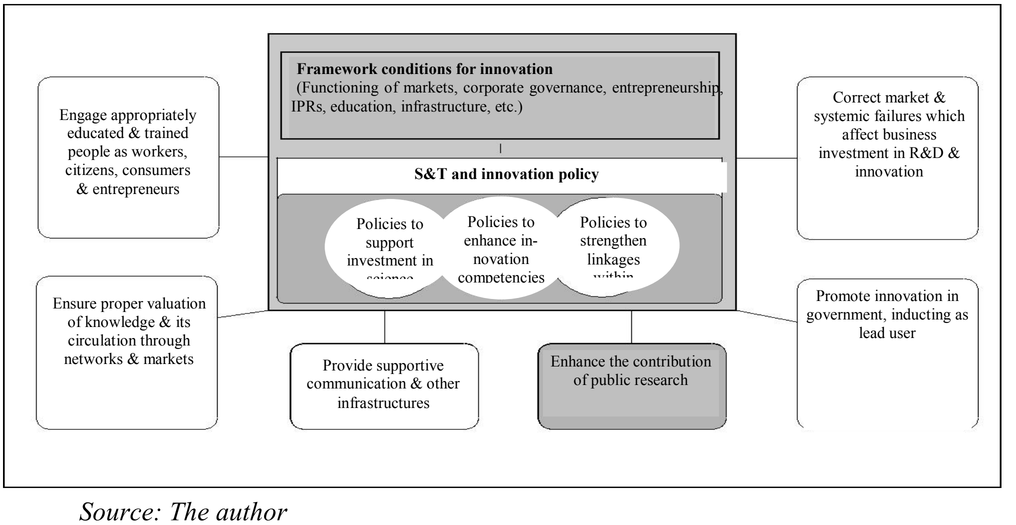
Changing Principles, Scope and Strategic Tasks of Innovation Policy

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 out-comes from the policies and programmes they fund.



Source: The author

Figure 12. The scope and strategic tasks of innovation policy

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.

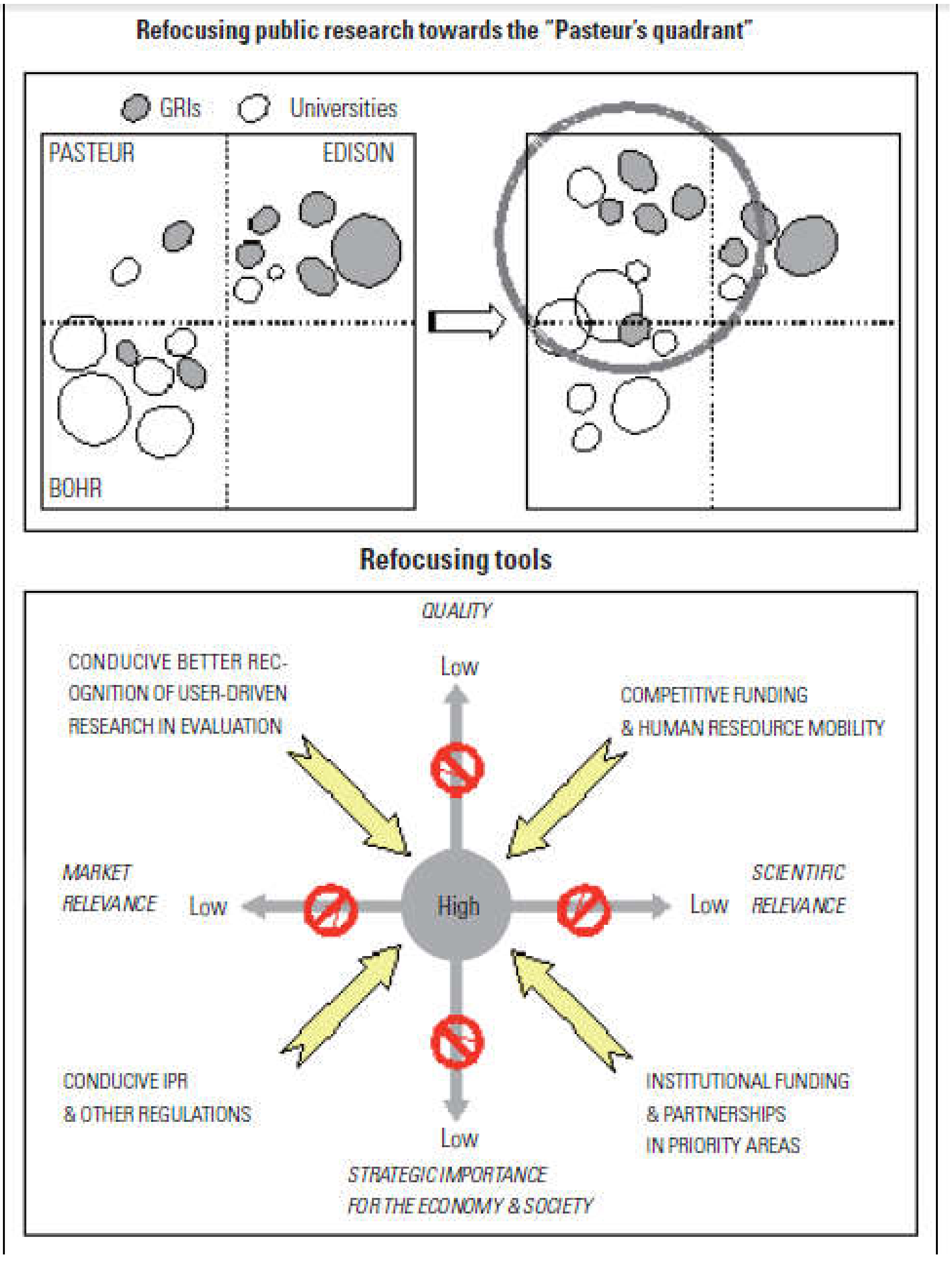
Broadly speaking, regarding public research the main concern of governments should be to ensure, through appropriate organizational arrangements and steering and funding mechanisms, that they can combine excellence, relevance and critical mass in accomplishing their public missions and in complementing 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 techno-logical 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 fields of multidisciplinary research)? GRIs must implement their own "open innovation model".



Source: OECD (2003).

Figure 13. Enhancing the contribution of public research to innovation

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.

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