Chapter 3

Government Innovation Policy

This chapter examines the innovation policies put in place by the Korean government to address the many issues discussed in previous chapters. It begins with a short history of developments in Korean innovation policy over the past 40 years and highlights the issues that dominate today's innovation policy agenda. The main policy-making institutions are then described, followed by an examination of the way policy is co-ordinated and governed. Funding programmes for research are discussed, as is Korean policy on human resources for science and technology, followed by consideration of more demand-side policies and policies aimed at improving the framework conditions for innovation. The final sections of the chapter take a spatial perspective by considering policy efforts for promoting the internationalisation and regionalisation of science and innovation.

3.1. Introduction to Korean innovation policy

This section presents a short history of Korean innovation policy over the last four decades to set the scene for outlining some of the major issues on the contemporary innovation policy agenda.

3.1.1. Korean innovation policy from the 1960s

Korean S&T policy can be traced back to the 1960s and the establishment in 1966 of the first government research institute (GRI), the Korea Institute of Science and Technology (KIST), followed by the formation of the Ministry of Science and Technology (MoST), and the drawing up of the S&T Promotion Law a year later. In the 1970s, several more GRIs were founded, further S&T promotion laws enacted, R&D tax credits introduced, and the training of scientists and engineers ratcheted up. This era has been described as one of imitation (see Table 3.1), with Korea putting in place a science and technology system that would allow it to absorb and adapt foreign technologies in support of its burgeoning industrialisation process.

The 1980s have been viewed as heralding an era of transformation, with the government looking to target core technologies that would actively lead Korean national economic growth rather than passively supporting industry's technological demands. This decade saw the introduction by MoST in 1982 of the first national R&D programme. Shortly afterwards, similar R&D programmes were set up in various ministries, and mission-oriented technological research was pursued in support of individual ministries' core missions in areas such as information and communications, environment, construction and transport, agriculture, and health. In addition to this shift in research funded by the public sector, the private sector was encouraged to engage in technology development through a wide range of measures, including tax incentives, financial provisions, public procurement and S&T-related infrastructure. Within a few short years, the level of R&D spending by the private sector had out-stripped that of the public sector.

Many changes then occurred in the second half of the 1990s, at the time of the Asian financial crisis. The government sought to shift policy towards supporting a more creative type of innovation system, with less emphasis on technology development by the *chaebol* (the country's large conglomerates), more spending on fundamental research so that Korea could increasingly work at knowledge frontiers, and the adoption of an innovation policy framework that emphasised a diffusion-oriented approach to programming. This period has been described as one of innovation and has been marked by very substantial increases in R&D spending by both the public and private sectors and by attempts to improve knowledge flows and technology transfer across the system. Demand-side policies have emerged to complement the traditional supply of innovation inputs, with attention increasingly paid to issues such as commercialisation of R&D, financing of innovative firms, and development of innovation intermediaries.

Table 3.1. A stylised history of Korean S&T innovation policies

Imitation	• Foundation of KIST (1966), MoST (1967)
1960s	• The S&T promotion act (1967)
1970s	• Establishment of GRIs (1970s) in the areas of machinery, shipbuilding, chemicals, marine science, electronics
	• Tax credit for R&D investment (1974)
	• Development of human resources for R&D (KAIST)
Transformation	• National R&D programme (NRDP, 1982)
1980s	• Establishment of Daedeok Science Town
	• Promotion of private firms' research: financial and tax incentives to stimulate R&D investments (reduction of tax for technology-based start-ups (1982); tax credit for technology and manpower development expense)
Innovation	• Promotion of university-based research Science Research Centres
1990s onwards	• Five-year plan for innovation (1997)
	• Establishment of the National Science and Technology Council (1999)
	• S&T vision 2025 (1999)
	• First National Technology Roadmap (2001)
	• New organisation of MoST(2004) – Deputy prime minister, establishment of the Office of the Ministry of Science, Technology and Innovation (OSTI)
	• Launch of the Ministry of Education, Science and Technology (MEST) (2008)

Source: Based on Hong (2005), "Evolution of the Korean National Innovation System: Towards an Integrated Model", in OECD (2005), *Governance of Innovation Systems*, Vol. 2, OECD, Paris.

Table 3.2. SWOT analysis of the Korean innovation system

Strengths	Opportunities
• Strong, mobilising 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	• Geopolitical positioning in one of the most dynamic regions of the world • Free trade agreements • Globalisation, 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 industrialising economies, both in the region and worldwide, offering new markets for Korean exports
Weaknesses	**Threats**
• Underdeveloped fundamental research capabilities and weak research capacity in universities • Weak linkages between GRIs and institutions of higher education • In education, rote learning, overemphasis upon university entrance exam, and crippling cost of private education • Underutilisation 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	• Low fertility rates and an ageing 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

With a broader suite of policies and a mushrooming of schemes and initiatives across several ministries and agencies, policy co-ordination and coherence have become challenges, as governments are generally not well organised to deal with cross-cutting policy issues such as innovation. Policy co-ordination and coherence involve not only co-ordination of simultaneous policy actions but also an evaluation of their possible interaction with policies pursuing other primary objectives. It concerns first of all core innovation policies such as S&T and education, but the impact of a number of other policies must also be taken into account, *e.g.* taxation policy, competition laws and regulations, etc., the so-called framework conditions for innovation. Taken together, these different areas point to the importance of viewing government intervention in terms of a policy mix in which many policy areas need to be linked to innovation policy in order to improve national innovative performance.

3.1.2. Policy challenges

The previous chapters have highlighted the strengths and weaknesses of the Korean innovation system, and have addressed some of the opportunities and threats that are likely to arise in the coming years. These are summarised in Table 3.2. In their own way, each of the factors identified provides a challenge for policy makers to tackle. For example, in the case of strengths, how can these be exploited as fully as possible? How should they be maintained so that they remain strengths? For weaknesses, how can their effects be reduced and/or eliminated? How might opportunities be seized and threats minimised? It is beyond the scope of this review to consider each factor systematically. Instead, some of the main challenges requiring a policy response are introduced in order to serve as a basis for discussion of more specific policy issues addressed in subsequent parts of this chapter.

In this regard, it is informative to consider earlier reviews of the Korean innovation system. For example, the OECD conducted a review of Korea's science and technology policy in the mid-1990s (OECD, 1996) and identified a number of important issues, including the need to broaden the technological base; to better manage policy co-ordination problems between "competing" ministries; to improve evaluation arrangements; to boost funding for basic research; to improve support for innovation by small and medium-sized enterprises (SMEs); to reassess the roles of the GRIs; to roll out information and communication technologies (ICTs) across Korean society; to enhance knowledge diffusion and technology transfer; to better focus the R&D efforts of the chaebol; to reform the education system to give greater attention to creativity; and to increase international R&D co-operation. In a later review of the innovation system carried out jointly by the OECD and the World Bank in the wake of the Asian financial crisis (World Bank, 2000), it was observed that the Korean innovation system remained largely based upon a catch-up model. The report acknowledged several new government initiatives which had been put in place to transform Korea into a knowledge-based economy in the wake of the Asian financial crisis and it recognised that these would take time to take effect. Nevertheless, several key issues requiring further attention were highlighted (see Box 3.1).

Box 3.1. Key issues for the Korean innovation system identified by the World Bank and the OECD in 2000

- Encouraging greater interaction among firms, universities, government research programmes and GRIs.
- Clearly justifying the rationale for public intervention and providing subsidies in a transparent and non-discriminatory manner.
- Providing support to R&D in large companies on stricter conditions, assisting only when they would not have undertaken the concerned projects, and stimulating partnership with other actors (enterprises, university and public laboratories), etc.
- Increasing the effort in basic research; this should be performed principally in universities, which should receive more resources. This also implies changing various forms of regulations and practices that discourage research activities.
- Reorienting the GRIs as their activities tend to duplicate those of industry. The GRIs have to be repositioned to do more upstream research or to become more focused on research of collective interest (*e.g.* health, transport, etc). A larger part of their budget has to be secured in the form of institutional funding.
- Developing better forms of support to innovation in SMEs with emphasis on effective networking and clustering, and the involvement of local authorities.
- Strongly encouraging contacts of all actors with foreign counterparts: exchanges of academics and research, technological co-operation, industrial joint ventures, participation in international regulatory bodies, etc.
- Enforcing co-ordination procedures involving key ministries.
- Implementing evaluation exercises, including an international review of Korea's basic research capacities.

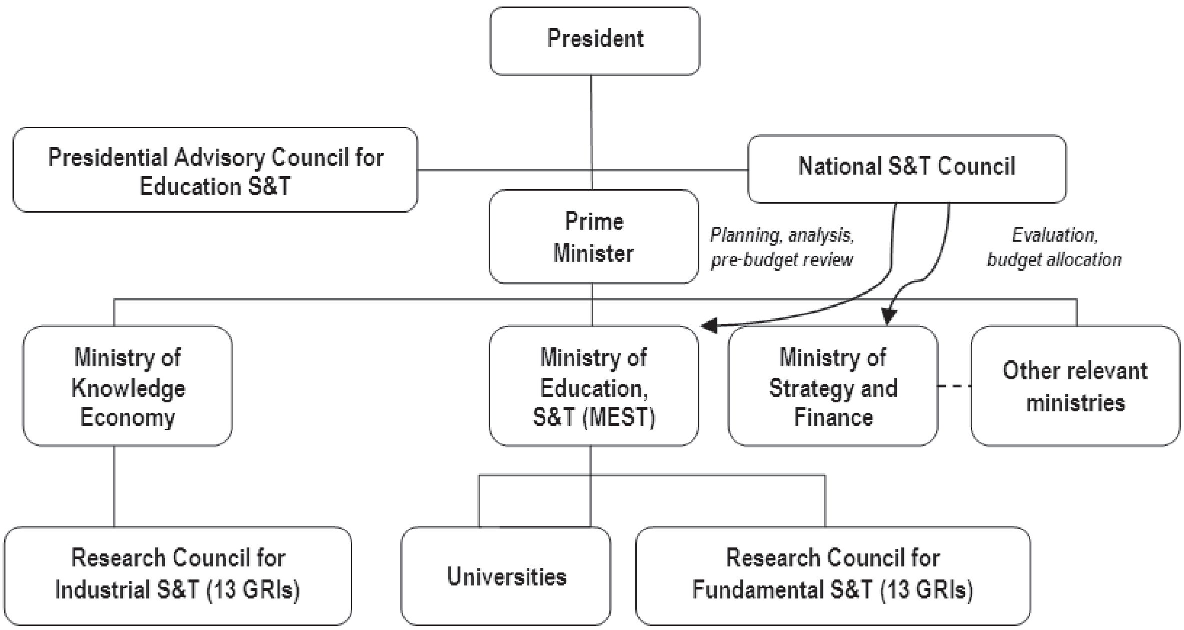
Source: World Bank (2000), *Republic of Korea: Transition to a Knowledge-Based Economy*, World Bank, Washington, DC.

Given the time needed for fundamental changes, it should be no surprise that a number of issues identified in 1996 and 2000 remain on policy agendas today, as earlier chapters in this review clearly demonstrate. However, there is also a strong suspicion that certain "lock-ins", many of which are legacies of past successes, are obstructing the change process. These include the still dominant role of the chaebol, despite efforts to improve the innovation capacity of SMEs; an emphasis on short-term, industrially oriented research at the expense of longer-term fundamental research; an R&D funding bias towards ICTs and the physical sciences at the expense of other areas of science, particularly life sciences; weakly developed research capacity in the universities; lagging productivity in services; relatively weak internationalisation of the domestic research system; and under-utilisation of labour resources, particularly women. Other continuing issues of concern include: a lack of clarity about the roles of the GRIs; the reform of tertiary education; the role of innovation policy in achieving better balanced regional development; the ability to incorporate a longer-term perspective in assessing the costs and benefits of public R&D funding; and the challenge of achieving better co-ordination of science and innovation policies enacted across various government ministries and agencies. The policy responses to these and other issues are examined in greater detail in the sections that follow.

3.2. Policy-making institutions

In most OECD countries, the governance of science, technology and innovation (STI) is organised around a multi-layered matrix of ministerial bodies, advisory structures and a range of actors, all concerned with the making and steering of policy and its implementation. The situation is similar in Korea, which has a rich organisational landscape of ministries, advisory bodies and executive agencies to formulate, implement and evaluate STI policy (Figure 3.1). This section briefly describes advisory and co-ordinating bodies for STI, with more detailed accounts of the main ministries in the area.

Figure 3.1. S&T administrative system in Korea, 2008



Source: MEST (2008), "Becoming an S&T Power Nation through the 577 Initiative", Science and Technology Basic Plan of the Lee Myung Bak Administration, Ministry of Education, Science and Technology, Seoul.

3.2.1. Advisory and co-ordination bodies

Most ministries with an S&T mandate have appointed their own advisory committees to help them formulate policy. In addition, the legislature has appointed committees with a strong interest in S&T and innovation. However, the most prominent advisory – and co-ordination – bodies serving the executive branch are the Presidential Advisory Council on Science & Technology (PACST) and the National Science and Technology Council (NSTC).

The PACST was established in 1991 under the Constitution to advise the president on S&T policy and developments. Its main objectives are to develop strategic policies related to technological innovation and development of human resources; to provide guidelines for system reforms to the ministries related to S&T as well as the president; and to undertake special tasks. PACST is composed of 30 members representing prominent industries, academia and research institutes. Members are appointed by the president for a one-year term. The council meets on a monthly basis and reports to the president at least once every six months. Since most advisory members come from the private sector, the president and deputy prime minister use the PACST to listen to the voices of the private sector and diverse S&T communities. The PACST conducts much of its work through a series of five sub-committees (see Box 3.2), which are in turn supported by expert committees. A secretariat, composed of more than two dozen officials from several relevant government ministries and public research institutes, also supports the PACST.

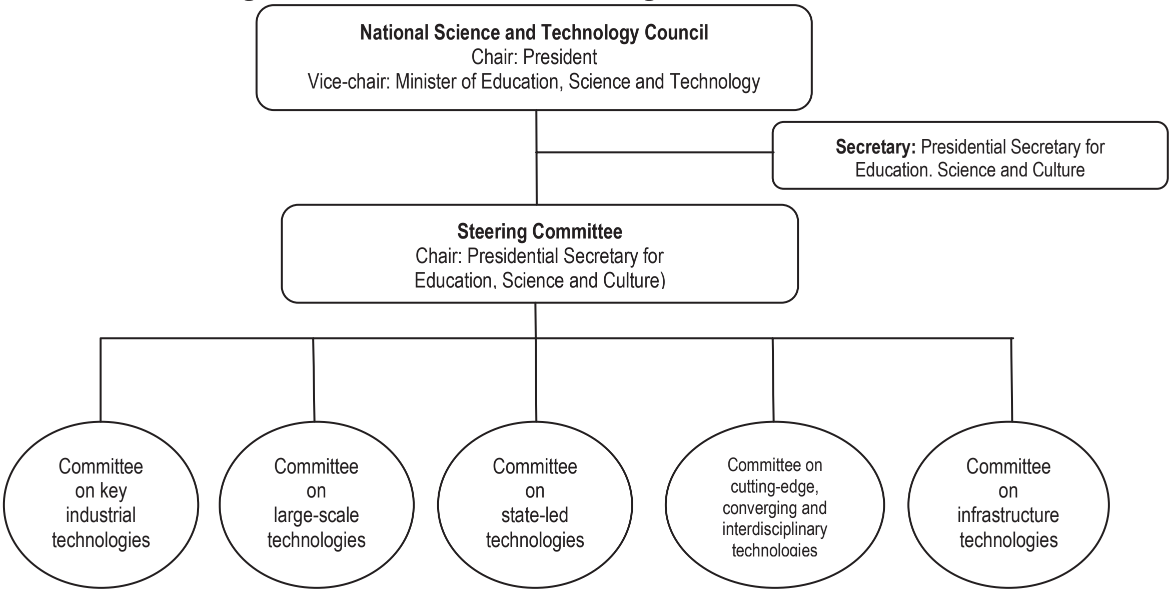
Box 3.2. The five sub-committees of the PACST

- Science and Technology Development Strategy Sub-committee: addresses major issues and the direction of development in the science and technology field.
- Basic Technology Sub-committee: nurtures basic science and deals with the development of breakthrough technologies.
- Public Technology Sub-committee: advises on health and medicine, energy, environment, marine, nuclear and aerospace technologies.
- Industrial Technology Sub-committee: advises on industry-related technological development and the direction of development including information, biotechnology, machinery, parts, chemical engineering and textiles technologies.
- Science and Technology Infrastructure Sub-committee: advises on the direction of development of the science and technology infrastructure such as human resources, research facilities, international co-operation and science culture.

The National Science and Technology Council has been the highest decision-making body of the Korean government on STI issues since the president took the chairmanship in 1999. Until February 2008, it was composed of 13 ministers with an STI policy remit, plus nine experts from the S&T community. As a cross-ministerial body, the NSTC has played a pivotal role in policy co-ordination among its member ministries. During the 1980s and 1990s, R&D programmes were established in various ministries which widely imitated each other's programmes to serve their own missions. Despite this compartmentalisation, there was much overlap and duplication between ministries' programmes and few co-ordination mechanisms at a higher level to give coherence to the policy system. This failure of co-ordination was the main rationale for strengthening the NSTC's role in 1999.

Until its abolition in 2008, MoST provided the secretariat for the NSTC, setting its agenda and providing supporting documents. A dedicated arm of MoST, the semi-autonomous Office of Science and Technology Innovation (OSTI), was created in 2004 specifically to fulfil this function, though this too was abolished in 2008 along with MoST. The newly formed MEST now fulfils this secretariat function without the assistance of any other entity. At the same time, as Figure 3.2 shows, the NSTC is supported by five expert committees on: key industrial technologies; large-scale technologies; state-led technologies; cutting-edge converging and interdisciplinary technologies; and infrastructure technologies.

Figure 3.2. New administrative arrangements for the NSTC



Source: MEST (2008), "Becoming an S&T Power Nation through the 577 Initiative", Science and Technology Basic Plan of the Lee Myung Bak Administration, Ministry of Education, Science and Technology, Seoul.

3.2.2. STI ministries

Table 3.3 lists the main ministries and research funding agencies and their respective R&D budgets for the period 2003-05. During this time, there were four main players (defence-related spending is excluded): the Ministry of Science and Technology (MoST) and the Ministry of Commerce, Industry and Energy (MoCIE) with very similar levels of funding; the Ministry of Education and Human Resource Development (MoE) with less than half the spending of MoST; and the Ministry of Information and Communications (MIC) with about one-third of the spending of MoST. As Table 3.3 shows, R&D budgets in MoST, MoCIE and MoE grew substantially over this short period, reflecting both the Korean government's commitment to raise spending on public research and its efforts to concentrate R&D funding in fewer agencies.

Since February 2008, MoST and MoE have been merged to form the Ministry of Education, Science and Technology (MEST), and MoCIE and MIC have come together in the Ministry of Knowledge Economy (MKE).[1] This consolidation was initiated by the new president as part of an overall drive to reduce the size of government and to cut the number of ministries in the executive branch. As such, it has had little to do with perceived problems in the operation or performance of these ministries. That being said, a long history of rivalry among these ministries has sometimes been unhelpful to Korea's drive to improve its S&T and innovation performance. Consolidation of rivals into new entities could reduce this rivalry and lead to enhanced co-operation on policies targeted at the innovation system. This potential is further discussed in section 3.3.

Since the operational details of the new ministries are still being worked out at the time of writing, the descriptions that follow include brief accounts of MoST and MoE, as well as MEST and MKE. This may help give a better appreciation of some of the many issues at play in trying to co-ordinate STI policy in Korea.

Table 3.3. R&D budgets of former major ministries

KRW 100 million and percentages

Ministries	Funding agents	2003	%	2004	%	2005	%
MoST	KOSEF KISTEP	12 830	19.7	16 905	23.9	19 549	25.1
MoCIE	KOTEF ITEP	11 533	17.7	16 403	23.2	18 393	23.6
MIC	IITA	5 991	9.2	6 996	9.9	6 968	8.9
MND	ADD	117	0.2	2 931	4.1	9 112	11.7
ME	KIEST	1 074	1.6	1 301	1.8	1 365	1.8
MoHW	KHIDI	1 318	2.0	1 544	2.2	1 663	2.1
MAF	ARPC	602	0.9	674	1.0	622	0.8
MoCT	KICTEP	768	1.2	916	1.3	1 506	1.9
MoMAF	KIMST	1 081	1.7	1 086	1.5	1 405	1.8
MoE	KRF	3 340	5.1	5 278	7.5	8 209	10.5
Others		26 500	40.7	16 793	23.8	9 204	11.8
Total		**65 154**	**100.0**	**70 827**	**100.0**	**77 996**	**100.0**

Source: NSTC (2006), *Survey and Analysis Report on 2006 National R&D Projects*, National Science and Technology Council, Seoul.

3.2.3. Ministry of Science and Technology (MoST)

The Ministry of Science and Technology (MoST) was, until its abolition in February 2008, the most important ministry for STI policy making in Korea, in terms both of budget size and mandate. It was responsible for providing central direction, planning, co-ordination and evaluation of all S&T activities in Korea, as well as the formulation of S&T policies, programmes and projects (including technology co-operation, space technology and atomic energy) in support of national development priorities. Accordingly, its functions were to:

- formulate policies for S&T development.
- formulate policies for R&D investment, human resources development, S&T information, and international S&T co-operation.
- support basic and applied research conducted by GRIs, universities and private research institutes.
- plan, promote and support the development of core, future-oriented S&T and large-scale technology.
- attain technological self-reliance and the safe use of nuclear technology.
- promote public awareness of S&T.

Over the years, MoST grew in importance as Korea moved towards high-technology industries as its motor for growth, and its mandate enlarged from a focus solely on S&T to one that also included innovation. At the same time, many other ministries started their own research programmes. This created a need for better co-ordination of this distributed effort, which MoST was called upon to perform. In 2004, the previous government made the following changes to MoST:

- The Minister of Science and Technology was promoted to deputy prime minister status and became vice chairman of the NSTC.
- The Office of Science and Technology Innovation was formed within MoST to facilitate inter-ministerial co-ordination on STI. The STI policies and programmes of the different ministries were reported to and evaluated and co-ordinated by OSTI in the name of the NSTC.
- To enhance its role as honest broker, most of MoST's R&D programmes on applied technologies were transferred to other relevant ministries. Under these arrangements, MoST only dealt with the implementation of R&D programmes associated with basic science, purposive basic research and large-scale composite technologies.
- The NSTC was given the authority to reallocate government R&D budgets to S&T programmes and projects after the Ministry of Planning and Budget (MPB) had allocated its R&D budgets to the various ministries.

The effectiveness of these co-ordination arrangements is reviewed in section 3.3.

3.2.4. Ministry of Education and Human Resources Development (MoE)

Until its abolition in 2008, the Ministry of Education and Human Resources Development (MoE) was responsible for planning and co-ordinating educational policies, formulating policies that govern the primary, secondary and higher education institutions, approving and publishing textbooks, providing administrative and financial support for all levels of the school system, supporting local education offices and national universities, operating the teacher training system, overseeing lifelong education, and developing human resource policies. In a move similar to that at MoST, the Minister for Education and Human Resources Development assumed (in 2001) the position of deputy prime minister to oversee and co-ordinate tasks and ministries related to human resources development policies, at the direction of the prime minister.

3.2.5. Ministry of Education, Science and Technology (MEST)

Launched in February 2008, the Ministry of Education, Science and Technology (MEST) was created through a merger of the former MoST and MoE. However, in line with its roots, MEST has two "wings", one dedicated to the education system and the other to science and technology, each headed by a different vice minister. This alignment is not complete, as the part of MoE that dealt with academic research policy is located in the science and technology wing along with the former MoST divisions. Each wing is divided into several offices or bureaus, which are, in turn, divided into several divisions:

- Education: Office of Human Resources Policy (including about a dozen divisions, dedicated to areas such as human resources for S&T, manpower supply and demand statistics, etc.); Lifelong and Vocational Education Bureau; School Policy Bureau; and Educational Welfare Support Bureau.
- Science and Technology: Office of Science and Technology Policy (including about a dozen divisions divided between the S&T Policy Planning Bureau, the S&T Policy Co-ordination Bureau, and the Big Science Support Bureau); Office of Academic Research Policy (again including around a dozen divisions organised under the Basic Research Policy Bureau, the Academic Research Support Bureau,

and the University and Research Institute Support Bureau); the International Co-operation Bureau; and the Atomic Energy Bureau.

3.2.6. Ministry of Knowledge Economy (MKE)

Launched in February 2008, the Ministry of Knowledge Economy (MKE) was created through a merger of the former MoCIE and MIC, and some elements of MoST were also incorporated. The mandate of MKE is as follows:[2]

- to expand co-operation and trade with other countries and promote Korean exports.
- to attract foreign investment.
- to promote energy conservation and energy security, develop an effective response to climate change, encourage the development of alternative energy sources, and support resource development projects at home and abroad.
- to make Korea's energy industry more competitive while securing a stable supply of resources such as oil, gas, electricity, nuclear power and coal.
- to achieve future-oriented industrial development by advancing the distribution industry and other knowledge-based service industries, and by promoting e-commerce and informatisation.
- to foster the development, transfer and commercialisation of industrial technologies, as well as industrial standardisation.
- to promote the Korean design industry internationally.
- to strengthen the competitiveness of key industries such as parts and materials, automobiles, shipbuilding, machinery, steel, petrochemicals and textiles.
- to promote the development and success of new growth engines such as semi-conductors, information technology, biotechnology and new materials.

More specifically, MKE has put in place strategies to enhance the development and commercialisation of advanced technologies as part of its industrial policy. These strategies include:

- establishment of an R&D network to advance information sharing and commerciali-sation.
- streamlining of research procedures.
- collaboration with universities, companies and institutes conducting R&D.
- increase in R&D outsourcing and encouragement of participation of associations and academic groups in carrying out large-scale R&D projects.
- strengthening of global co-operation in joint technology development.
- expansion of financial support for developing and commercialising technologies.
- enhancement of companies' intrinsic ability to innovative.
- facilitation of private investment in R&D.

3.3. STI policy and governance

A key challenge for Korea has been to co-ordinate its fast-growing list of policy measures (and the activities of institutions devoted to delivering such measures). Perhaps more than most countries, Korea has taken the issue of policy co-ordination seriously and has in recent years introduced several reforms to improve policy coherence. This section examines two aspects of this co-ordination: first, the horizontal co-ordination of innovation policies across different ministries; and second, the vertical co-ordination of research performers, with particular attention to the governance arrangements for the GRIs. This is followed by a summary of the evaluation arrangements which have been put in place to augment these and other vertical governance arrangements. The section begins with an account of the various visions and plans that guide and frame policy intervention and seem to have a prominent role in the policy system.

3.3.1. Visions, plans and roadmaps: guiding and framing policy intervention

The promulgation of laws and national plans is an important mechanism for directing and co-ordinating science, technology and innovation in Korea. Moreover, in recent years, these have been bolstered by the development of national visions and roadmaps, a reflection perhaps of an evolving multi-actor landscape which makes top-down direction setting more difficult and thus necessitates the use of complementary system-wide approaches. At the top level is Vision 2025: Development of Science and Technology, which was formulated by the PACST in 1999. It proposed the following fundamental shifts in science and technology policy: *i)* from a government-led and development-oriented innovation system to a private industry-led and diffusion-oriented innovation system; *ii)* from a closed R&D system to a globally networked R&D system; *iii)* from a supply-dominated investment enhancement strategy to an efficient utilisation and investment-distribution strategy; *iv)* from a short-term technology-development strategy to a long-term market-creating innovation strategy; and *v)* towards establishing a science- and technology-led national innovation system. The goal of Vision 2025 is for Korea to become a global leader in specific S&T sectors and employ more than 300 000 R&D personnel and spend USD 80 billion a year on R&D by 2025.

Based on Vision 2025, the Science and Technology Framework Law of 2001 aimed to promote S&T more systematically. It includes provisions for the formulation of mid- and long-term policies and implementation plans, and is the legal basis for inter-ministerial co-ordination of S&T policies and R&D programmes. It also provides the overall support mechanism for R&D activities and S&T agencies, and the legal basis for fostering an innovation-driven culture. Based on the Framework Law, five-year Basic Plans of Science and Technology (2003-07 and 2008-12) have been formulated. The first had five policy goals with 14 core strategic targets. The five goals were: to create future economic growth engines; to build up basic research capabilities; to internationalise and regionalise S&T; to advance the S&T innovation system; and to improve S&T awareness. The first priority was the development of future growth engines; the other four goals addressed perceived deficiencies of the Korean STI system.

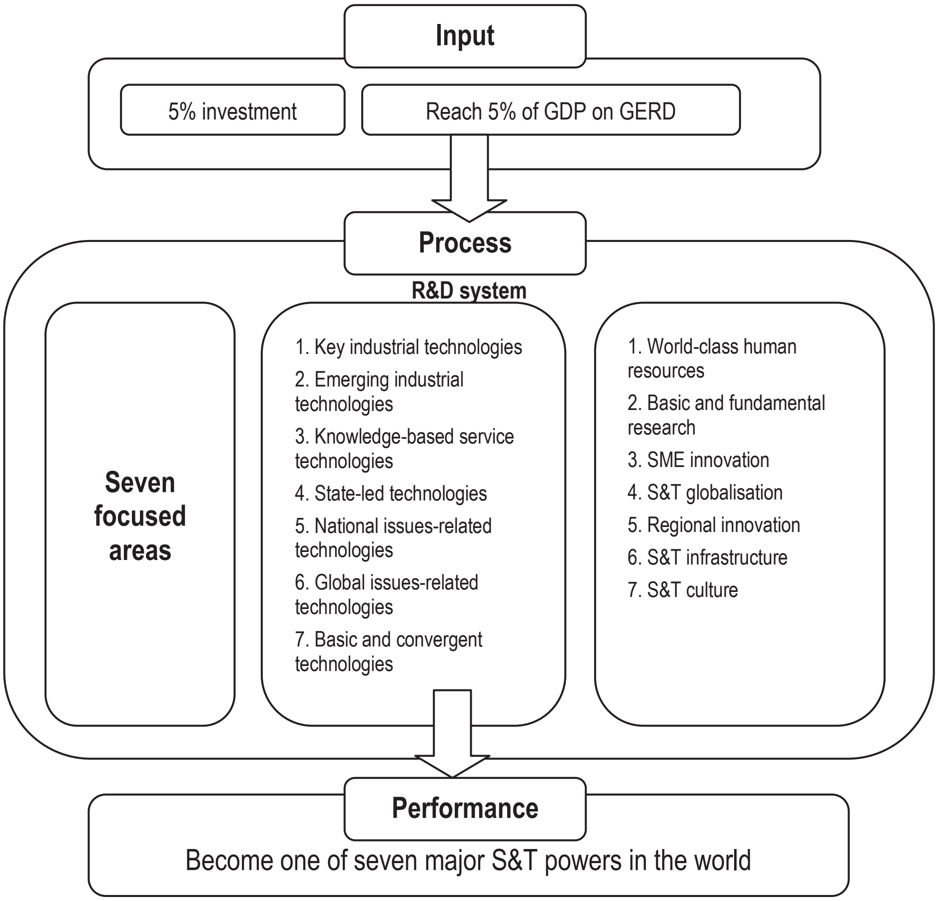
In addition to the basic plans, several plans are targeted at specific elements of the innovation system. These include the Basic Research Promotion Plan (2006-10) as well as plans for biotechnology, nanotechnology, space technologies and nuclear technologies, among others. In addition, in mid-2004, the Implementation Plan for the National Innovation System was launched, with the aim of moving from a catch-up to a creative innovation system. This reflected the government's view that the Korean economy had reached technological frontiers in several areas (particularly in the ICT sector) and that the innovation system needed to be transformed to better incorporate aspects of innovative and creative technological development. Clearly, governments alone cannot implement national innovation systems; the form and functioning of the latter tend to depend upon the actions of and linkages between a constellation of actors, both public and private. But governments can build new capacities and institutions and can provide incentives for others to follow. In Korea, the government identified a number of institutional weaknesses that would militate against the development of a creative innovation system. The catch-up system had centred upon large-scale strategic technology development with government-affiliated research institutes and large global conglomerates, the chaebol, taking the leading role. Such an environment was deemed less than conducive for nurturing innovative start-ups or technology transfer and for building basic research capabilities. Some 30 strategic measures, organised under five domains, were therefore identified to remedy inefficient aspects of the Korean national innovation system and to strengthen the innovation capability of the private sector:

- In the area of innovative actors, the plan targeted improvements to the innovative capabilities of business (including SMEs and innovative start-ups), universities, and government-affiliated research institutes.
- In the area of innovative inputs, the plan emphasised strategic concentration on future technologies and efficient utilisation of innovative inputs in order to improve the commercialisation of R&D results. Moreover, it stressed the development of human resources in certain S&T areas with a view to future industry demand and expected shifts in market trends.
- In the area of technological diffusion, the plan stressed the need to improve technology evaluation and to further develop venture-capital financing, with a view to promoting successful commercialisation of technological developments.
- In the area of system innovations, the plan targeted industry-academia linkages and S&T innovation policy co-ordination, with a view to improving the efficiency of the Korean innovation system.
- In the area of institutional infrastructures, the plan emphasised societal and cultural awareness issues so as to move towards innovation-friendly institutions and cultures in the Korean innovation system.

In addition, the Korean government has drawn up several R&D roadmaps that further operationalise some of these plans and that seek to improve the strategic capabilities and efficiencies of public R&D investments from a longer-term perspective. In an attempt to consolidate these roadmapping efforts and to give general direction to all medium-term public research programmes, a single R&D Total Roadmap was formulated in 2006 and included medium- and long-term R&D strategies (5-15 years) for public R&D investment portfolios. It provides basic principles and guidelines for: strengthening basic scientific research capabilities; building competency in areas of technology fusion; supplementing national R&D infrastructures; identifying national foci of strategic technologies; advancing the development of strategic technology development projects; and improving the co-ordination, coherence and alignment of R&D planning and R&D programmes among diverse governmental ministries and R&D agencies. Each of these areas is further elaborated in later sections of this chapter.

The latest set of initiatives, announced by the new administration of Lee Myung Bak, aim for Korea to become one of the world's S&T powerhouses by 2012. Known as the "577 Initiative", the new plans include several ambitious targets: to reach an R&D intensity of 5% by 2012 (it stood at 3.23% in 2006); to focus upon seven key areas of R&D and seven systems; and to become one of the seven major S&T powers in the world (Figure 3.3). Several elements of this initiative are discussed in later sections of this chapter.

Figure 3.3. Outline of the "577 Initiative"



Source: MEST (2008), "Becoming an S&T Power Nation through the 577 Initiative", Science and Technology Basic Plan of the Lee Myung Bak Administration, Ministry of Education, Science and Technology, Seoul.

3.3.2. Institutionalising horizontal co-ordination

An important challenge for the Korean government has been to improve co-ordination among the many ministries and agencies with a stake in R&D and, more broadly, in innovation. This is clearly evident in the prominence given to this issue in the various plans and roadmaps published by the government. The scale of the task of co-ordination facing Korea has been complicated by its rich organisational landscape of ministries, advisory bodies and executive agencies involved in STI policy and programming. In this regard, it is important to understand the division of labour among the various ministries that support research. Prior to February 2008, MoST focused on funding universities and public research institutes associated with basic and applied research, while MoE focused on supporting R&D activities of universities associated with basic research. At the same time, MoCIE emphasised support for SMEs associated with developmental research at the pre-commercial stage, while MIC supported similar initiatives in the ICT industry. In reality, however, there was some overlap between the targets and types of funding available so that ministries' traditional foci had become somewhat blurred.

This blurring was perhaps exacerbated by the adoption by most of the ministries of an innovation systems perspective – which leads policy makers to look beyond their immediate area – and led to some policy and programme duplication, for example, around the issues of regionalisation and internationalisation (see below). The political priority assigned to innovation by the government also resulted in something of a scramble for new responsibilities among ministries, as symbolised by the dispute concerning which ministry should lead the government's flagship Next-generation Growth Engines R&D Programme (see below). According to several analysts (*e.g.* Hong, 2005), this fierce competition has tended to work against close co-operation and, ultimately, system coherence. It is one of the rationales for the recent merger of these four ministries into two super-ministries, although, as will be argued below, such mergers do not necessarily solve such co-ordination issues.

These problems are hardly unique to Korea, and all OECD countries must find ways to manage efficiently the interfaces between different, but related, policy programmes. Moreover, there are no simple solutions, and countries adopt different co-ordination arrangements. In principle, the existence of similar sorts of programmes administered by different ministries and agencies need not be a problem. Indeed, localised knowledge combined with a degree of autonomy can provide useful flexibility in targeting programmes appropriately. Problems arise when similar programmes try to target the same groups or where scale benefits are unnecessarily compromised as a consequence of bureaucratic competition (thereby leading to allocative inefficiencies). Even when these are not an issue, arrangements to ensure that different policies and programmes have overall coherence are important; otherwise there is considerable risk that they may cancel one another out.

Oversight is therefore required to eliminate unnecessary duplication and enhance the coherence of a distributed set of policies and programmes. With this in mind, some countries have created inter-ministerial committees or co-ordinating councils, which often operate at the top or highest levels of government, to improve the coherence and co-ordination of their innovation policies. For example, Japan has created a Headquarters for Innovation Promotion, chaired by the prime minister, to promote measures outlined in its national strategy, and Finland has had a long-standing S&T Council with a co-ordinating role.

In a similar vein, Korea created the National Science and Technology Council in 1999. However, after five years of operation, the government decided that insufficient progress had been made. Accordingly, in 2004, the government announced a radical shake-up of the STI governance system. Rather than being abolished, the NSTC was strengthened as part of an overall package to better rationalise and co-ordinate the various strands of S&T activities. MoST was tasked with facilitating the activities of the revamped NSTC, though not directly: to avoid accusations of MoST acting as both "player" and "referee", the Office of Science and Technology Innovation was created within MoST to support the NSTC and thereby facilitate inter-ministerial co-ordination on science, technology and innovation. Critically, 40% of OSTI staff were recruited from other ministries,[3] a further 40% from MoST, and the remaining 20% from the S&T

community and the private sector.[4] This so-called "4-4-2 formation" was intended to free OSTI from the existing MoST culture and to lead to an active exchange of policy information and policy learning among S&T ministries. Moreover, as a further concession to the other main funding ministries, MoST relinquished several of its R&D funding initiatives, retaining only programmes in basic research and composite technology, such as space and nuclear technologies.

Box 3.3 describes how these co-ordination arrangements operated. As these were only initiated in 2004 and were only in operation for around three and a half years, it is difficult to judge their merits. However, they seem to have had the following benefits:

- First, a common forum for agenda setting, prioritisation and implementation of various ministries' STI policies and programmes improved policy co-ordination. This reduced programme duplication, created greater synergy across the policy system, and improved policy efficiency. This co-ordination was achieved in part by policy learning between ministries, which resulted in the mutual adjustment of STI programme portfolios as ministries sought to avoid duplicating one another's initiatives.
- Second, science, technology and innovation could speak with a single, powerful voice through the NSTC/OSTI and the deputy prime minister. Having such dedicated advocates is likely to have played an important role in securing significant budget increases for STI from the national budget.
- Third, the availability of expertise in OSTI provided for a more informed overview and a more credible allocation of resources than could be achieved by the Ministry of Planning and Budget alone. Indeed, ministry and research community complaints about the previous arrangements often centred on MPB's apparent lack of expert knowledge to allocate funds rationally, leaving it open to lobbying by different interests.[5] The NSTC/OSTI arrangements reduced this sort of behaviour.
- Finally, the wide-ranging strategic intelligence necessary for the systemic co-ordination of innovation policy was accumulated. Co-ordination requires a broad overview of policies and programmes, an appreciation of their likely effects and limitations, and an understanding of their complementarities and conflicts. Moreover, in an environment of competing demands, sound evidence needs to be brought to bear to settle disputes. Social scientists played an essential role in providing the in-depth research needed to support the NSTC's evidence-based co-ordination. These studies have enhanced knowledge of the Korean innovation system and provided a sounder basis for evidence-based public policy-making.

Box 3.3. R&D co-ordination by NSTC/OSTI

Co-ordination by NSTC/OSTI worked as follows: funding agencies and public-sector research institutes (*e.g.* the GRIs) requested a budget from their host ministries on an annual basis. These requests were considered by the ministries as they prepared their own budget proposals. Previously, ministerial budget proposals went straight to the central funding body for government R&D activities in Korea, the Ministry of Planning and Budget (MPB). However, under the revamped arrangements, budget proposals were first passed to OSTI for review in the name of the NSTC. OSTI examined ministry plans for programme duplication, in which case, ministries were requested to reach a compromise before proceeding. To aid this process, the Minister of Science and Technology – with the status of deputy prime minister – chaired regular S&T ministerial meetings to co-ordinate policies. After OSTI confirmed or adjusted budget proposals, ministries then sent them to the MPB, and the latter finally decided the R&D budget size of each ministry through the examination process of the National Assembly.

At the same time, a number of challenges and limitations remained:

- First, existing programmes and laws were designed to achieve goals set by individual ministries. Although the new governance arrangements emphasised co-ordination of policies and collaborative work among ministries for future innovation policies, policy makers were still likely to work towards achieving the goals of their ministries alone.
- Second, although the new governance arrangements promoted a more collaborative culture and behaviour, ministries still continued to guard the autonomy of their R&D programmes against perceived outside interference.[6] Furthermore, ministries continued to compete, in one way or another, to have early ownership of fashionable policy concepts so as to enlarge their mandate and resources and continued to develop and implement various (sometimes overlapping) policy initiatives (Seong and Song, 2007).
- Third, with budget ceilings for each ministry still ultimately controlled by the MPB, the scope of NSTC/OSTI's co-ordinating role was constrained by the fact that it did not allocate budgets to the various ministries. This meant that OSTI was unable to move resources between ministries to improve strategic co-ordination.
- Fourth, for such arrangements to work, it was essential for the co-ordinating body – in this case, NSTC/OSTI (and by extension, MoST) – to have sufficient authority, credibility and legitimacy in the eyes of the various ministries to perform such a function. This was attempted through a political solution, *i.e.* by making the Minister of Science and Technology a deputy prime minister. It is doubtful whether this had the desired effect, since other ministries perceived NSTC/OSTI to be weak in comparison to the MPB and its predecessors, which had had *de facto* responsibility for co-ordination through their budgetary powers.
- Finally, intra-governmental co-ordinating agencies that lie outside of the main mission-oriented ministries often face problems of labour mobility on account of civil service career structures. OSTI faced the same issue, with concerns that the novel staff rotation arrangements would prove to be unsustainable in the long run. Moreover, from a Korean point of view, the two-to-three year contracts offered by OSTI were considered unstable in terms of job security. This raised concerns that OSTI would be unable to continue to recruit competent experts from the science and technology community.

Such challenges may have been met to some extent with the passage of time. But the new Korean government has preferred to abolish the system – in a drive for smaller government – and to deal with co-ordination failures, at least in part, through ministry mergers. Such mergers are hardly unprecedented, with many other countries co-locating S&T with industry or education. However, evidence from these countries suggests that this is not without new challenges. First, where S&T is co-located with mainstream education policy, it tends to be crowded out. For this reason, recent combinations of education and S&T, for example, in Spain and the United Kingdom, have been careful to merge S&T only with higher education under the responsibility of a single ministry or department. Second, when such mergers are used simply to conceal co-ordination problems without addressing their root causes, they tend to fail, leaving departmental factions fighting for supremacy.

Although it is too early to pass judgment on the ministerial mergers, certain legitimate concerns deserve attention. First, the creation of MEST sees S&T housed in the same ministry as mainstream education, which, as noted above, risks crowding it out. This prospect might not be very serious in Korea, which continues to place S&T at the heart of its development strategy – as evidenced by the ambitious 577 Initiative. However, it is a risk that should continue to be monitored. Second, the organisational structure of MEST gives the ministry two distinct wings – one focused upon education and the other on S&T. It appears – at least on the surface – that little integration of the two has really occurred. On the other hand, with the planned merger of the main funding agencies under MoST and MoE, respectively KOSEF and KRF, there is the potential for better alignment of strategies and initiatives. Furthermore, some degree of continuity with previous institutional arrangements is probably necessary to ensure consistency and stability. The government will nonetheless need to pay close attention to the operation of MEST to minimise the scope for factional infighting and to exploit the complementarities that undoubtedly exist between the two wings of the ministry.

Third, in the case of the Ministry of Knowledge Economy – the other super-ministry created by the new administration – there is concern among those who formerly dealt with the MIC that their interests will not be adequately represented under the new arrangements. Their concern relates to the special attention given to the ICT industry in recent decades and the fear that the new institutional arrangements represent a weakening of government support for a key Korean industry. While this review argues that Korea needs to broaden its S&T base, it also acknowledges that specialist knowledge and capabilities have been accumulated in the ICT sector and that these will continue to require nurturing. Furthermore, ICTs are in some ways exceptional in that they represent a pervasive technological "paradigm" which enables many developments in other technological fields. The Korean government seems to recognise this, as MKE continues to give strong support to the ICT sector, in addition to the support available through MEST's 577 Initiative.

More broadly, the issues of system coherence and of co-ordination among the ministries that remain – and particularly between MEST and MKE – will continue to be important. A related issue concerns the new arrangements for allocation of resources. With the abolition of OSTI, MEST no longer has the influence it once had in this area. The successor ministry to the MPB – the Ministry of Strategy and Finance (MoSF) – is solely responsible for resource allocation. This looks like a backward move and the MoSF risks lacking sufficient expert knowledge to allocate funds rationally, thereby leaving it open to lobbying by different interests. This tendency might be reduced if MEST provided secretarial support to the NSTC and might result in a situation that is essentially little different from the preceding one.

3.3.3. The role and governance of the government research institutes

Co-ordination and coherence are also concerns from a vertical perspective, as ministries seek to align the activities and performance of lower-level actors with their policies. Indeed, co-ordination capacity is cumulative in the sense that higher-level co-ordination functions depend on the existence and reliability of lower-level ones. As the activities of research performers, such as universities and public research organisations (PROs), should contribute to the overall coherence of the innovation system, this has implications for the way they are managed and governed.

Chapter 2 has described the continuing debate on the role(s) of the GRIs in the national innovation system. In interviews carried out by the OECD review team, as well as in the Korean science policy literature, alternative future roles have been proposed, including the following (somewhat overlapping) options:

- *Servicing SMEs*. Korea is often compared to Chinese Taipei, where PROs have played important roles in the development of technologically strong and innovative SMEs. A similar role is often proposed for the 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 the GRIs should be involved in developing commercial technologies or collaborating with SMEs, the GRIs might be better off leading a shift towards more public and welfare-oriented R&D around important national challenges (see Box 3.4). 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 the 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*. The 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 the GRIs' claim to this role. Moreover, if the GRIs are 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 (many projects are mission-oriented and relatively short-term).
- *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 often require dedicated research centres and research infrastructures that are not commonly found in Korean universities. The GRIs could occupy this territory, but would themselves need to break down cultural and epistemic barriers between institutions.

Box 3.4. Grand challenges in the European Union context

While there is a pressing need to improve the effectiveness of the public research system, the ultimate justification of the resources and commitment needed to achieve this lies in increasing the value of the contribution that public- and private-sector research makes, and is seen to make, to Europe's economic, social and environmental goals. The central means to achieve this is to engage the research system in Europe's response to a series of "grand challenges" which depend upon research but which also involve actions to ensure innovation and the development of markets and/or public service environments. The challenges may be rooted in economic, social or scientific goals but share a need to demonstrate their relevance at the European level, their feasibility in terms of Europe's capability to engage with them, and a clear research dimension such that they gain the commitment of the research community and pull-through the necessary improvements in its efficiency and effectiveness.

Source: European Commission (2008), *Challenging Europe's Research: Rationales for the European Research Area (ERA)*, Report of the ERA Expert Group, Directorate-General for Research, EUR 23326 EN, Office for Official Publications of the European Communities, Luxembourg.

Different options for the institutionalisation of the 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 privatisation and mergers with universities. GRIs of course vary widely; they have different types of organisation and face different issues which require different policy responses. The government should be sensitive to this differentiation when formulating policy *vis-à-vis* the GRIs and should consider the future of each institute on a case-by-case basis. Furthermore, the GRIs should be expected to play a number of roles and no institute should be pigeon-holed into performing a single function, even if this gives the appearance of administrative untidiness.

As for the governance of the GRIs, an additional institutional layer was established in the late 1990s between the ministries and their funding agencies and the GRIs in the shape of five research councils. Inspired by similar structures in the United Kingdom and Germany, the rationale for the research councils was to give the 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 the 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 the GRIs by the Ministry of Planning and Budget.

On the positive side, the research council system has secured a more autonomous research environment for the 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 organisational structure of the 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 and they criticise the standardised evaluation criteria used as failing to take sufficient account of the differences between institutes (see below).

- Second, the names of the research councils – referring to fundamental, industrial and public S&T – do not necessarily reflect the orientation of the GRIs assigned to them, as the 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, and therefore little capacity and few capabilities. If the roles of the research councils do not increase markedly, it might be better to amalgamate them to create a single organisation with greater critical mass. In fact, given that standardised evaluation arrangements are used – and evaluation is perhaps the research councils' main role at present – such amalgamation would create relatively little disruption for the GRIs and would achieve scale efficiencies. It could also promote greater interdisciplinary research co-operation.

At the time of writing, some reforms of the research councils have been announced 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 is unclear.

Box 3.5. The main providers of STI strategic intelligence

The **Korea Institute of Science and Technology Evaluation and Planning (KISTEP)** is the main STI planning agency in Korea, and supports MoST (and its successor, MEST) in its policy planning and co-ordination efforts. Its specific functions are: to formulate, co-ordinate and support major S&T policies, including forecasting S&T development trends; to analyse and evaluate S&T-related programmes implemented by all government ministries while providing support for co-ordinating and distributing R&D budgets; to conduct research into domestic and overseas research planning, evaluation and management systems; and to disseminate R&D policy information and data.

The **Institute for Industrial Technology Evaluation and Planning (ITEP)** operated under the supervision of the Ministry of Commerce, Industry and Energy (MoCIE) before the latter's dissolution in 2008. It now operates under the supervision of the Ministry of Knowledge Economy (MKE). ITEP is dedicated to the evaluation and management of national industrial technology R&D programmes, to undertaking technology demand surveys and technology forecasting, technology diffusion and technology transfer promotion, and to the evaluation and promotion of industrial technology, particularly to SMEs.

The **Institute for Information Technology Advancement (IITA)** operated under the supervision of the Ministry of Information and Communications (MIC) before the latter's dissolution in 2008. It now operates under the supervision of the MKE. The purpose of IITA is to provide strategic intelligence on the ICT sector. Its areas of focus include R&D demand research and technology forecasting; technology assessment; project management; funds management; human resources development; technology policy research; information analysis and service; and promotion of technology transfer.

The **Science and Technology Policy Institute (STEPI)** operates under the supervision of the National Research Council for Economics, Humanities & Social Sciences (NRCS), which oversees several research institutes in the fields of economics, humanities and social studies, and reports directly to the Prime Minister's Office. The role of STEPI is to conduct research and analysis on issues relating to science, technology and innovation; to provide government agencies with policy ideas and suggestions for the promotion of innovation; to suggest strategic options for technological development by the public and private sectors; and to create and disseminate S&T policy information and data. It operates through three research centres (Centre for Techno-economic Research; Centre for Innovation Policy; and Centre for Techno-management Research) and three research groups (Futures Studies Group; Human Resources Policy Research Group; and International S&T Policy Research Group).

Source: Various brochures and websites of agencies concerned.

3.3.4. Evaluation of public R&D programmes

The evaluation of public R&D programmes only began during the 1990s, when the various ministries with extensive R&D programmes (essentially, MoST, MoCIE and MIC) established agencies (see Box 3.5) with R&D planning and evaluation capabilities (Lee *et al*., 1996). According to Oh and Cervantes (2007), the Korean system of evaluation is centralised, but also has strong decentralised features. Each ministry and organisation is responsible for evaluating its own initiatives and programmes through an internal or self-evaluation. The results must be shared with interested external parties, such as the president, the National Assembly, the MPB and the general public. In addition to setting evaluation policy, the National Science and Technology Council contributes to the programme evaluation function by establishing standards for evaluation, providing technical advice, ensuring the availability of training for stakeholders, monitoring the quality of the evaluations conducted by ministries and agencies, and leading centrally requested evaluation projects.

In 2006, the Korean government introduced a new evaluation system for R&D. Known as the National Evaluation System (NES) of R&D, it has three components: self-evaluation by each ministry, and meta-evaluation and focused evaluation by the NSTC. The objective is to ensure the accountability of each ministry and to monitor its performance. The generation of information to inform NSTC's co-ordinating role is also important. While the new arrangements are an improvement on the previous ones, Oh and Cervantes (2007) report several continuing problems, including the lack of a long-term perspective on account of the close linkage of evaluation to annual budgeting cycles; insufficient feedback to those evaluated, thereby undermining the learning potential of evaluation; under-developed methodology with heavy reliance upon peer review and expert panel review; and the lack of a cadre of R&D evaluation specialists who could further professionalise the activity. Moreover, the frequency of evaluation and the use of a standard set of indicators have been criticised. The new government has responded to some of these criticisms, for example, by reducing the frequency of evaluation o from each year to every three years.

3.4. Research funding

The Korean National R&D Programme (NRDP) was initiated by MoST in 1982 with the aim of developing technology to enhance industrial competitiveness. The NRDP was closely related to the development of the GRIs, which were intended to focus on research areas that would not be pursued by the private sector alone. A number of other national R&D programmes soon followed, including the Industrial Generic Technology Development Programme of MoCIE in 1987, the Alternative Energy Development Programmes of the Ministry of Power and Resources in 1988, the IT R&D Programme, the Energy Saving Technology Development Project, and the cross-departmental G7 Project (Leading Technology Development Programme, the so-called Han Project) in 1992.

Today, most departments have their own R&D programmes, and government expenditure continues to soar. Indeed, the government has increased its spending on R&D at an even higher rate than the business sector and at more than twice the OECD average (Table 3.4). Moreover, the new administration has set a very ambitious mid-term target of achieving an R&D intensity of 5% by 2012. In the meantime, the programmes and their targets have naturally broadened. Analysts in KISTEP have divided Korean R&D programmes into four broad groups based on economic and social perspectives (Oh and Kim, 2006). These are further classified into 15 sub-groups for practical overall co-ordination procedures (see Table 3.5). At the same time, several ministries have established their own funding agencies for financing and managing their R&D projects. The main agencies are briefly summarised in Box 3.6.

**Table 3.4. Change in government R&D budgets:
Average annual growth rate of GBAORD, 2000-06 or closest available years**

In constant PPP USD

Country	GBAORD
Korea	**9.5**
Sweden	6.2
United States	5.7
OECD	**3.9**
United Kingdom	3.8
Finland	3.5
Japan	2.7
EU27	1.8
Germany	0.3
France	-1.1

GBAORD = gross budget appropriations or outlays on R&D.

Source: OECD, Main Science and Technology Indicators, October 2008.

Table 3.5. Classification of R&D programmes in Korea

Major classifications	15 sub-groups
R&D programmes for basic, public and welfare technology	Generic and basic technology
	Public technology
	Welfare technology
R&D programmes for industrial technology	Short-term industrial technology
	Mid- and long-term industrial technology
R&D infrastructure	International co-operation
	Development of human resources
	Regional R&D centres of excellence
	R&D facilities and equipments
Support for public research institutes	National laboratories (three sub-groups)
	Government-supported research institutes for basic technology
	Government-supported research institutes for industrial technology
	Government-supported research institutes for public technology

Source: Oh and Kim (2006), "Overall Coordination of Government-Funded Research and Development Programs in Korea", *Journal of Multi-Disciplinary Evaluation*, Vol. 3, No. 5.

Box 3.6. Main Korean research funding agencies

Korea Science and Engineering Foundation (KOSEF). Established in 1977 by MoST, KOSEF has been an important bridging institute between the government, public R&D institutes, universities and some private firms. The main functions of KOSEF are to support research activities in the areas of science and technology, to foster research personnel, to enhance and develop science and technology education, to contribute to domestic and international scientific activities, and to increase international exchanges of science and technology. KOSEF is located in Daedeok Science Town with its clusters of many public R&D institutes and universities.

Korea Industrial Technology Foundation (KOTEF). KOTEF was established by MoCIE in 2001 and is similar to KOSEF, but focuses on the promotion of industrial technology. Its main functions include nurturing industry-academia co-operation in research and innovation (*e.g.* through the funding of industry-academia co-operation centres in universities, improving corporate technology management, especially in SMEs, through education); promoting a technology-oriented culture (*e.g.* through award schemes and festivals); fostering development of human resources (*e.g.* through revamping engineering education, supporting SMEs' employment of master's and PhD graduates, fostering development of human resources for regional innovation); promoting international co-operation (*e.g.* through the activities of the Korea Global Innovation Network [K-GIN] Programme, various bilateral co-operation agreements, international human resource exchange programmes); and supporting Korean technology policy (*e.g.* through research and statistical analysis, trend and competitor analysis, technology roadmapping).

Korea Research Foundation (KRF). Founded in 1981, the KRF focuses on promoting and supporting academic activities and on upgrading research quality through its support of academic research foundations and new researchers. Overseen by MoE until recently, the KRF implements programmes to support research activities, executes and manages academic research funds, provides subsidies for operating academic research organisations, supports domestic/international academic exchanges, supplies facilities and accommodation for academic activities, provides scholarships or loans for education, conducts surveys and analyses/evaluation, and collects statistics on support and management of research conducted in universities.

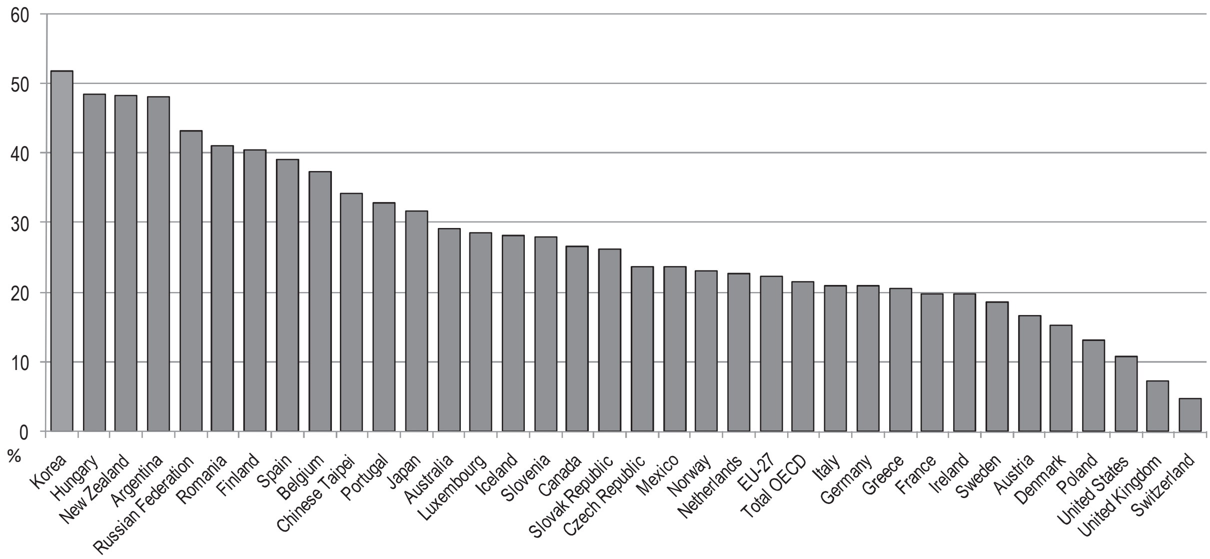
Source: Various brochures and websites of agencies concerned.

While the KISTEP classification of R&D programmes is useful, it will not be used to structure the analysis that follows. Instead, this section begins with a discussion of the government's continuing drive to increase the proportion of fundamental research carried out and describes some of the main programmes. It is followed by an account of industrial technology development programmes which still account for the majority of government spending on R&D. A continuing concern in the Korean economy is the need to diversify beyond a few key sectors. With this in mind, programmes for diversifying the research base – for example, in biotechnology and "services science" – are considered. A discussion of research infrastructure funding in the universities and GRIs then precedes consideration of new proposals to establish an International Science and Business Belt (ISBB).

3.4.1. Moving towards more fundamental research

As Korea moves towards knowledge frontiers, the public sector should perform a more prominent "system-anchoring" role by increasing spending on fundamental research that firms are unlikely to fund themselves. This is something the government recognises, and the Total R&D Roadmap aims to strengthen basic scientific research capabilities to provide the foundations of new high-technology and science-based industries. This emphasis has been maintained in the new 577 Initiative. However, until recently, the public R&D funding system has been more inclined to provide funds for technological development in business and the GRIs than to fund fundamental scientific research, for example, in universities. The proportion of R&D spending on basic research has therefore been low compared to leading OECD countries.[7] As Figure 3.4 shows, Korea has the largest proportion of economic development programmes within its civil gross budget appropriations or outlays on R&D (GBAORD) in the OECD area, a pattern of funding that reflects the legacy of the catch-up nature of Korean economic development. Shifting away from this is proving challenging; data highlighted in Chapter 2 showed a continuing fall in basic research performed in the GRIs and universities and their turn to more experimental development work.

Figure 3.4. Economic development programmes as a percentage of civil GBAORD (2006)



Notes: 2005 instead of 2006 for Hungary. 2001 for the Russian Federation.

Source: OECD, Main Science and Technology Indicators, October 2008.

An important question remains over whether Korea has sufficient capabilities to shift the research system to more fundamental research and whether the right incentives are in place. Researchers with doctorates are concentrated in the universities, yet most fundamental research is currently being conducted elsewhere. In fact, Korean university researchers complain that the funding system is biased against them, as it favours larger (often mission-oriented) projects that require the construction of large collaborative teams. University professors feel that this places them at a disadvantage vis-à-vis the GRIs. There have therefore been calls for more individual researcher grants, which are better suited to the single researcher or small research group. MEST has heeded these calls and has earmarked some KRW 500 billion for promoting grassroots efforts in basic research in 2009, an increase of 37% from 2008. At the same time, 7 000 individual or small-group researchers will be granted research fees during 2009, and an expanded KRW 255 billion will be invested in the general researcher support project. The latter will place particular emphasis on facilitating basic R&D activities by young university faculty, general professors, female professors and faculty at local universities. On a longer-term basis, the 577 Initiative commits the government to expanding its investment in basic research to 50% of the public R&D budget by 2012, up from around 25% in 2007, a very ambitious target by any standard. To reach this goal several sub-targets have been set, including:

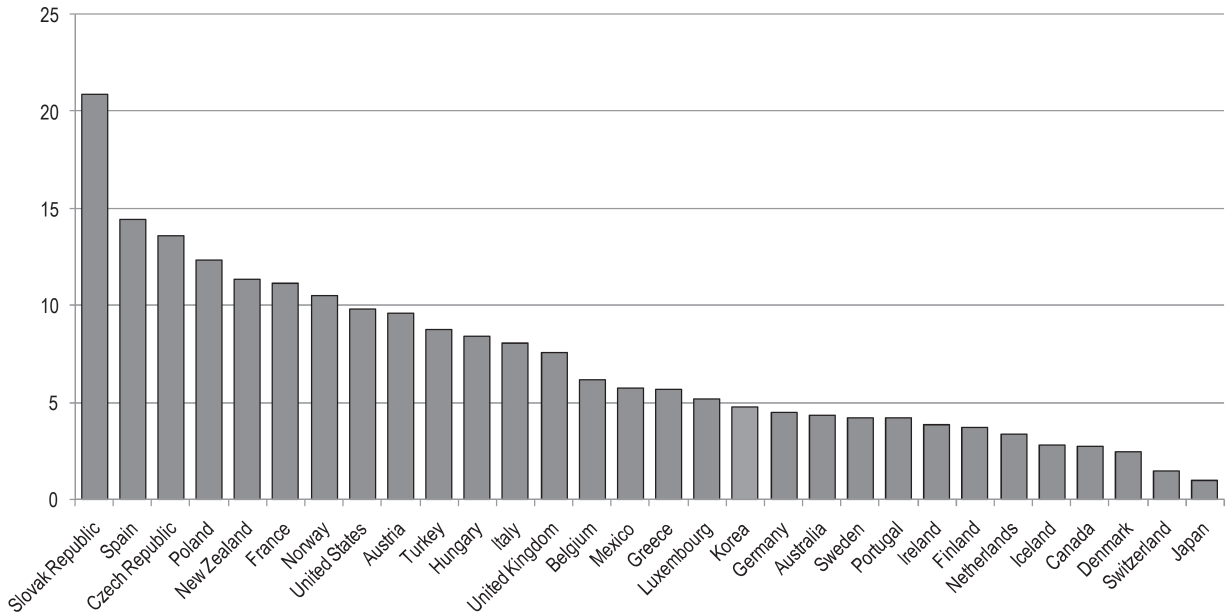
- Expanding research grants for individual investigators (including small groups) from KRW 368 billion in 2008 to KRW 1.5 trillion in 2012.
- Increasing the ratio of university professors in S&T fields receiving basic research grants from around 25% in 2006 to 60% in 2012.
- Increasing the ratio of young researchers in their 20s-30s receiving basic research grants from around 18% in 2006 to 25% in 2012.
- Expanding support for basic research in GRIs.
- Expanding research support for high-risk high-return projects.

These investments are to be welcomed, though it will be important for the Korean government not to equate basic research with curiosity-driven basic research alone. While the latter has an important role to play – and has been largely neglected in Korea so is in need of strengthening – it is also wise to remember that in OECD countries most fundamental research is carried out in the context of strategic missions. In many instances, *ex ante* assessments of mission contributions should therefore be possible, even if there are difficulties in measuring such contributions *ex post*. This points to the need for appropriate expectations regarding the contributions of fundamental research. In this regard, the development of embodied skills and understanding from fundamental research tends to have a more significant and lasting impact than the generation of codified results. Acknowledging this has consequences for the way fundamental research is evaluated and ultimately governed, since many of the returns to investment are unlikely to be immediate and can thus create attribution problems. Understanding these benefits of fundamental research also highlights the need to put in place policies and programmes that will facilitate the flow of skills and knowledge throughout the innovation system, and to avoid a situation in which universities are "ivory towers" disconnected from the rest of the system.

3.4.2. R&D programmes targeted at industrial technology

Figure 3.4 shows the dominance of economic development programmes in the Korean government's spending on R&D. Much of the funding comes from MKE and, to a lesser extent, MEST, and is largely channelled through public-private collaborative research projects (see below). Because of this approach, the Korean government's funding of business enterprise expenditures on R&D (BERD) falls in the mid-range of OECD countries and is roughly on a par with that of Germany (Figure 3.5). Governments in the United States, France and the United Kingdom fund proportionally more BERD than the Korean government, but this is on account of their high defence R&D spending. In fact, with the exception of these three countries, most OECD countries whose governments contribute a higher proportion of BERD than Korea would seem to be trying to address a market failure, with their business communities spending relatively less on R&D than the OECD average. Clearly, this is not the case in Korea, at least not at the aggregate level, as private-sector R&D spending accounts for one of the highest proportions of gross domestic expenditure on R&D (GERD) in the OECD area. At the same time, the majority of countries in which government funding accounts for a smaller share of BERD have a high BERD/GERD ratio, which suggests they may see less need to subsidise business R&D. This would certainly seem to be the case in Japan and many of the Scandinavian countries. The question, therefore, is whether the Korean government needs to continue funding BERD at the current rate. Given that much government funding of BERD is now directed at SMEs, the answer may well be yes, especially given the traditional weaknesses associated with small firms in the Korean industrial landscape. Indeed, data for 2005 show that the average R&D subsidy for SMEs amounts to 44% of their total R&D expenditure, an indication of their heavy dependence on government funding.

Figure 3.5. Government-financed R&D in business, as a percentage of BERD (2006)



Notes: 2005 instead of 2006 for Denmark, Greece, Iceland, Luxembourg, Mexico, New Zealand, Portugal and Sweden. 2004 for Switzerland. 2003 for the Netherlands.

Source: OECD, Main Science and Technology Indicators, October 2008.

Public R&D programmes in support of industrial technological development have tended to evolve in line with industrial demand or the strategic R&D direction of government. Thus, public R&D programmes traditionally targeted mostly large-scale industrial technology, with the intention of supporting near-immediate industrial development by the chaebol. Since the 1990s, however, many public R&D programmes have taken a longer-term view which takes account of future strategic technology needs and developments. This has led to a focus on core source technology development. More recently, with Korea reaching technological frontiers, industrial technology programmes have incorporated more basic scientific research. Greater attention is also being given to support for R&D commercialisation and for technological developments in SMEs.

As mentioned, MKE has the largest support measures for industrial technology development – including sectoral technology programmes to support "flagship industries" (Table 3.6). Its predecessor, MoCIE, established the Industrial Generic Technology Development Programme in the 1980s to enhance Korea's industrial competitiveness. Today, about 60% of the projects funded under the programme involve research collaboration between industry, higher education institutions (HEIs) and GRIs. The programme's main focus is the improvement of the technical strength of SMEs and the enhancement of the on-site technology development of HEIs and GRIs. Similarly, MIC rolled out its expansive IT R&D Programme – with a budget exceeding USD 1 billion by

2004 – to bolster technological development in the ICT sector. This, too, is now under the supervision of MKE.

Table 3.6. MKE's strategies for upgrading flagship industries

Sector	Goal	Strategy
Automobiles	Develop and commercialise cutting-edge vehicles with embedded IT functions.	Develop innovative auto technologies such as telematics and integrated control systems to increase safety and comfort. Secure source technologies for hybrid and fuel-cell vehicles. Provide incentives for eco-friendly vehicles.
Shipbuilding	Develop additional core technologies to increase value-added process.	Obtain source technologies and developing technologies for key parts of offshore plants and icebreaking ships. Build a new ship model equipped with advanced IT technologies.
Semiconductors	Maintain status as the world's largest memory chip producer.	(In the memory sector) Develop new memory chip technologies; secure advanced technologies in equipment and material industries.
	Enhance competitiveness of non-memory chip sector.	(In the non-memory sector) Support R&D in promising areas and build infrastructure for long-term technology development.
Steel	Maintain status as leading global steel producer.	Expand investment in overseas iron ore development projects. Increase supply of insufficient steel materials.
General machines	Secure advanced technologies to stimulate production and exports.	Develop core technologies for localisation of general machines. Conduct joint development by plant producers and equipment companies of key equipment for future power plants.
Textiles	Develop core textile technologies.	Promote convergence of textile and IT. Produce new types of textiles such as green textiles.
Parts and materials	Obtain source technologies.	Develop technologies for imported parts and materials. Construct business-friendly infrastructure.

Source: MKE website (*www.mke.go.kr/language/eng*), accessed November 2008.

In a more targeted manner, MKE is also responsible for the Next-generation Growth Engines R&D Programme, a scheme started in 2003 which targets ten strategic "growth engine" industrial sectors (see Table 3.7). These were selected after much debate between MoCIE, MoST and MIC, the three ministries previously responsible for administering different sectors in the programme. The programme is further supported by MEST's HR Development Plan for Next-generation Growth Engines Sectors to ensure a supply of appropriately skilled human resources and by the Ministry of Finance and Economy's Commercialisation Support Programme. Under the ten selected strategic sectors, 36 product groups have been identified for support. While it is too early to judge the impact of the programme, it generated 5 353 patent applications and 932 patent registrations during 2004-06.

Table 3.7. Next-generation Growth Engines R&D Programme

Technology area	2004	2006	Number of technologies
Intelligent robot	Car-manufacturing robot Cleaning & secure robot IT-based intelligent robot Network-based humanoid	Manufacturing robot Individual serve robot Professional service robot Network robot	Increasing or Integrating series of products (4→4)
Future vehicle	Hybrid car Fuel cell vehicle Intelligent vehicle	Hybrid car Fuel cell vehicle Intelligent vehicle	No change (3→3)
Next-generation cell	Second battery Fuel cell	Second battery Capacity	Adjusting series of products (2→2)
Display	LCD, PDP, OLED	LCD, PDP, OLED	No change
Next-generation semiconductor	SoC Semiconductor equipment Nano semiconductor SiC semiconductor IT SoC IP IT SoC, designing SoC CAD	SoC Nano process Memory, IT SoC IP	Decreasing or Integrating series of products (6→4)
Digital TV/broadcast	DTV receiver DMB terminal	DTV receiver DMB terminal	No change (2→2)
Next–generation mobile telecommunications	Wibro/4 generation mobile telecommunication Next-generation- fusion mobile assistant Ubiquitous sensor network Tele-matrix high-tech system Tele-matrix system loaded on vehicle	Wibro/4 generation mobile telecommunication Next-generation- fusion mobile assistant Ubiquitous sensor network Tele-matrix system	Decreasing or Integrating series of products (5→4)
Intelligent home network	Home platform Middleware Intelligent electronic appliance Home networking	Home platform Ubiquitous home networking Intelligent electronic appliance Wire/wireless home networking	Changing product's name or adjusting groups (4→4)
Digital content/SW solution	Creating content Securing & distributing content Producing content Middleware Basic SW Application SW	Next-generation online game Digital images, Intelligent SW Free software-based system SW Information securing SW	Changing product's name or adjusting groups (6→5)
Bio Pham./equipment	Hetero-organ producing pig clone Bio-chip for analysis/ diagnosis Drug delivery system Cellular therapy New bio-medicine	Hetero-organ producing pig clone Bio-chip for analysis/ diagnosis Drug delivery system Cellular therapy New bio-medicine	No change (5→5)
Total	40 series of products	36 series of products	-

Source: MoST (2007), *Annual Report on Science and Technology 2006*, Ministry of Science and Technology, Seoul.

MEST is also a major player in industrial technology development, though it has sought to take a longer horizon than the programmes supported by MKE. For instance, the Total Roadmap included a foresight project that identified 90 strategic technologies with the potential for considerable impact upon Korea's economic growth. The selection criteria included assessments of: *i)* future demand; *ii)* the innovative nature of the technology; *iii)* the strength of the rationale for governmental intervention; *iv)* existing R&D capabilities; *v)* industrial capabilities to exploit the technology and the likely returns to R&D investment; and *vi)* the possibility of technological realisation in the selected time horizon. In all, 33 technologies were subsequently selected as national strategic technologies that are intended to shape new national R&D programmes (see Table 3.8).

Table 3.8. Total Roadmap: 33 priority technologies

Category	Technology	No.
Information technology and electronics	Next-generation network technology, mobile Internet and 4G mobile communications technology, USN technology, information protection technology, next-generation system S/W technology	5
Bio science and biotechnology	Stem cell application technology, preclinical/clinical technology for new drug development, new drug target and new drug candidate development technology, drug delivery technology, high added-value processing and production technology of agricultural, marine, and livestock products, Technology for early diagnosis of cancer, safety and risk assessment technology	7
Machinery and manufacturing process	Intelligent service robot technology, environmentally friendly automobile technology, ultra-precision processing and device technology, Intelligent production system technology (machinery, processing, textiles, etc.)	4
Energy and resources	Hydrogen energy production and storage technology, next-generation cell (secondary cell, fuel cell) technology, new and renewable technologies, highly efficient energy use technology	4
Space, aviation, and marine	Satellite (body, payload) development technology, marine technology, marine environment investigation and conservation and management technology	3
Environment	Environmentally friendly production and processing technology, air pollution reduction and treatment technology, resource recycling and safe waste treatment technology, environment preservation and restoration technology, technology to mitigate and respond to natural disasters	5
Materials and nano	Photon and electron fusion materials, nano-level material processing technology	2
Construction, transport and safety	Technology to create high-speed trains with a max speed of 400km/h, state-of-the-art light rail transit and urban-type magnetic levitation train technology, high-tech logistics technology	3

Source: MoST (2007), *Innovation for the Future: Science and Technology in Korea*, Ministry of Science and Technology, Seoul.

More recently, the 577 Initiative has identified 50 "critical" technologies and 40 "candidate" technologies in seven major technology areas (Table 3.9). These are strategic technology areas, differentiated only in terms of their level of priority. They were proposed by various experts, including researchers, R&D planners and industry, working in committees over a period of several months. The strategic technology areas identified by these expert committees were further screened by the relevant ministries before being approved by the NSTC.

Table 3.9. List of "critical" and "candidate" technologies in seven major technology areas

Technology areas	Critical technologies (50)	Candidate technologies (40)
Key industrial technologies	1. Environmentally friendly automotive technology 2. Next-generation shipbuilding and offshore-platform technology 3. Intelligent production system technology 4. High-precision micro-machining and instrumentation control technology 5. Next-generation network technology 6. Mobile Internet and 4G mobile communication technology 7. Non-memory semiconductor technology 8. Next-generation semiconductor equipment and process technology 9. Next-generation display technology	1. Intelligent automotive technology 2. Next-generation production process and equipment technology 3. Next-generation memory semiconductor technology
Emerging critical technologies	10. Cancer diagnosis and treatment technology 11. Drug discovery and development technology 12. Clinical testing technology 13. Medical apparatus development Technology 14. Stem-cell Technology 15. Proteomics and Metabolics Applied Technology 16. Technology of Identification of Drug Target and Drug Candidate 17. Brain Science Research and Brain Disease Diagnosis and Treatment Technology 18. Next-generation System Software Technology 19. Next-generation high performance computing Technology 20. Next-generation Human-Computer Interaction Technology	4. Biomaterials and process technology 5. Conservation of marine resources and utilisation technology of marine biotechnology 6. Regulation technology of cellular function 7. Genomics applied technology 8. Application and analysis technology of biomedical information 9. Gene therapy technology 10. Oriental medicine and treatment technology 11. Next-generation computing solution technology 12. Information security technology
Knowledge-based service technologies	21. Converging contents and knowledge service technology 22. Advanced logistics technology	13. Converging technology of communication and broadcasting
State-led technologies	23. Satellite development technology 24. Next-generation airplane development technology 25. Nuclear fusion technology 26. Next-generation nuclear reactor technology 27. Next-generation weapon development technology	14. High-rise building technology 15. Next-generation railroad system technology 16. Construction-based technology 17. Super-long bridge construction technology 18. Advanced transportation system technology 19. Advanced residence and education environment technology 20. Intelligent national geographic information system development technology 21. Satellite propulsion technology 22. Utilisation technology of satellite information 23. Planet exploration and space monitoring system development technology 24. Global navigation satellite system technology 25. Efficiency and safety enhancement technology of sea-air aviation 26. Utilisation technology of radiation and radioactive isotope 27. Nuclear fuel cycle technology 28. Nuclear power use and safety enhancement technology

Table 3.9. List of “critical” and “candidate” technologies in seven major technology areas *(continued)*

Technology areas	Critical technologies (50)	Candidate technologies (40)
National issues-related technologies	28. Immune disease and infectious disease response technology 29. Human safety and risk evaluation technology 30. Food safety evaluation technology 31. Agricultural resources development and management technology 32. IT nano-device technology 33. High-efficiency energy management technology	29. Food resource utilisation and management technology 30. Insect pest and disease prevention and control technology 31. Applied technology of environment-friendly nano-materials 32. Nano-bio materials
Global issues-related technologies	34. Hydrogen production and storage technology 35. Next-generation fuel cells & energy storage and conversion technology 36. New and renewable energy technology 37. Energy and resource exploration & development technology 38. Marine territory management technology 39. Marine environments maintenance technology 40. Atmospheric environmental improvement technology 41. Environment conservation and restoration technology 42. Water quality management and water resources protection technology 43. Climate change prediction and adaptation technology 44. Natural disaster prevention and management technology	33. Next-generation superconductivity and power IT technology 34. Highly efficient technology for resource utilisation 35. Environmentally friendly process technology 36. Resource recycling and waste safe treatment technology 37. Integrated management and utilisation technology of environmental information 38. Life safety and anti-terror technology 39. Fire safety and future fire extinguishing equipment development technology
Basic and convergent technologies	45. Drug delivery technology 46. Biochip and biosensor technology 47. Intelligent robot technology 48. Nano-based functional materials technology 49. Nano-based convergent and composite materials technology 50. Advanced city planning and construction Technology	40. Nano measuring and evaluation technology

Source: MEST (2008), “Becoming an S&T Power Nation through the 577 Initiative”, Science and Technology Basic Plan of the Lee Myung Bak Administration, Ministry of Education, Science and Technology, Seoul.

MEST is also responsible for funding several national R&D programmes that seek to improve national competitiveness. For example, the 21st Century Frontier R&D Programme is a medium-to-long-term funding programme to develop a selection of future technologies which would allow Korea to exploit its technological capabilities to achieve global competitiveness. The programme aims to develop these technologies within ten years with a view to their rapid contribution to economic growth. The likely economic impact and marketability of the future technologies constitute major selection criteria for this programme. As of 2006, the programme had an annual budget of KRW 147 billion devoted to 22 projects, each of which is supported for up to ten years (Table 3.10). Like its predecessor, the G7 Project, the programme is cross-departmental, with MoST supervising 16 projects, MoCIE five and MIC one.

Table 3.10. 21st century frontier R&D programmes by year

Year	Project agency
1999 (2)	The Centre for Functional Analysis of Human Genome
	Intelligent Microsystems Centre
2000 (3)	Tera Level Nano Devices
	Plant Diversity Research Centre
	Resource Recycling R&D Centre
2001 (5)	The Centre for Biological Modulators
	Crop Functional Genomics Centre
	Centre for Advanced Materials Processing
	Centre for Applied Superconductivity Technology
	Sustainable Water Resources Research Centre
2002 (8)	Microbial Genomics & Applications Centre
	Stem Cell Research Centre
	Functional Proteomics Centre
	Centre for Nanoscale Mechatronics & Manufacturing
	Centre for Nanostructured Materials Technology
	Carbon Dioxide Reduction & Sequestration R&D Centre
	Smart UAV Development Centre
	Information Display R&D Centre
2003 (4)	Centre for Intelligent Robotics
	Ubiquitous Computing & Network
	Brain Research Centre
	Hydrogen Energy R&D Centre

Source: MoST (2007), *Science and Technology Yearbook 2006*, Ministry of Science and Technology, Seoul.

Another national competitiveness initiative supported by MEST is the National Research Laboratory programme, which aims to identify and further develop laboratories in areas of core technology. Almost USD 40 million was made available for the programme in 2006, with selected laboratories benefiting from annual grants of USD 200 000 to USD 300 000 each for up to five years. On a much larger scale are the Space R&D and Nuclear R&D programmes. The former had a budget of around USD 250 million in 2006 for seven projects. The aim of the Space R&D programme is to establish self-reliance in space technology, including launch capabilities and the development of satellites. The Nuclear R&D programmes were started in 1992 in order to create new high-value industries, advance core nuclear technology and expand the applications of nuclear technology to areas such as medicine and industry. These programmes had a budget of USD 186 million in 2006. The government is also making significant investments in developing future nuclear fusion technologies, with a budget of KRW 129 billion for this area in 2009.

3.4.3. Promoting diversification

The dominance of the Korean economy by the ICT sector and a few large firms raises concerns about excessive concentration, as this contributes to the dualism of the Korean economy and may fail to provide a broad enough base for convergence to the income levels in the most advanced OECD countries. Furthermore, Korea has recently suffered significant terms-of-trade losses partly because of a downward trend in prices in high-technology products, such as semiconductors and mobile telecommunications. Other countries in which ICT is important – Sweden, Finland, Ireland and Japan – also show large terms-of-trade losses. This demonstrates the importance of implementing structural reforms, including a more diversified approach to R&D, in order to promote productivity growth in other sectors (OECD, 2007a).

Table 3.11. Association of R&D expenditures to "6T", 2006

Percentages

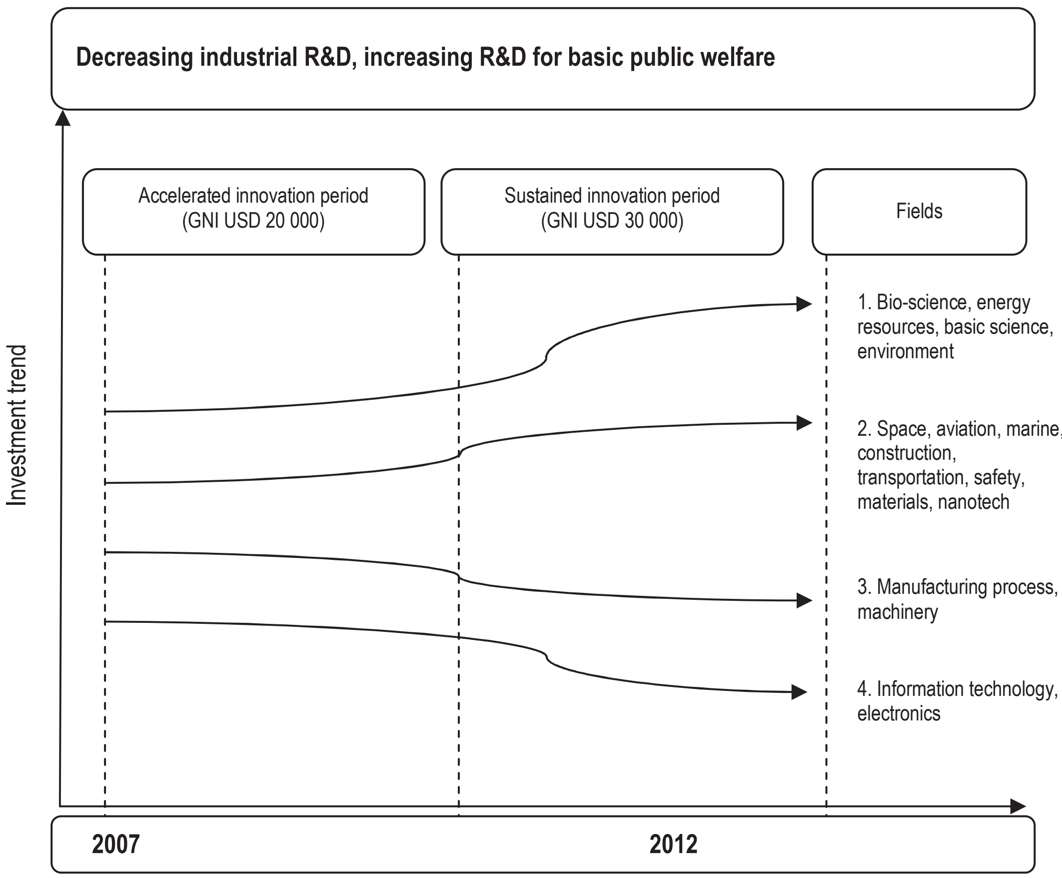
	Public research institutes	Universities	Companies	Total
IT (information technology)	19.4	25.7	39.5	35.6
BT (biotechnology)	12.7	24.2	3.3	6.6
NT (nanotechnology)	4.8	9.7	15.3	13.4
ST (space technology)	9.2	2.0	0.6	1.8
ET (environment technology)	13.1	8.6	5.0	6.4
CT (culture technology)	0.0	2.7	1.2	1.2
Other	40.8	27.2	35.1	35.0
Total	100.0	100.0	100.0	100.0

Source: MoST and KISTEP (2007), *Report on the Survey of Research and Development in Science and Technology*, Ministry of Science and Technology and Korea Institute of Science and Technology Evaluation and Planning, Seoul.

The Korean government is well aware of these dangers and has been active in trying to establish a broader spectrum of future growth engines through R&D spending. However, a central issue for policy makers when prioritising R&D spending is whether to build on existing strengths and capabilities or to spread resources across a diversity of emerging opportunities. Rarely are such options considered rationally, however, because of the powerful influence of existing interests. This may be the case in Korea, as evidenced by the continuing dominance of ICTs in public R&D expenditures (see Table 3.11). With government accounting for less than 25% of R&D spending in Korea, large firms, particularly in the ICT and automobile sectors, have a powerful pull on public research agendas. On the other hand, IT is hardly a narrow field and there seems to be a continuing flow of new developments and applications. This leads advocates of IT research to argue that levels of public R&D investment should be maintained to support a key industry in which Korea excels.

This is not a view shared by MEST, whose predecessor, MoST, explicitly argued for the need to diversify public support for R&D away from IT (see Figure 3.6). According to MoST (2007b), if government R&D investments are made in accordance with the technologies contained in the Total Roadmap, R&D investments for technologies such as biotechnology, energy technology, environmental technology and basic sciences should increase, whereas investments for technologies such as machinery, manufacturing process, and information and electronics technologies should decrease. However, there appears to be a significant amount of lock-in across the research system which favours continuing strong government support for R&D in areas such as IT and manufacturing machinery. For example, Table 3.12 shows the dominance of engineering professions in the research workforce, both in the public and private sectors. Clearly, it is important to consider such existing knowledge capabilities and assets when seeking to diversify R&D expenditures. Furthermore, the distribution of Korean scientific publications in SCI journals shows a strong focus on the physical sciences and engineering, with far fewer publications in the life sciences (see Table 3.13). Figure 3.7 suggests this may be changing, but only slowly.

Figure 3.6. Future prospect of mid- and long-term government R&D investment by S&T area



Source: MoST (2007), *Innovation for the Future: Science and Technology in Korea*, Ministry of Science and Technology, Seoul.

Table 3.12. Researchers by major field of study and sector of performance

Head count and percentages

	Public research institutes		Universities		Companies		Total	
	Researchers	Ratio	Researchers	Ratio	Researchers	Ratio	Researchers	Ratio
Natural science	3 088	8.8	12 840	36.4	19.311	54.8	35 239	100.0
Engineering	9 719	5.3	30 187	16.3	144 991	78.4	184 897	100.0
Medical science	928	5.3	14 960	86.0	1 503	8.6	17 391	100.0
Agriculture, etc.	2 396	33.6	3 444	48.3	1 292	18.1	7 132	100.0
Others	640	5.4	4 492	37.6	6 807	57.0	11 939	100.0
Total	16 771	6.5	65 923	25.7	173 904	67.8	256 598	100.0

Source: MoST and KISTEP (2007), *Report on the Survey of Research and Development in Science and Technology*, Ministry of Science and Technology and Korea Institute of Science and Technology Evaluation and Planning, Seoul.

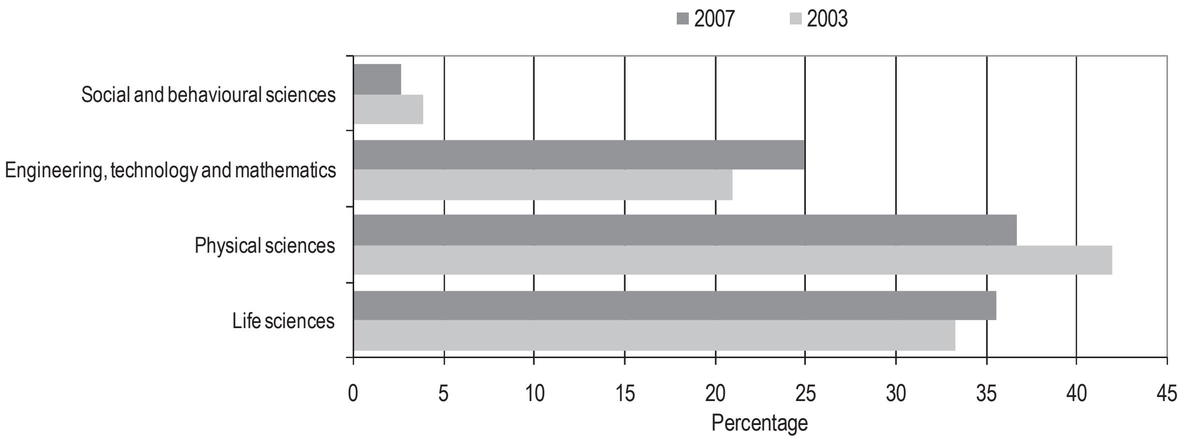
Table 3.13. Distribution of scientific articles by field, 2003

Percentages

Country	Life sciences	Physical sciences	Engineering, technology and mathematics	Social and behavioural sciences
Finland	59.6	22.2	9.9	8.4
Sweden	59.4	22.9	9.3	8.5
United States	54.1	22.2	10.7	12.9
United Kingdom	52.5	23.5	10.2	13.9
EU15	52.1	30.1	9.6	8.2
OECD	**51.8**	**28.2**	**10.7**	**9.3**
Germany	50.3	34.6	9.7	5.5
Japan	46.8	38.6	12.5	2.0
France	46.6	36.6	9.6	7.3
Korea	**33.3**	**42.0**	**21.0**	**3.9**

Source: OECD (2007b), *Science, Technology and Industry Scoreboard 2007*, OECD, Paris.

Figure 3.7. Distribution of scientific articles by field, 2003 and 2007



Source: MEST (2008), "Becoming an S&T Power Nation through the 577 Initiative", Science and Technology Basic Plan of the Lee Myung Bak Administration, Ministry of Education, Science and Technology, Seoul, and OECD (2007), *Science, Technology and Industry Scoreboard*, OECD, Paris.

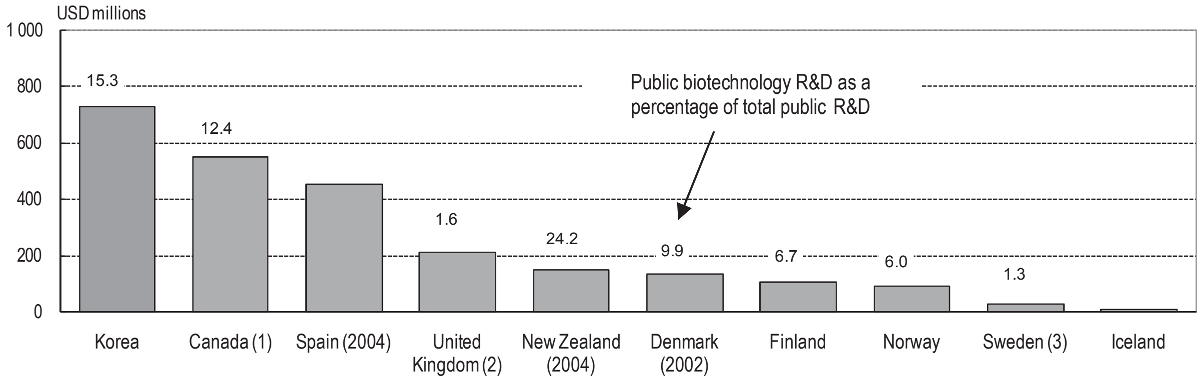
In addition to structural lock-ins, a lack of alignment between MEST's stated aim of diversification and continuing strong support for ICT R&D might also be explained in part by the fact that much public support for R&D still flows through the mission-oriented ministries, including MKE. For example, the ten strategic industries identified as part of the Future Growth Engine R&D Programme (administered by MKE) show a considerable bias towards ICT (see above). This demonstrates the limits of the steering capabilities of MEST when other ministries have strong agendas as well.

Despite these challenges, nanotechnology, environmental technology and biotechnology have each received considerable public R&D support as part of the government's effort to diversify the economy into new high-technology growth areas. For example, although still far behind spending on information technology, government funding of biotechnology has increased markedly over recent years and compares very favourably to international levels (see Figure 3.8). To some extent, the same can be said of nanotechnology and environmental technology.[8] In an interesting twist to the debate on whether public support for R&D in emerging areas should increasingly displace support for the ICT sector, the Total Roadmap proposes building research and innovation competencies in areas of technology fusion. These would centre upon ICT, given Korea's capabilities in the field, but would see the incorporation of areas such as biotechnology and nanotechnology. This has been further picked up in the 577 Initiative, where one of the seven major technology areas to be supported concentrates upon convergent technologies.

The Biotechnology Promotion Act of 1983 provides the legal framework governing support policies in the biotechnology field. The latest development plan for the field, Bio-Vision 2016, is briefly set out in Box 3.7. MEST also supports a specific national R&D programme dedicated to biotechnology development, with funding of USD 48 million in 2006.

Figure 3.8. Biotechnology R&D expenditures by the public sector (government and higher education)

Millions of USD current PPP, 2003



1. Biotechnology R&D financed by the federal government only (excludes provincial funding) and excluding business funding of public sector research.

2. Central government budget provision for R&D expenditure data.

3. Higher education only.

Source: OECD Biotechnology Statistics 2006.

Box 3.7. Bio-Vision 2016

Bio-Vision 2016 (2007-16) is a ten-year plan intended to succeed Biotech 2000 (1994-2006) and has two central visions: a society oriented toward a healthy life and a prosperous bio-economy. Bio-Vision 2016 has several targets, including achieving seventh place in the world ranking of academic publications and patents and creating an industry with a market size of KRW 60 trillion. A four-part strategy has been developed to achieve these goals: *i)* innovative restructuring of the national biotechnology promotion system; *ii)* expanding infrastructure for upgrading R&D; *iii)* accelerating growth and achieving globalisation of the bio-industry; and *iv)* regulatory and legal overhaul and enhancement of public acceptance.

Detailed plans outline promotion strategies for key biotechnology fields, including life sciences; health care and medicine; food, agriculture and livestock; and industrial processes/environment. As a high-level plan, Bio-Vision 2016 is intended to oversee biotechnology promotion across various parts of government. As such, it contains measures to promote greater efficiency in inter-governmental project co-ordination, such as the introduction of a meta-evaluation system and improvement of the inter-agency co-ordination system.

Measures to enhance the business environment for companies would include the acceleration of the industrialisation of research results, expanding the pool of technology transfer organisations, and increasing sources of business funding. The plan also contains various initiatives to facilitate the development of human resources. For instance, there will be increased support for post-doctoral and other junior researchers, as well as initiatives to broaden female participation in the workforce. Finally, the plan includes directions for gaining broader public support and participation by strengthening research ethics guidelines and stepping up awareness and information efforts. Taken together, the government plans to inject more than KRW 14 billion into Bio-Vision 2016 projects during the programme's lifetime.

Source: MoST (2006).

It is interesting to consider how an emerging science-intensive field like biotechnology can be developed and exploited by a country more familiar with catching up. While Korea is a technological leader in a few ICT areas, it remains a fast-follower in many others. An important question concerns how exploitation of these emerging technologies will differ from the country's experience with information technology. Recalling that Korea entered the IT sector at a relatively late stage, are current conditions conducive to becoming a technology leader in emerging fields like biotechnology and nanotechnology? In other words, what does it take to be a successful first-mover in an emerging field?

Researchers at STEPI (*e.g.* see Cho *et al.*, 2006 and Cho, 2008) have explored such questions in reference to biotechnology. They have shown that R&D investment and human capital formation in this field have drastically increased as a result of government investment. Employment in the sector is growing rapidly (by 18% annually from 1997 to 2004), and skills levels are exceptionally high. Indeed, around one-third of all Korean PhDs are in the life sciences and 38% of undergraduates were female in 2005 (up from 29% in 1999). The number of biotechnology companies has also grown quickly during the past decade. Today, the Korean biotechnology industry is composed of approximately 300 pharmaceutical companies, 650 bio-venture companies, and 250 functional food processing companies. Most are SMEs, with two-thirds employing fewer than 50 persons. Only around 200 of the 650 bio-venture companies are producing and selling their products in the market; the others mainly conduct R&D without production/sales.

There are, however, problems. As Cho (2008) reports, biotechnology companies have struggled to raise funds and their small size means they lack the capabilities to create new drugs and materials. Instead, many focus on mass production and improvement of generic products developed in advanced countries, and most firms are considered medium or even low level. The lack of bio-infrastructure, such as cGMP (cyclic good manufacturing practices), is also a major barrier. Moreover, there is little collaboration among local R&D players (companies, universities and GRIs) and a lack of international collaboration. Public R&D players are relatively successful at generating papers and patents (though there is some question about the usefulness of the latter) but are less successful at transferring technology to local biotechnology firms. Interestingly, firms have relied mainly on in-house R&D to acquire technology and have rarely sought to import technology from abroad. This is in contrast to the familiar catch-up route of technology acquisition by other industries in Korea.

Given these challenges, government intervention centres upon: *i)* improving the cycle of technological development and commercialisation by strengthening collaboration among industry, universities and GRIs; *ii)* fostering the bio-ecosystem by raising bio-clusters and human capital to world-class levels; *iii)* developing bio-business models that advocate entrepreneurship and induce private-sector investment; and *iv)* rapidly increasing the levels of R&D investment (Cho, 2008). On the latter, the public R&D budget increased annually at a rate of 23% from 1994 to 2006 to reach more than USD 630 million in 2006. The main sectors are health care (34%), bio-science (30%), and bio-agriculture/food/livestock (21%). MoST accounted for the largest investment (41%), followed by MoCIE (18%), the Ministry of Health and Welfare (17%) and the Ministry of Agriculture and Food (13%).

Thus, the government – and especially MEST – has sought to give the sector a strong push, but questions remain as to whether government policies are having the intended effects. In particular, the industry remains underdeveloped, and linkages between the public and private sectors are weak, as are international linkages. Such problems are hardly unique to Korea and are relatively common elsewhere in the OECD area. They are associated with emerging fields, where risks and uncertainties abound and where there are few guarantees of success. To some extent, it will be necessary to wait and see, while actively fostering the infrastructure and human resources that will allow opportunities to be seized as they arise.

Services is another area in which Korea could seek to diversify. As highlighted in earlier parts of this review, there is significant scope for Korea to improve productivity in this area. However, for the most part, the Korean services sector does not face the same pressures from global competition as the manufacturing sector and thus has fewer incentives to innovate (and improve productivity). Further opening up domestic services markets to international competition would promote innovation, although it is often said that Korean services firms are too weak to compete and need to be protected as part of an infant industry development strategy. Another route could involve the creation of lead markets through a public procurement strategy that incorporates an active innovation agenda (see section 3.7). This would see the government, as a major procurer of services, set standards and service requirements requiring local firms to invest in innovation.

To be fair, the government has not been blind to the need to develop the services sector. For example, the previous administration launched several flagship “hub” projects to boost Korea’s service industries, including positioning the country as an Asian financial hub (Box 3.8), an Asian logistics hub and the Northeast Asia R&D Hub. The new government has also indicated a strong interest in promoting innovation in services. As part of a new roadmap for the services sector announced in 2008, the government plans to promote the creation of a high value-added business services market by encouraging outsourcing to boost demand for knowledge-based services (for example, SMEs are to receive subsidies for management consulting services) and by doubling the share of government R&D in industrial technology that goes to the services sector from 3.1% in 2008 to 6.2% in 2012 (OECD, 2008b). One of the seven major technology areas to be supported under the 577 Initiative is knowledge-based service technologies. Proposals include developing software, culture technology, design capabilities, and intelligent manufacturing system technology.

Box 3.8. Korea as an Asian financial hub

Becoming a financial hub for Asia would increase the productivity and efficiency of Korea’s financial services industry by strengthening competition with foreign financial institutions. However, Korea faces severe competition from existing financial centres and other locations with ambitions to become a hub. For example, Shanghai announced its so-called "three-step strategy" in 2002 to become a regional financial centre. Sydney has also been focusing on attracting foreign asset management companies and venture capital business as part of its “Axis Australia” initiative. Tokyo has undertaken financial reform programmes aimed at revitalising its financial industry.

Furthermore, according to a 2007 survey of foreigners working in Korea’s financial sector (KDI, 2007), 43% responded that strict regulation makes it difficult for Korea to become a hub. In addition, the need for domestic companies to achieve international competitiveness is complicated by a general lack of expertise. Indeed, Korea ranked 45th in terms of financial experts, compared to 11th for Hong Kong, China, and 15th for Singapore (IMD, 2008). In sum, creating a financial hub depends on modernising the regulatory structure and increasing the number of financial experts by improving the business and living conditions, in part through reforms in education and health care, to attract more foreign investment.

Source: OECD (2008), *OECD Economic Surveys: Korea*, OECD, Paris.

While these R&D budget increases are to be welcomed, there seems to be a widespread lack of understanding of the nature of "services science". To complicate matters further, process innovation and management innovation are often just as, or even more, important than technological innovation in improving the productivity of service industries. In other words, services science must include a heavy dose of social science and humanities (SSH) research. This highlights the necessarily interdisciplinary nature of services science and calls for a largely new partnership between the natural sciences and SSH. How this might be done will require careful consideration and lessons should be drawn as far as possible from international experience. Already, detailed studies have been carried out for MKE and MEST which offer recommendations for moving forward, while the need for close collaboration between these two ministries, as in other STI areas, should be self-evident. A further promising sign is the recent establishment of the Service Science National Forum, which involves the participation of 35 leading public and private member organisations and a further 1 000 or so individual members. It has established more than a dozen sub-committees dedicated to different service industries and seeks to promote services science by publishing a new academic journal, developing new university curricula, and generally raising awareness of the importance of the field among policy makers, industry and academics.[9]

3.4.5. Funding for research infrastructures

Shifting the government's R&D portfolio towards more fundamental research also requires the development of suitable capabilities and the provision of adequate resources, notably research infrastructures. The GRIs are relatively well endowed with the latter, but the Korean government has sought to focus its efforts on strengthening the research capacities of the universities, as these have historically been weak. These will take considerable time to develop and it would be unrealistic to expect too much too soon.

The distribution of S&T funds is rather unbalanced in terms of region, university and academic field of study (KEDI, 2006). According to the KRF, much of its funding is concentrated on the top five universities, while research funding by KOSEF shows a similar distribution. For the majority of universities, particularly in the regions, there is said to be a vicious cycle in R&D investment. Since their R&D facilities are less well developed, they have insufficient strength to compete for funding with other R&D actors (especially the GRIs), and have thus attracted fewer national R&D resources. But without this funding, universities are unable to strengthen their R&D facilities and research teams.

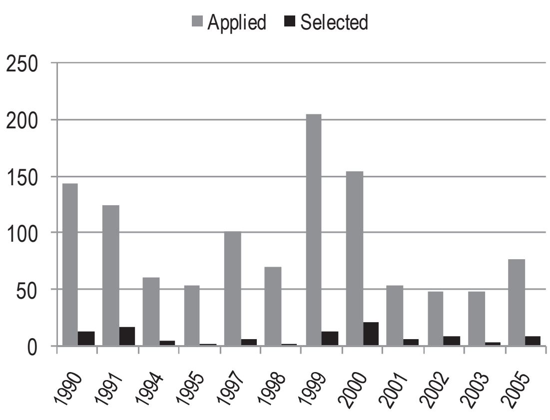
The government has sought to circumvent this vicious cycle by targeting specific funds for the development of centres of research excellence in universities. MEST is especially active here, and its predecessor, MoST, established in the early 1990s a programme for promoting the establishment of Science Research Centres (SRCs) and Engineering Research Centres (ERCs). The objectives are: *i)* to raise leading scientific groups to world-class level; *ii)* to facilitate co-operation between industry and academia; and *iii)* to establish research-oriented universities. SRCs focus upon creative basic research that should lead to outstanding academic publications and the development of advanced technologies. ERCs are engaged mainly in basic engineering research with the potential for industrial advances, while encouraging interdisciplinary collaboration between industry and academia. Table 3.14 presents the number of SRCs and ERCs established by academic field and shows that the life sciences account for more than a quarter of centres, followed some way behind by ICT and electrical engineering. This is an interesting pattern that is largely at odds with the overall pattern of R&D funding and human resource profiles in Korean S&T. As Figure 3.9 shows, the competition for centre status is intense, but the rewards immense by university funding standards: each selected centre receives around USD 10 million over nine years; this provides a sound basis for establishing leading-edge research activities.

Table 3.14. Number of SRCs/ERCs funded according to field, 2005

Field	Number of centres		Total	Ratio (%)
	Active	Retired		
Mathematics	2	2	4	3.5
Physics	7	4	11	9.7
Chemistry	5	4	9	8.0
Geosciences	1	1	3	2.7
Life sciences	20	13	33	29.2
ICT and electrical engineering.	10	6	16	14.2
Mechanical engineering and energy	5	6	11	9.7
Materials science	4	5	9	8.0
Chemical engineering	6	6	12	10.6
Civil and environmental engineering	4	1	5	4.4
Total	**64**	**48**	**113**	**100**

Source: KOSEF website (*www.kosef.re.kr/english_new/*), accessed February 2008.

Figure 3.9. University research centres of excellence, 1990-2005



Source: Cho, Hwang-Hee (2005), “Material for Discussion on Innovation Korea and Activation of University R&D”, STEPI, Seoul.

The SRC/ERC programme was later extended, with the establishment of Medical Research Centres (MRCs) and National Core Research Centres (NCRCs). The MRCs conduct large-scale, long-term R&D, the outputs of which are used in bioengineering and clinical medicine. They also have an important brief for developing human resources and provide clinical medicine graduates with opportunities to enter medical research. Each centre receives approximately USD 300 000-500 000 a year for a maximum of nine years.

The NCRCs are intended to create world-class knowledge in core science and technology fields that will underpin Korea's future competitiveness. As with the other types of centre, development of human resources is an important element of the NCRC's remit. Each centre benefits from approximately USD 2 million of funding annually for a maximum of seven years.

As already mentioned, the GRIs tend to have superior research infrastructure to the universities. One idea being considered by the government is to encourage much closer co-operation between the GRIs and universities, as they seem to have complementary assets, at least at face value. The form this co-operation might take remains open, but might involve full merger of at least some GRIs with some universities. Although hardly an unprecedented move in OECD countries (for example, see Box 3.9, which describes the merger of the French CNRS into the university system), such developments would need to be carefully considered on a case-by-case basis. Furthermore, various models of university-GRI co-existence are found around the world and any lessons from these would need to be carefully interpreted in the Korean context.

Box 3.9. The French *Centre National de la Recherche Scientifique* (CNRS)

Obstacles to the integration of universities and public R&D institutes can be overcome. The CNRS successfully made agreements with universities to locate more than 90% of its laboratories on university campuses. CNRS laboratories now utilise graduate students and professors at universities, thereby reducing their R&D expenses. At the same time, universities that invited CNRS laboratories to participate in their research projects also utilise CNRS R&D professionals as teaching staff. Both parties benefit from a situation which can be truly called a win-win game.

Source: OECD (2003), *Governance of Public Research: Toward Better Practices*, OECD, Paris.

A further issue for research infrastructures is highlighted in the Total Roadmap and concerns problems of effectiveness in utilising large-scale S&T equipment and facilities. Korea has made some major investments over the last decade or so in such equipment and facilities, not least to improve national basic research capabilities. However, their use has often been criticised as ineffective and inefficient. Again, this is not a problem unique to Korea. By way of solution, the Total Roadmap proposes to promote better facility utilisation through improved co-ordination and conciliation among widely distributed ministerial R&D planning, operation, evaluation and management systems. The new 577 Initiative goes even further, setting a target of increasing the ratio of shared utilisation of research facilities and equipment from 14% in 2006 to 30% by 2012.[10] In addition, a master plan has been formulated for securing, managing and utilising national bio-resources.

Finally, the new government is considering the injection of large sums into building new world-class facilities for basic and applied science. A task force set up by the Presidential Transition Committee in early 2008 has drawn up plans for a new city of science and culture that would involve constructing several big facilities, including a heavy ion accelerator, a next-generation synchrotron light source, and a research hospital. Known as the International Science and Business Belt (ISBB), the plans attempt to make connections with several overarching goals on the current Korean STI policy agenda. These include a shift towards more fundamental and interdisciplinary research, efforts to further internationalise research, and support for national competitiveness through the commercialisation of research findings and the development of highly skilled human resources. Besides the large scientific facilities, the plans include establishing the Asia

Basic Science Institute, a research centre of some 2 000 researchers, many from overseas; a Global Knowledge Platform dedicated to the dissemination of knowledge to benefit all mankind; and a Science and Business Network to connect the research sector with business partners and government sponsors. The proposed location of the ISBB lies in Chungcheong province, where ready connections can be made to the Daedeok Innopolis (see section 3.9), the Osong biosciences cluster, the Ochang information technology city, and the new administrative complex at Sejong City.

The vision for the ISBB outlined in Box 3.10 is inspiring and certainly commendable but is also extremely ambitious and likely to be very costly. Furthermore, to succeed, it will need to take into account a number of important factors:

- *Demand for the new facilities*: The new infrastructures to be provided under the ISBB are intended as a way to attract world-class researchers to Korea. If this is to prove the case, it will be important for the facilities to be distinctive when compared to infrastructures in other countries, particularly in the Asian region. This calls for international co-operation in scoping and designing facilities to maximise their attractiveness and potential usefulness. In this regard, the ISBB plans refer to co-operation with India, but no mention is made of Korea's closest neighbours, China and Japan.[11] This is a curious omission, particularly as both of these countries have large facilities and plan further investments (including plans for new light sources and synchrotrons). It would seem only prudent therefore for the Korean government and scientific community to work with their counterparts in neighbouring countries to better ensure the development of infrastructures with wide appeal that will complement existing/planned facilities elsewhere in the region.
- *Translating basic science into commercial success*: The plans for the ISBB make much of the idea that breakthrough scientific discoveries will translate into technological developments, which will in turn increase the competitiveness of Korean business. This line of reasoning follows the classic linear model of innovation, which has long been discarded by innovation academics and policy makers. Such a model does not do justice to the multi-level, non-linear processes that firms, entrepreneurs and users engage in to create successful and sustainable innovations. Furthermore, the model places too much emphasis upon the utility of the outcomes of basic research when in fact the most significant return to basic research tends to be the skills and understanding embodied in the researchers themselves. This is not to deny the potential for significant spillovers from the ISBB's proposed basic research activities, but instead to highlight the conceptual, let alone practical, challenges in trying to harness them in a directed manner.
- *Positioning the ISBB* vis-à-vis *other research performers*: The ISBB plans are careful to distinguish it from the scope and scale of research activities already performed by the GRIs and universities. Accordingly, the ISBB is presented as a basic science complex distinct from the applied science Daedeok Innopolis; and as a place for basic science using larger facilities than those available in the universities. Interdisciplinarity and a multi-stage research and innovation scope are also presented as distinguishing factors. While there is merit in these distinctions, they do not necessarily lead to the conclusion that the ISBB is an essential investment for Korea. For instance, the GRIs with their substantial facilities could engage in more basic research than they do at present. And with further infrastructural investments and/or closer co-operation with the GRIs, the universities could readily perform more large-scale experiments. An assessment of the relative

costs and benefits of these and other options should therefore be carried out before committing to the building of the ISBB.

Box 3.10. The promise of the International Science and Business Belt (ISBB)

The International Science and Business Belt (ISBB) will be Korea's showpiece for a science nation of the future. With the ISBB as an exemplar, Korea as a whole will become an international focus for science and business. Korea will become a leading country in the world as it establishes a Global Knowledge Platform where the applied sciences flourish on the foundation of strong basic science. In this way, the ISBB will be the heart that pumps the economic lifeblood of the country to become one of the Big Seven Powers. More specifically:

- The ISBB promises to add much value to academia and to other related industries. The leading researchers gathered in the ISBB from across the globe will drive a "Korean Wave" in science, much like the cultural wave that has swept Asia in recent years. The country that used to send a great number of students overseas will bustle with students from abroad.
- As a city where people desire to live and visit, the ISBB will be a showpiece for 21st century cities. The city will enable science, art, culture and industries to merge creatively and produce synergy between the basic and applied sciences. A top-class basic science research institute comparable to the world-renowned Brookhaven National Laboratory in the United States and the Max Plank Institute in Germany will be established at the centre of the city.
- The ISBB will be the hub of a "21st century creative network", where science, art, culture and industries converge. It will be Korea's "21st century Silicon Valley", where the latest scientific knowledge in service, medical, banking, manufacturing, communications, transportation, real estate, architecture, and many other industries can be readily translated into business.
- At the ISBB, experts will meet and exchange ideas with other experts in the same field as well as with those in different fields. Research preparation, knowledge creation and propagation/transmission will be carried out systematically. The city will thus become the leader of international knowledge distribution as the central axis of science shifts to Asia, following similar shifts in industry.
- As more than a city for scientists, the ISBB will be a global nexus where research and industry, East and West, and traditional Asian culture and modern culture converge. Not only will it bring about differentiated scientific competitiveness to participating organisations, it will also become a place where science and the humanities, and industry and art come together for lively exchange and co-operation.

Source: Excerpt from the report of the International Science and Business Belt Task Force (2008).

3.5. HRST policy

Various ministries are involved in policies related to human resources for science and technology (HRST), but by far the most important is MEST, which combines the previously two most important ministries for HRST, MoE and MoST. Much of this section describes the policies of these two ministries, together with a brief description of the programmes of MoCIE and MIC (now combined to form the MKE). A discussion of tertiary education reform follows, specifically the attempts to enhance autonomy and accountability in higher education institutions, to improve HEIs' specialisation and linkages with industry, and to foster the development of research skills. Programmes addressing vocational training and lifelong learning are then considered. The section ends with an assessment of the policies directed at promoting greater female participation in Korean science and engineering.

3.5.1. Policy responsibility and co-ordination

Before the establishment of MEST in 2008, MoE was the most important ministry for HRST policy. In 2001, its minister was elevated to the position of deputy prime minister (in a manner similar to the MoST minister in 2004) in order to establish, oversee and co-ordinate human resource development (HRD) policies on a national level. The MoE implemented the First Basic Plan for National Human Resource Development (NHRD) during 2001-05. The plan contained some important policy initiatives for HRST, including the establishment of infrastructure for supporting the supply of human resources in six strategic fields (information technology, biotechnology, nanotechnology, environmental technology, space technology and culture technology), and the renewal of universities as the centre for tripartite co-operative arrangements among industries, academic communities and research institutions (including the GRIs) to manage issues of HRST supply and demand. While these initiatives met with some success, there were also problems: the heterogeneity of the six technology fields in terms of their industrial base in Korea made it difficult to implement the policy under a single set of criteria. The tripartite co-operative arrangements also failed to fully alleviate the mismatches between demand and supply, since the overall signalling mechanism of labour markets and educational institutions was underdeveloped.

Upon completion of the First Basic Plan, MoE developed the Second Basic Plan for NHRD (2006-10), which brought together HRD policy tasks to be carried out by some 20 government ministries and offices from 2006 to 2010. The plan includes 200 policy tasks, including 67 key tasks in four policy areas: the development of a globally competitive core workforce; the empowerment of all individuals for lifelong learning; the facilitation of social integration and educational and cultural welfare; and the expansion of the HRD infrastructure. In its specific application to tertiary education, the plan's main strategy has been to:

- promote restructuring and competition through the use of various incentives and disincentives.
- target funding for specialisation and regional parity.
- finance learners rather than providers through new student loans.
- improve labour market information on skill requirements.
- enhance networking and partnerships between higher education and local governments and the business community.

Most of these points are further elaborated in later sub-sections. Implementation of the NHRD Plan is now the responsibility of MEST.

As for the other ministries, MoST sought to shift the focus of HRD from quantity to quality. Using its centres of excellence programmes (discussed above), it encouraged the development of high-calibre researchers in the universities. Furthermore, it used its budget to directly support three special schools that set out to nurture high-calibre S&T manpower. These are the Korea Advanced Institute of Science and Technology (KAIST), the Gwang-Ju Institute of Science and Technology (GIST), and the Korea Institute for Advanced Study (KIAS).

Before the establishment of MEST, the respective roles of MoE and MoST were not clearly distinguished, particularly in the steering of HRST policy. This sometimes led to programme overlap. For example, both ministries, through their respective funding agencies (KRF and KOSEF), supported individual research projects in S&T fields without a clear distinction between their programmes. The formation of MEST should, at least in theory, offer opportunities for eliminating such redundancies and for exploiting greater efficiencies and scale benefits.

For its part, MoCIE was charged with fostering industrial technology manpower and e-business manpower. Its policy focus was on regional innovation systems (see below), and its HRST policies and programmes addressed that level. Its sister ministry, the MIC, was responsible for nurturing ICT professionals. In 2003, it introduced a supply chain management model into its programme to form ICT professionals, help ICT-related schools to improve their equipment and education curricula, encourage universities to scout for ICT professionals with work experiences in companies or research institutes (both at home and abroad), and provide assistance for ICT internships so that more students could gain on-the-job experience. All of the activities of MoCIE and MIC now fall under the responsibility of MKE.

3.5.2. Enhancing autonomy and accountability

From a legal perspective, Korean tertiary education institutions (national, public and private) have significant autonomy with respect to academic and substantive issues. Nevertheless, their autonomy is limited in several ways, most notably student selection and enrolment quotas. With a view to guaranteeing fairness in the student selection process, written exams set by the universities, donations from students, and high-school classification systems are prohibited – the so-called "Three Nots". Instead, student selection has been governed by test scores from the CSAT (College Scholastic Ability Test). Enrolment quotas also apply for all universities in the capital region, for national and public universities (they affect the national budget), and for schools for medical personnel.

In the last couple of years, the government has sought to reform the student selection process to give universities greater autonomy in terms of the students they enrol. The methodology for using CSAT scores and high-school grade point averages has been altered, and the importance of other admission criteria and diversity of social composition has increased. This means that universities may now use student records, CSAT scores, essay writing, certificates and letters of recommendation to choose students and determine the weight given to these elements. Furthermore, by 2012, the government will reduce the number of required subjects in the university admission exams; and from 2013, it is planned that universities will be granted complete autonomy in admission procedures. The liberalisation of student recruitment regulations already provides colleges and universities with greater freedom to adjust the number of graduates to balance supply with demand in the labour markets.

This increased institutional autonomy is balanced by new regulatory policies related to quality assurance, evaluation, transparency and improved information for student choice. It is widely acknowledged that Korean HEIs need to improve their capacity for effective decentralised governance and management, and should be more accountable to key stakeholders and the public for performance, quality and efficient use of resources. This has led the government to introduce more targeted funding linked to specific requirements for eligibility and institutional change (see below).

At the same time, the government has sought to increase transparency by improving information on HEI performance (Box 3.11 describes the level of quality assurance and public accountability in place until recently). In 2008, the University Information Disclosure System was introduced; it includes information on graduate employment rates, enrolment rates, full-time faculty, scholarships, research achievements, curricular operation and school management. In this way, the government seeks to provide students and parents with accurate information on each school and help them choose the institutions that fit their needs. Furthermore, it is expected that the new system will induce sound competition among HEIs and thereby facilitate their restructuring efforts.

Box 3.11. Quality assurance and public accountability of Korean universities

As the government pursues regulatory reform and seeks to increase institutional autonomy, development of an effective system of quality assurance and public accountability is essential. Korea currently relies on four approaches to quality assurance in tertiary education:

1. The MoE utilises an indirect means of quality assurance by supporting the work of non-governmental accrediting organisations. These include the Korean Council for University Education (KCUE), the Korean Council for College Education (KCCE), and specialised accrediting boards for medical, engineering and nursing education.

2. The MoE undertakes direct evaluations linked to institutional participation in targeted funding and initiatives. The government includes an evaluation component in all funding initiatives related to tertiary education.

3. The Korean Education Development Institute (KEDI), a policy centre linked to the MoE, evaluates teacher education programmes and undertakes special studies of the education system.

4. The daily newspaper, *JoongAng Ilbo*, publishes evaluations and rankings of institutions and programmes to guide students and parents.

Source: OECD (2007), *Korea: Progress in Implementing Regulatory Reform.*

A different, though complementary approach to raising quality, in which engineering faculties have sought to raise standards through a national accreditation system, is briefly described in Box 3.12.

Box 3.12. The Accreditation Board of Engineering Education of Korea (ABEEK)

The Accreditation Board of Engineering Education of Korea (ABEEK) was founded in 1999 to ensure that the quality of educational programmes in engineering and related disciplines meets the needs of changing industrial demand. The accreditation is intended to enhance the professional competence of the graduates of affiliated engineering programmes by giving the universities incentives to meet the quality standards of engineering education that reflect industrial needs. It also reduces mismatches of demand for and supply of graduates caused by insufficient information about the quality of engineering education. ABEEK has been well received and was boosted by Samsung Electronics' decision to preferentially hire job applicants who had acquired the accreditation. As of 2006, ABEEK had accredited 2.5% of engineering and related programmes in Korea. Furthermore, Korea has recently joined the Washington Accord,* which is expected to facilitate the inward and outward international mobility of engineers.

* The Washington Accord is an agreement concluded in 1989 by organisations responsible for accreditation of professional engineering educational programmes in six countries (the United States, the United Kingdom, Australia, Canada, New Zealand and Ireland) which guarantees mutual recognition of one another's accreditation of scholastic ability. As of 2006, Hong Kong (China), South Africa, Chinese Taipei and Korea became regular members.

3.5.3. Promoting specialisation and linkages

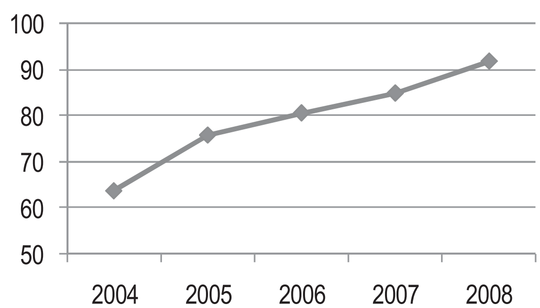
The prospect of falling student numbers (on account of shifting demographics), together with prospective students' preference for universities in and around the Seoul metropolitan area, has raised the question of the sustainability of several regional HEIs. Matters have not been helped by many HEIs' "department store" strategy of offering a wide range of often mediocre courses. Furthermore, courses have tended to be unresponsive to changing industrial needs, as linkages with industry have been traditionally weak. This has led to relatively low employment rates among graduates of many regional HEIs and has further intensified the preference for Seoul, thereby undermining efforts to achieve more balanced regional development.

Box 3.13. New University for Regional Innovation (NURI) programme

The NURI programme was initiated in 2004 to strengthen the capabilities of colleges and universities located outside the Seoul metropolitan area. Regional universities have experienced difficulties in recruiting students owing to the socio-economic gap between the Seoul metropolitan area and other areas, and the low probability of employment for graduates of regional universities. The NURI programme works by concentrating support for universities on strategic areas of their region's economic development. It seeks to nurture an excellent local labour force and to boost the employment rate of regional university graduates through specialised education programmes and, in the process, to reduce brain drain towards Seoul.

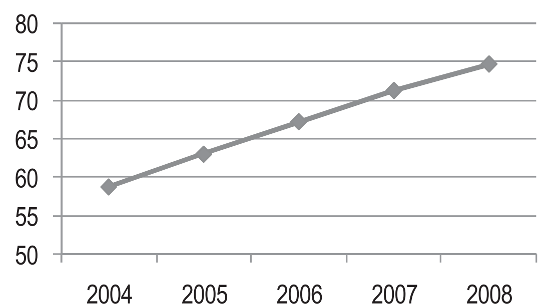
The NURI programme is set to invest a total of USD 1.3 billion over five years (2004-08). According to interim assessments, NURI shows visible progress in terms of facilitating local university specialisation, enhancing student competitiveness for employment, and fostering collaboration between universities, industries and local governments. For instance, full-time faculty provision rates reached over 90% in 2008 compared to just 64% in 2004 (Figure 3.10), while the employment rate of NURI graduates has improved from around 60% in 2004 to 75% in 2008 (Figure 3.11). At the same time, some 2 300 revisions have been made to curricula to reflect the demands of regional economies, while on-site training at major companies has been made available to 21 169 trainees.

Figure 3.10. Full-time faculty in NURI beneficiaries (%)



Source: MEST press release, 6 August 2008.

Figure 3.11. Graduate employment among NURI beneficiaries (%)



Source: MEST press release, 6 August 2008.

Box 3.14. Education Research Industry Campus Asan (ERICA)

Industry-academia-research institution linkages have been encouraged by various kinds of regional innovation clusters since the early 1970s. Among these is the Banwol/Shihwa Industrial Complex, where the Education Research Industry Campus Asan (ERICA) is located. The goal of ERICA is to provide ways to improve national/local components and parts industries. Education has been led by Hanyang University (HYU) which aims to supply practical specialists through a tailored curriculum. R&D activities are led by the Korea Institute of Industrial Technology (KITECH), the Korea Electro-Technology Research Institute, and the Korea Testing Laboratory (KTL). Kyunggi Technopark fosters industry-university co-operation. HYU develops new curricula to respond to new requirements of industry, government policy and the local community. The programmes are characterised by links between university education and work sites, practical training activities, invitations to researchers or instructors with practical experience, and student-centred autonomous learning.

Box 3.15. HEIs and regional development

Emerging models of regional development emphasise development that is based on unique assets and circumstances of the region as well as the development of knowledge-based industries. This has resulted in a re-examination of the role of regional HEIs. A knowledge-based or learning economy requires a larger number of graduates and an employment orientation in teaching. It also requires the provision of lifelong learning opportunities for a wide variety of traditional and non-traditional learners. In the globalising knowledge economy HEIs are seen as sources of knowledge and innovation and engines of growth and of contributors to the economic, social and cultural development of their societies. This has meant that HEIs must meet new expectations. The question is how to translate these into appropriate policy measures and institutional reforms.

If HEIs are to contribute to regional economic development, they must engage with the regions and contribute to the development of knowledge-intensive jobs so that graduates may find local employment and remain in their communities. They must also respond to the needs of established firms in terms of skills upgrading and technology transfer. HEIs are thus expected to be involved not only in the creation of knowledge, but also in its application, often in co-operation with their local and regional communities. They are expected to take an interdisciplinary approach to their activities and engage in partnerships with industry, with communities and with a wide variety of stakeholders. These factors affect all aspects of the role of HEIs – teaching, research and community service.

The need for greater regional engagement and mutual development of capabilities is becoming widely acknowledged. Many OECD countries have strengthened the regional role and contribution of higher education. Often, the regional mission has been characterised as a part of a “third task” or social obligation of HEIs. There is, however, a growing recognition that the third task must be integrated with longer-standing teaching and research functions if higher education’s contribution to students’ learning, to knowledge exploitation by business, and to civil society in the region is to be maximised.

Source: OECD (2007), *Higher Education and Regions*, OECD, Paris.

The previous Korean government was very concerned about these problems and started to pursue policies to promote increased specialisation, encourage HEI consolidation and merger, and strengthen the links between HEIs and regions. From 2004, a number of prominent government schemes were put in place by MoE, including university and junior college specialisation programmes and the New University for Regional Innovation (NURI) programme (see Box 3.13). These schemes provide support to HEIs for developing curricula for selected disciplines of comparative strength and offering scholarships for students in those fields. They provide strong incentives for HEIs to identify their strengths and to revise their curricula, strategic focus and missions accordingly. Evaluation of these schemes points to substantial increases in graduate employment rates over a relatively short time. Moreover, they seem to have spurred competition for diversity and specialisation among HEIs.HEIs have been encouraged to specialise in fields in which graduates are likely to find local employment opportunities, thereby boosting the regional economy and relieving some of the pressure on Seoul. While there are good examples of HEIs working closely with local industries and research institutes (see Box 3.14), they are relatively rare. Accordingly, the specialisation schemes sponsored by the government, including the NURI programme, insist that HEIs work with firms and local governments on the redesign of curricula, thereby enhancing their receptivity to demand signals. In addition, the government has funded the Industry-Academic Co-operation programme to further bolster these linkages. These schemes signal the government's view that HEIs should be sources of knowledge and engines of growth, which contribute to the socio-economic development of their regions. This is a view widely shared across OECD countries, as highlighted in Box 3.15.

Schemes such as NURI have led to a fundamental shift in the way HEIs are financed, with a decrease in the percentage of formula funding for the operation of national and public universities and an increase in the percentage of targeted funding for specialised projects awarded through a competitive application and evaluation process. However, the regulations to implement these projects add to the complexity of funding arrangements and also limit HEIs' freedom to distribute block grants according to their own strategies. This was, of course, intentional, as the government believed the HEIs needed to be steered to shift their strategies in more appropriate directions. However, the new government has decided that formula funding will be re-instated and competitive targeted funding abolished from 2009. Based on a non-competitive evaluation formula, MEST will assess and award the best performing four-year universities according to eight group divisions, by region (metropolitan/rural), size (large/medium/small) and specialty (general/industrial). Two-year junior colleges will be assessed in two groups by regional division (metropolitan/rural). Pre-determined quantitative indices will be used to evaluate each HEI's educational achievement level and environmental status. Criteria will include the graduate employment rate, ratio of student enrolment to total quota, share of full-time faculty, scholarship coverage rate and educational expense per student. In this way, many of the criteria used to determine funding under the targeted schemes are being maintained, and the administrative autonomy of HEIs is increased.

3.5.4. Fostering research skills

Both MoST and MoE had schemes to foster the development of research skills. Through KOSEF, MoST funded the National Science Scholarship scheme to support outstanding undergraduate and graduate students majoring in science and technology subjects. Each student receives around USD 7 000 a year for up to four years. In 2006, 22 000 students benefited from the scheme at a total cost of more than USD 230 million. The scheme is now funded by MEST.

In 1999, the MoE launched (through KRF) the Brain Korea 21 (BK21) scheme aimed at fostering world-class researchers. Over the first seven years of the scheme, the government invested a total of USD 1.34 billion, with support provided for students in selected master's and doctoral programmes, international exchange and co-operation, and innovative curriculum development. The programme aimed at nurturing world-class graduate schools with the capability to produce creative knowledge in strategically important sectors for Korea. The research topics covered were classified into four subject areas: applied science, art and social science, Korean indigenous science, and newly emerging industries.

Despite criticism of favouritism towards a small number of large research-oriented universities such as Seoul National University, BK21 is credited with having played a pivotal role in enhancing Korean S&T capabilities. From 1999 to 2005, 6 602 students obtained PhDs in S&T fields with the aid of the programme. The number of S&T SCI papers written by beneficiaries of the programme increased from 3 765 in 1998 to 20 418 in 2006. Moreover, this quantitative increase came with qualitative improvements in the impact factor per article, from 1.9 in 1998 to 2.43 in 2005.

As the first phase of the BK21 programme was judged a success, a second phase has been implemented. From 2006 to 2012, a total of USD 2.3 billion will be invested in graduate schools to nurture ten top research-oriented universities in key fields with a view to joining the world's elite universities in terms of SCI publication levels. To achieve this, the government has focused its investment on more strategic S&T fields. The second phase also emphasises university-industry linkages, with the hope of doubling technology transfer rates over the lifetime of the scheme. Finally, the regional graduate school of excellence programme is part of the second phase programme in order to foster balanced growth of research capabilities among regions.

3.5.5. Improving vocational training

For vocational training, the need to raise perceptions of the levels of institutions and qualifications is widely acknowledged. As the demand for bachelor's degrees is unlikely to diminish, this may mean making vocational training bachelor's degree-level courses. The Korean government would seem to be moving in this direction by allowing junior colleges – where a great deal of vocational training is conducted – to award bachelor's degrees. Furthermore, under a new law, a junior college graduate who has been working in a company related to their major for at least one year may apply for an expansion programme in that field. This is designed to provide a path of continuing education for adults, from junior college to employment and then to extended studies leading to a higher degree. The expectation is that many graduates will study for a bachelor's degree part-time during employment.

The government is also planning to transform 50 vocational high schools into high-quality "Meister schools", to train qualified technicians in selected specialised fields. Meister schools are expected to help tackle the problem of the decreasing numbers of students in vocational high schools and also help overcome the financial difficulties of schools committed to developing these technicians.

3.5.6. Moving towards lifelong learning

In recent years Korea has established important elements of a system of lifelong learning. However, according to a 2005 OECD review of Korean adult education, these elements were insufficiently connected and inadequately linked with the employment system, and too few resources were allocated to adult learning. These criticisms were widely shared by the Korean government, which, in late 2007 announced a roadmap to enhance lifelong learning capacities as part of the Second Five-year Lifelong Learning Promotion Plan (2008-12). This plan follows the completion of the first national lifelong learning promotion plan (2002-06), and acknowledges the importance of facilitating flexibility between work, study and leisure, in order to counter the lessening of hours of learning per person as individuals grow older.

The plan encompasses two core strategies: developing lifelong learning tailored to the practical needs of individuals at each stage of their life; and facilitating a lifelong learning network that links all related organisations and programmes horizontally and vertically. With regard to the latter, a new government body, the National Institute for Lifelong Education, was launched in early 2008 to oversee and implement Korea's lifelong learning policies. It integrated the existing Lifelong Education Centre and Credit Bank Centre under the Korea Education Development Institute and the Individual Bachelor's Degree Examination Department under the Korea National Open University. By bringing these three together into a single organisation, the Institute aims for greater consistency and synergy in carrying out lifelong learning policies.

At the operational level, a number of schemes exist. In-company training and training for the unemployed are financed through the employment insurance system. This is now Korea's most important programme of incentives for training both employees and the unemployed. The government also supports training consortia involving large and small firms (see Box 3.16 for an example). The creation of correspondence high schools, cyber colleges and the Korea National Open University offers opportunities to adults who have no school-leaving qualification or who wish to return to study to obtain a college qualification or university degree. Furthermore, National Technical Qualifications have been developed for the various skill levels (from craftsman to professional engineer, and for administrative services). Through the Academic Credit Bank System (see Box 3.17) those who have participated successfully in courses at other institutions may also be recognised, and credit points accumulated in various ways can be used to achieve qualifications (OECD, 2005b). Finally, the government has recently put forward new plans to encourage junior colleges and universities to establish courses that match the learning needs of those already in work.

These initiatives no doubt improve the supply of lifelong learning opportunities open to adult learners. However, there are still significant problems on the demand side: the way in which the Korean labour market is structured constitutes one of the main barriers to adult education as it offers too few incentives for lifelong learning. Individuals in regular employment are paid in accordance with seniority rather than qualifications, and irregular workers have no prospects of promotion, so that education/training brings them few benefits (see Box 3.18).

Box 3.16. A training consortium: the Volvo Training Centre

In response to the low take-up of training grants by smaller enterprises, the Korean government is supporting training consortia, whereby large enterprises organise training for SMEs. One example is Volvo, which established a training centre for its suppliers in 2003. The consortium's training courses are financed through the Employment Insurance System and are all approved by the Ministry of Labour. By 2004, Volvo, the Ministry of Labour and more than a dozen suppliers were represented on the consortium's management board, with training aimed at 1 023 Volvo suppliers. The training centre works in close co-operation with Volvo and its suppliers and ensures a high level of technical and educational input, which the suppliers, most of them small companies, would be unable to offer with their own in-company training. In the first year of operation, over 600 workers participated in courses lasting between two days and one year. Half of the participants have high-school-leaving qualifications.

Source: OECD (2005) *Thematic Review of Adult Learning: Korea Country Note*, OECD, Paris.

Box 3.17. Academic Credit Bank System

Established in 1998, the Academic Credit Bank System (ACBS) is an open educational system that recognises diverse learning experiences gained not only in school but also out of school. When the learner accumulates the necessary ACBS-approved credits, he/she can be awarded a degree. In 2008, nearly 20 000 bachelor's degrees were conferred on non-regular learners who had successfully acquired the necessary credits. The number of degree awardees has been increasing steadily over the years to a total of nearly 110 000 by 2008. With over 80% of all degree achievers aged 25 and older, the system serves as an important means of providing adult learners with lifelong education opportunities.

Source: MEST website (*http://english.mest.go.kr*), accessed August 2008.

Box 3.18. A need to better integrate the employment and education systems

Access to non-formal and informal learning depends not so much on decisions the individual makes about training, but rather on work organisation in enterprises and mobility prospects on the labour market. Opportunities for lifelong learning cannot be increased simply by improving learning opportunities within the education system. As most adults are in employment, people will only take advantage of these opportunities if an adequate number of incentives and adequate provision are embedded in the employment system. Lifelong learning can be successful only in association with adequate education and training opportunities for adults and with an employment system that promotes learning.

Source: OECD (2005) *Thematic Review of Adult Learning: Korea Country Note*, OECD, Paris.

In the area of HRST, the former MoST recently launched a new programme for "life-cycle support of HRST" (known as *Injae-Jigi* in Korean), which aims to support S&T talents from primary education through to retirement. The programme includes subsidies for unemployed S&T workers and an increase in on-the-job training for R&D workers as well as industrial technology workers.

3.5.7. Enhancing gender balance

While the graduation rates of women in S&E subjects is close to the OECD average, many fail to take up employment in the field. There are a number of explanations for this, some unique to or at least unusually severe in Korea. They include: *i)* the largest gender wage differentials in the OECD area; *ii)* the fact that 60% of female S&E professionals are on temporary contracts, and thus with fewer prospects for career advancement, compared to 25% of their male counterparts; *iii)* the domination of Korean S&T by traditionally male-oriented fields, such as engineering; *iv)* a family-unfriendly long-hours culture; and *v)* traditional views on the role of women in Korean society. These reasons are in addition to the usual factors seen across OECD countries that militate against higher levels of female participation in S&E careers, including childbirth career breaks and childcare responsibilities.

With so many contributory causes, approaches for solving the gender imbalance in S&T need to be comprehensive and multifaceted. Before 2002, the Korean government had few policies in place for addressing this issue, but this changed with the Act on Fostering and Supporting Women in Science and Technology. This legislation seeks to strengthen the capacity of women in science, engineering and technology and has heralded the establishment of various centres and initiatives funded by several ministries. The initiatives that have been started are wide-ranging and reflect a high degree of international learning (see Box 3.19), with programmes aimed at attracting more females to S&E careers, recruitment targets set for some parts of the public sector, and favourable point systems for research project selection. Some of these schemes are further described below.

Box 3.19. Policies to promote female participation in science across the OECD area

Against a background of growing demand for HRST, policy makers have started to pay greater attention to encouraging women to pursue careers in S&T. Women have increased their numbers in higher education and the workforce, but their participation in science education and S&T careers remains low in comparison to men, especially at senior levels, and wide discrepancies exist across scientific fields. OECD countries are addressing the issue of women's participation in science to varying degrees. Most have specific programmes which aim to achieve a better gender balance in science education and research. Measures range from grants to support positions for women at universities, gender-neutral performance assessment to preferential policies towards equally qualified women candidates and mentoring programmes. On the employment side, equal opportunity policies, flexible working hours, access to childcare and parental leave are used to encourage women to pursue research careers in the public and private sectors.

Source: Basri (2008), "Enhancing the Role of Tertiary Education in Research and Innovation", in OECD (2008), *Tertiary Education for the Knowledge Society*, Vol. 2, OECD, Paris.

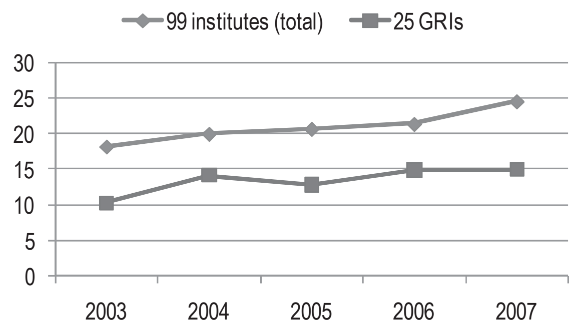
As part of the new legislation to improve the position of women in S&T, the National Institute for Supporting Women in Science and Technology (NIS-WIST) was established in 2004 and there are now a further four regional institutes in Korea. Its tasks include investigation and research in support of policies for fostering and supporting women in S&T; education, training, and consulting; and the provision of employment information. It has conducted several reviews and statistical analyses of the situation of women in S&T and divides government policies and programmes into three broad categories, according to their objective: programmes for fostering female S&T resources; programmes that encourage utilisation of female S&T resources; and programmes that support female scientists, engineers and technologists. Using this categorisation, the main programmes pertaining to women in science are listed in Table 3.15. On account of space limitations, just a few of these programmes are considered here.

The Recruitment Target System (RTS) for Women in S&T and the RTS for Female Faculty (see below) have perhaps had the most visible impact over the short term. The former was started in 2003 by MoST and set recruitment targets in 99 public institutes (including 25 GRIs). The long-term target is for 30% of all new recruits to be women across all 99 institutes, with a short-term target (to 2010) of 25%. Different targets have been set for different types of institutes, with the GRIs aiming overall for 20% female recruitment by 2010 – although different GRIs have different targets, with the more engineering-oriented institutes typically having much lower targets (as low as 5%) while the biological sciences institutes have targets as high as 30%. As Figure 3.12 shows, the policy has had some success, with a 6.4% increase in the female recruitment rate across the 99 institutes in the period 2003-07. This brought the recruitment rate to 24.6% in 2007, just short of the 2010 target of 25%. The picture is less impressive for the 25 GRIs, which have seen a 4.6% increase over the same period and a recruitment rate of 15.0% in 2007, still some way from the 2010 target of 20%. Furthermore, the rates of female employment are still chronically low and the overwhelming majority of women scientists remain on temporary contracts.

Turning to the universities, the MoE established the RTS for Female Faculty in 2003 with the aim of improving recruitment rates in national and public universities. As Figure 3.13 shows, during the time prior to the implementation of the programme, from 1999 to 2002, the ratio of female faculty in national and public universities increased by only

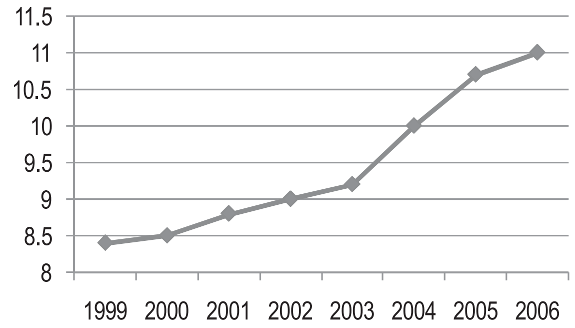
0.6%. After implementation of the programme, the rate of increase jumped threefold from 2003 to 2006. As of 2006, the ratio of the female faculty is still at a low 11.0% but the programme would seem to be having positive effects.

Figure 3.12. Share of female recruitment in 99 PROs (including 25 GRIs) during the RTS for Women in S&T programme



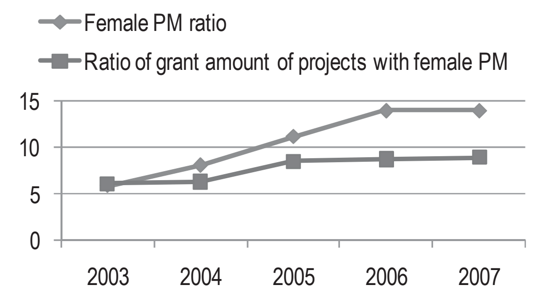
Source: NIS-WIST (2007), *Women in Science and Technology: Why and How Must They Be Supported?* Strategic Report, National Institute for Supporting Women in Science and Technology, Seoul.

Figure 3.13. Share of female faculty in national and public universities before and after the implementation in 2003 of the faculty RTS



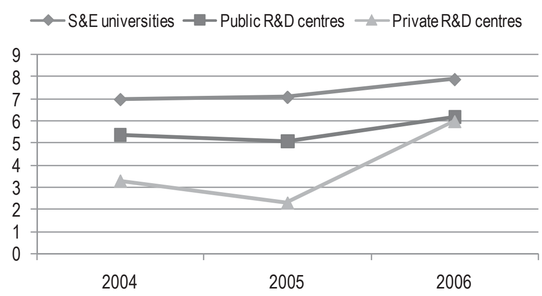
Source: NIS-WIST (2007), *Women in Science and Technology: Why and How Must They Be Supported?* Strategic Report, National Institute for Supporting Women in Science and Technology, Seoul.

Figure 3.14. Share of female project managers (PM) in basic research projects and grant amounts



Source: NIS-WIST (2007), *2007 Report on Women in Science and Engineering*, National Institute for Supporting Women in Science and Technology, Seoul.

Figure 3.15. Share of female project managers in various organisations



Source: NIS-WIST (2007), *2007 Report on Women in Science and Engineering*, National Institute for Supporting Women in Science and Technology, Seoul.

Other programmes offer support to female scientists using point award systems, whereby project proposals with various levels of female participation score extra points in proposal assessments. The best-known point award system is associated with the Basic Science Research Programme and was introduced by MoST in 2003 and further enhanced in 2005. It awards extra points (on a sliding scale) to proposals with female project managers and female participation. As Figure 3.14 shows, the scheme seems to have had some positive effects, with an increase in the share of female project managers from 5.9% in 2003 to 14.0% in 2007. This compares favourably to an average of 6.9% across all R&D projects funded during 2006 (with some variation between types of S&T organisation (see Figure 3.15). On the other hand, the ratio of the grant amount on projects for which females were project managers fails to show a similar increase (see Figure 3.14), which signifies that the projects in which females are project managers tend to be small in scale. Furthermore, growth in the ratio of female project managers seems to have stalled in the last few years (see Figure 3.15), suggesting that additional steps may be required to spur further growth.

Table 3.15. Major policies pertaining to women in S&T, 2007

Objective	Policy project title	Government branch
Fostering	WISE Project	MEST
	Scholarship for Outstanding Female Students in S&E	MEST
	Support Programme for Leading Universities in Engineering Programmes for Female Students	MEST
	WATCH21 Project	MEST
	University IT Research Centre Support Project (Point Award System)	MEST
Utilisation	Recruitment Target System for Women in S&T	MEST
	Recruitment Target System for Female Faculty	MEST
	Project to Increase Female Participation in Committees	MoGE
	Affirmative Action for Employment Improvement	MoL
	Promotion Target System for Women in S&T	MEST
Support	Support Centre for Women in S&T: WIST	MEST
	Daedeok Research Complex Infant & Childcare Centre Construction Project	MEST
	Basic Science Research Project / Specialised R&D Project (Point Award System)	MEST
	Support Project for Female Scientist - Support Project for Fostering Outstanding Female Scientist - Support Project for Enhancing Competitiveness of Outstanding Female Scientist	MEST
	University IT Research Centre Support Project (Point Award System)	MIC
	Project to Increase IT Professors in Korea (Point Award System)	MIC
	Commissioner for Woman Scientists & Engineers	MEST

Source: NIS-WIST (2007), *2007 Report on Women in Science and Engineering*, National Institute for Supporting Women in Science and Technology, Seoul.

Thus, there are signs that these policies are having some effect, but progress is slow and from a low base. NIS-WIST (2007) has therefore called for further measures to effect a more pronounced shift in the system. These include:

- Affirmative action to improve female participation, including an enhanced recruitment and promotion target system, an enhanced point award system, and quotas for female enrolment in engineering universities.
- Policies to support the transformation of institutes, including competitive grants and tax breaks for institutes with outstanding plans to better utilise and support female scientists and engineers.
- Policies to support maternity and childcare, including a research fund for women returning to work after childbirth, a childcare support programme, and the construction of further childcare facilities, particularly within high-technology clusters.

The extent to which the government will heed these calls is uncertain. Clearly, it will take considerable time to enact the changes that are needed to significantly increase female participation rates, but failure to do so is likely to prove costly to Korea's future development.

3.6. Knowledge diffusion and linkages

Besides supporting the creation of new technologies, it is important for government policy to facilitate the adoption and adaptation or further development of existing technologies. This brings to the fore the importance of linkages across the innovation system, particularly between public and private partners, with special emphasis on SMEs. In this section, efforts at promoting public/private partnerships (P/PPs) are considered, together with policies directed at enhancing the innovation capabilities of SMEs.

3.6.1. Promoting public/private partnerships

The Korean government has encouraged P/PPs in R&D since the early 1990s through a rich variety of measures administered by several ministries and agencies (Table 3.16). One is the Law on Fostering Industrial Education and Industry-University Co-operation (2003), which, by 2005, had seen the establishment of 333 industry-university co-operation offices (IUCOs) in Korean universities and colleges (Table 3.17). These institutes draw up contracts between firms and universities, stipulating management of budgets and patents; foster technology transfers; operate business incubators; and support research institutes within HEIs or located in industrial districts.

Besides IUCOs and the like, several long-established bridging institutes play important intermediary roles in the innovation system. The three types are grouped according to their roles and sources of funding:

- *Government-funded bridging institutes* which can be classified as diffusion-oriented intermediary organisations. These are legally independent organisations, but are strongly influenced by the government, not least through their sources of funding. Their missions vary depending upon their funding ministries and their intended roles. Box 3.20 describes a bridging institute of this type.
- *Privately funded bridging institutes* which are financed by private firms and focus on linking government and firms mainly to serve the interests of their member companies. They are primarily involved in the development of an industrial sector. Some institutes of this type are established by government in order to channel policy ideas and implementation. Others are established by leading companies in a

sector to protect their interests. These bridging institutes are usually obliged to register at a relevant ministry, although they do not receive government support. As of 2007, 201 industrial associations were registered with the government. Some are briefly described in Box 3.21.

- *Self-funding bridging institutes* which are mainly professional societies such as non-governmental organisations (NGOs) and academic associations composed of university professors and researchers. While such institutes often receive donations from private firms and some grants from the government for specific activities, a relatively high proportion of their budget comes from voluntary membership fees. However, membership in these institutes is generally weak, which limits their ability to perform a strong and dynamic bridging role, despite expectations to the contrary. Three such organisations are described in Box 3.22.

Table 3.16. Government policy programmes that support P/PPs, 2006

	Technology development	R&D personnel	Technology transfer	Support for new business
MoST	- Designation of national labs - Excellent research centres - Basic research centres for medical science - International co-operative R&D	- National core research centres - Support for foreign MA & PhD - National research centres for mathematical science - Basic research centres for nanotechnology - Education centre for research personnel	- National S&T information system	- Business incubators of KAIST, CGRIs, etc.
MoCIE	- Development of industrial technology - Building industrial technology base - Next-generation growth engine technologies - Nano cluster - Regional technology innovation - Fostering strategic industry of regions - New technology fusion - Designation of national lab - International co-operative R&D	- Labour force for industrial technology - Industrially oriented university - Regional research centres (RRC) - Labour force for energy technology	- Diffusion of R&D outcomes - Support for leading TLOs - Development of dual use technology	- Technoparks - Specialised regional innovation - Business incubators for new technologies
MIC	- Development of strategic IT - Development of next-generation core IT - International co-operative R&D	- Excellent research personnel - Specialised IT education - Global IT personnel	- Diffusion of R&D outcomes	- Designation of new IT technologies
SMBA	- Industry-university-research co-operative technology development - Technology development with industries	- Support for hiring young employees - Internships of SMEs	- Support for commercialisation by SMEs	- Business incubators - Graduate schools for new business - New technology-based business package
MoE	- Support for core research institutes - International co-operative R&D			

Source: MoST (2006b), *National R&D Programs 2006,* Ministry of Science and Technology, Seoul.

Table 3.17. Establishment of industry-university co-operation offices, 2005

Universities			Colleges			Total
Public	Private	Sum	Public	Private	Sum	
46	133	179	15	139	154	333

Source: KRF (2006), *White Book on University-Industry Co-operation*, Korea Research Foundation, Seoul.

Box 3.20. Korea Technology Transfer Centre (KTTC)

Established to implement the aims of the Technology Transfer Promotion Act 2000, the Korea Technology Transfer Centre (KTTC) promotes technology transfer by bringing together technology users and suppliers. It conducts a range of activities, including technology transfer brokerage, M&A brokerage for SMEs, consulting for new business and commercialisation strategies, technology marketing, domestic network building, operation of overseas technology transfer programmes, and technology business incubating programmes. It has set up regional technology transfer centres in eight major regions of Korea and has tried to globalise its activities by networking with 16 overseas organisations. It has also launched an online valuation system known as "OK-Value".

As Table 3.18 shows, the KTTC reported arranging 1 001 technology transfers during the period 2000-05. Nevertheless, the rate of technology transfer remains low – at around 12% in the private sector over the period – with KIPO reporting that about half the patents owned by private firms are "sleeping". This "exploitation gap" is largely due to the underdevelopment of patent management systems, especially in SMEs.

Table 3.18. Technology transfer and commercialisation by the KTTC

	2000	2001	2002	2003	2004	2005	Total
Sales	68	40	34	42	33	67	284
Evaluations	35	53	115	134	120	170	627
Investments	10	13	10	2	6	1	42
M&A/consulting	3	2	5	10	10	18	48
Total	**116**	**108**	**164**	**188**	**169**	**256**	**1 001**

Source: KTTC website (*www.kttc.or.kr/eng/main.asp*), accessed June 2008.

Box 3.21. Selection of privately financed bridging institutes

Korea Industrial Technology Association (KOITA). Acts as an intermediary between government and industry, voicing the concerns and desires of companies with R&D institutes. KOITA has recommended and suggested policies to the government that are in line with industry's technological development efforts and has put them into practice. It has also sought to enhance international co-operation with overseas counterparts and to bolster technology transfer to developing countries. KOITA also provides education, training and consulting services to researchers and R&D planning experts, offering companies the latest information on technology development and management trends.

Korea Automobile Manufacturers Association (KAMA). Established by leading auto makers in 1988 in order to play a bridging role between government and the automobile industry. It has recommended industrial policies to the government for improving auto-related systems and regulations. It promotes international co-operation with major trading counterparts, administers trade-related systems and represents members' interests in international markets. It has also carried out environmental and safety-related activities, providing policy recommendations on certification, safety standards, fuel economy and exhaust emission standards, and self-certification systems. It has also organised a human resource development council for the automobile industry.

Korea Semiconductor Industry Association (KSIA). Founded by leading semiconductor producers in 1991, KSIA's primary objective is to advance technological developments in Korea's semiconductor industry. It has provided opportunities for promoting co-operation among its members and members of international organisations in the areas of device, equipment and material suppliers and has sought to facilitate the balanced development of Korea's semiconductor-related industries. KSIA has also arranged domestic and foreign industry/academia joint research projects on advanced technology and has formulated a long-term development plan for Korea's semiconductor industry.

Box 3.22. Selection of self-funding bridging institutes

The Korea Institute of Metals and Materials (KIM). Established in 1949, KIM has carried out a wide range of activities in academic areas as well as in practical fields to build a foundation for the metals and materials field in Korea. Major activities include making space for academic exchanges and business networking and providing information on domestic market trends and industrial property rights.

Korea Institute of Chemical Engineering (KIChE). Founded in 1962 as a scientific, engineering and professional organisation dedicated to the advancement of the theory and application of chemical engineering technology, KIChE had (as of 2007) more than 5 000 members, nine regional sections and 13 technical divisions. It endeavours to improve the technological level in academia and promotes the development of technology through educational-industrial co-operation. It also publishes a number of regular journals and newsletters.

Korean Society for Innovation Management and Economics (KOSIME). Established in 1992, KOSIME aims to diffuse innovation theories to achieve effective management of innovation at the level of private firms, government and public organisations. It also aims to develop strategies and policies associated with innovation, science and technology for the central government as well as for local governments in order to promote a science- and technology-led society. It has around 500 members including professors, graduate students, researchers, government officials and industrialists with an interest in innovation management.

Taken together, all of these measures and institutional arrangements represent an impressive array of activities concerned with knowledge (and technology) transfer. However, there are criticisms that such efforts are inadequate, particularly when compared to the far more substantial activity of knowledge creation: the equivalent of just 1% of the public research budget is devoted to technology transfer and commercialisation activities. The fragmentation of such activities across several ministries and agencies is also a point of concern. While this may offer advantages – for example, in terms of scope for experimentation, and perhaps a better ability to provide bespoke solutions to individual sectors – these are likely to be outweighed by the disadvantages associated with a lack of critical mass, and overlaps and gaps in support. The consolidation of innovation-supporting ministries and agencies should therefore be taken as an opportunity to better streamline the various activities under way. Finally, the infrastructure of technology transfer remains weak in that reliable systems for evaluating new technologies are under-developed. This problem is discussed further in section 3.7.

3.6.2. Support for research and innovation in SMEs

Although the situation shows some recent signs of improvement, a structural imbalance in innovation between larger companies and SMEs remains, with the resources and outputs of innovative activities heavily concentrated in a few large companies. The key is to further develop supporting industries and technologies in which SMEs play a critical role. In this context, strong producer-user interactions, which are an essential source of innovation and technology utilisation, need to be built. But this has proven difficult in Korea, where the stable relationships between large business groups and SMEs (as in the Japanese *keiretsu*), or between multinational enterprises/public research institutes and SMEs (as in Chinese Taipei) have not been established (Lim, 2005). This gap has led several government agencies to pursue various types of cluster policies, which are discussed in section 3.9.

Box 3.23. Main SMBA programmes in support of technological innovation in SMEs

To strengthen the innovation capabilities of SMEs, SMBA is pursuing various policies to: foster innovative SMEs; reinforce the networking of industry, academia and research institutes; and promote the commercialisation of developed technology. Some of its main programmes are:

Fostering Innovative SMEs (Inno-Biz). Prospective SMEs with technology development and innovation capabilities are designated as "Inno-Biz" and fostered as a core engine of growth. Under this scheme, the SMBA identifies innovative SMEs with superior technologies which are able to raise their technological level through their own technological innovation system. The purpose is to ensure that they will develop into global blue-chip firms by providing comprehensive support through schemes such as technology assurance and preferential treatment for credit loans.

Korea Small Business Innovation Research (KOSBIR) system. Under this system, government ministries and government-financed institutions are required to allocate at least 5% of their R&D budget to support SMEs' technology development and to cover R&D expenses of SMEs capable of separately developing technology. SMBA spent approximately USD 920 million in 2005 on this system.

SMEs' Technology Innovation Programme. SMEs capable of developing technologies without support can recover up to 75% of the expense of developing new products or enhancing product quality. The financing ceiling is USD 300 000 for two years for strategic tasks or USD 100 000 for one year for general tasks. Under this programme, the SMBA supported 1 912 SMEs in 2005 alone.

Industry-University-Research Consortium Programme. Various policy measures have been put in place to reinforce networking for technological innovation among enterprises or among industry, academia and research institutes. The measures include the Industry-University-Research Consortium Programme, which seeks to boost the technological capabilities of manufacturing SMEs through collaborative technological development with universities or GRIs. About 220 consortia were formed in 2005, to support 2 700 SMEs in developing new technologies.

Transferred Technology Development Project. This project aims to prevent superior technologies from being discarded and to enhance the technological innovation capabilities of SMEs. To this end, the SMBA covers the additional development costs required to commercialise transferred technologies owned by universities, research institutes and businesses. In 2005, the SMBA supported about 90 such tasks.

Source: SMBA website (*www.smba.go.kr/smba/main/english/index.jsp*), accessed December 2007.

In addition, there has been a drive to promote research capacities in SMEs, with the government initiating a broad array of incentive schemes including direct R&D funding, tax waivers, tariff exemption for R&D equipment, and exemption from military service for research personnel. Indeed, in a wide-ranging analysis of Korean technology promotion policy measures, STEPI (2006) identified more than 250 government programmes, the vast majority of which targeted innovation by SMEs. These included business incentive policies, public R&D programmes, and even infrastructure policies and were under the authority of a variety of ministries and agencies, including MoCIE, MoST, MIC and the Small and Medium Business Administration (SMBA). The latter, which was founded in 1996, operates several schemes to support SMEs, covering areas such as entrepreneurship, human resources, financing, marketing and innovation. A selection of its innovation promotion support schemes, aimed largely at existing (as opposed to start-up) SMEs, is provided in Box 3.23.

Besides encouraging existing SMEs to innovate and conduct their own R&D, another popular policy approach with many governments has been to catalyse the development of new (often high-technology and/or innovative) firms, for example, through university spin-offs. In the immediate aftermath of the Asian financial crisis, the government enacted the Special Law to Promote Venture Firms (1998) with a view to achieving economic recovery through the creation of knowledge-intensive SMEs. The law was later revised to include some articles for activating spin-offs from public research institutes and universities. Under this law, professors and researchers can obtain a temporary release of up to three years from their home universities and institutes for running a venture business. The law also allows professors and researchers to locate their operations in the laboratories of their home universities and research institutes. The SMBA has been responsible for pursuing policies to promote spin-offs from universities and research institutes. One prominent policy is the Incubation Centre Promotion programme. In 2007, the SMBA provided around USD 15 million for 278 incubation centres, located mostly on university campuses. Around 4 000 venture companies are currently located in these incubators and have benefited from financial support and consulting services. Researchers and professors with more than five years experience running spin-offs from universities and research institutes which employ fewer than ten workers qualify to apply for this programme.

In sum, government intervention in support of research and innovation in SMEs is extensive. Thousands of new private research institutes have been established in SMEs and thousands of venture firms have been established as well, many of which are spin-offs from HEIs and GRIs. To some extent, however, the increasingly powerful performance of the largest companies and the spectacular growth in their R&D activities has tended to mask these successes.

3.7. Improving the framework conditions for innovation

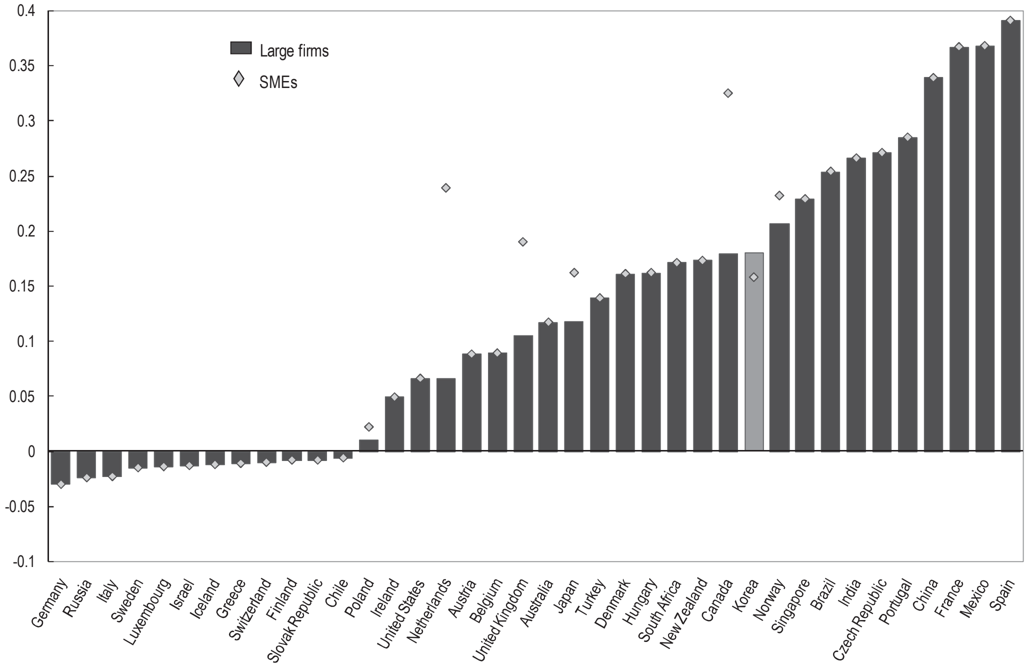
Besides their direct spending on research, governments are increasingly paying attention to improving the framework conditions for innovation. The Korean government is no exception in this regard and has introduced new legislation and programmes that deal with tax incentives for innovation, innovation financing, intellectual property rights regimes, and the building of lead markets through public procurement of products and services. This section discusses each of these topics in turn.

3.7.1. Tax credit schemes

In 2007, 21 OECD countries offered tax relief for business R&D, up from 12 in 1995 (18 in 2004), and most have tended to make it more generous over the years. The appeal of R&D tax credits stems from their non-discriminatory nature in terms of research and technology fields or industrial sectors. As Figure 3.16 shows, Korea's tax treatment of R&D is among the more generous. It is also interesting to note that large firms seem to benefit more than SMEs, a situation apparently unique to Korea among the countries surveyed.

Prior to the 1990s, direct financial support was the preferred instrument of the Korean government. That is not to say that tax incentives were non-existent; on the contrary, the Korean government made strategic use of tax incentives to encourage technology imports during the period of catch-up. But by the 1990s, tax incentives had become progressively more important and their focus had clearly shifted towards encouraging the development of indigenous technological capabilities. Among these were tax credits for technology and expenses for labour force development, tax exemption for the real estate of private enterprises' affiliated research centres, tax exemption for research devices and samples, and duty abatement or exemption on goods for research.

Figure 3.16. Tax treatment of R&D in OECD and non-member countries[1] (2007)



1. Tax subsidy to R&D calculated as 1 minus the b-index, defined as the present value of before tax income necessary to cover the initial cost of R&D investment and to pay corporate income tax.

Source: Warda (2007), Generosity of Tax Incentives", presentation at the TIP Workshop on R&D Tax Treatment in OECD Countries: Comparisons and Evaluations, 10 December, Paris, based on national sources.

More recently, tax incentives for S&T innovation have continued to evolve. For example, since 1992, tax incentives for large firms have been progressively reduced because large firms' R&D activities no longer appear to warrant strong support from government policy interventions. Other changes have aimed at improving the targeting of tax incentives towards innovation policy goals. The targets include: *i)* the service industries, especially those that are software-related, as the services sector's economic importance has increased; *ii)* raising the R&D personnel tax exemption in view of the importance of human resources in the knowledge-based economy; and *iii)* strengthening the tax exemption for industry-academic R&D collaboration in order to promote technology transfer and open innovation. Moreover, various tax incentives for HRST, such as income tax deductions for researchers, special tax treatment for foreign HRST, income tax exemptions for research expenses, and temporary tax exemption for HRST sent abroad have been implemented. Currently, a total of 17 tax incentive measures are in operation to promote private R&D activities. Box 3.24 presents a selection of these.

Box 3.24. Selection of tax incentive measures for increasing business innovation capacity

Tax credit for research and labour force development costs: *ex post* credit against corporate tax or income tax on research and labour force development costs for each taxable year at a prescribed rate (Article 10 of the Tax Exemption Limitation Act).

Tax credit for equipment investment related to research and labour force development: credit against tax on equipment investment related to research and labour force development or new technology commercialisation at a prescribed rate (Article 11 of the Tax Emption Limitation Act).

Local tax breaks related to real estate for enterprise research institute annexes: local taxes (acquisition, registration and property taxes) related to real estate waived for enterprise research institute annexes (Article 282 of the Local Tax Act).

Income tax credit for the R&D activity costs of SME researchers: credit against taxable income of a specific amount if personnel in charge of research at an SME research institute receive funds for research activity expenses as per the wage regulations (Article 38 of the Enforcement Decree of the Income Tax Act).

Customs exemption or reduction for goods for industrial technology R&D: reduction and exemption for 80% of the customs duty imposed on machines, tools and materials for R&D as separately announced among advanced machines, tools and materials imported and reagents, parts, goods, raw materials and samples for R&D (Article 90 of the Customs Act).

Source: MoST (2007b), *Innovation for the Future: Science and Technology in Korea*, Ministry of Science and Technology, Seoul.

More specifically, the R&D tax credit scheme has undergone many changes over the past 15 years (Table 3.19). It has two forms: an incremental tax credit available to large firms and a volume-based tax credit. SMEs can claim one or the other (but not both) of these credits. In 2005, 22% of large firms and 44% of SMEs surveyed benefited from the tax credit. The average tax credit in 2005 was USD 5.9 million for large firms and USD 0.13 million for SMEs.

Table 3.19. History of the Korean tax credit scheme

1991	10% volume tax credit of R&D expenditure +10% incremental tax credit (large firm)
	10% volume tax credit of R&D expenditure +15% incremental tax credit (SME)
1992	5% volume tax credit of R&D expenditure +25% incremental tax credit (large firm)
	10% volume tax credit of R&D expenditure +25% incremental tax credit (SME)
1993	5% tax credit of R&D expenditure (15% for SME) or 50% incremental tax credit
1999	Changed base periods from two previous years to four previous years in incremental tax credit
2001	Only 50% incremental tax credit applied for large size firm
2003	Only 40% incremental tax credit applied for large size firm
2004	Reduced upper limit of corporate income tax rate to 10% from 12% for SME and to 13% from 15% for large firm
2007	Abolished reserve fund for R&D expenditure
	Extended sunset periods towards 2009

Source: Song (2007), "The impact of fiscal incentives for R&D investment in Korea", Presentation at the TIP Workshop on R&D Tax Treatment in OECD Countries: Comparisons and Evaluations, 10 December, Paris.

There is an extensive literature on the role and effectiveness of tax incentives as a promoter of R&D investment. While evaluations have produced widely varying findings, there is clear agreement on the effectiveness of tax credits for stimulating R&D: additional tax credits will normally produce additional R&D expenditure and will generally be cost-effective. In terms of the choice between tax credits and government subsidies through grants, the research clearly demonstrates that the tax credit is preferred (by businesses) and is the most influential of all forms of government support. The tax credit is also preferable in terms of incurring the lowest level of compliance costs (Sawyer, 2005). A detailed analysis of Korean programmes to promote industrial R&D seems to confirm these findings (Song, 2007): for large firms at least, R&D subsidies have relatively limited influence; tax credits are a more effective way of encouraging R&D. More controversially for Korean policy, the same study suggests that for smaller firms, subsidies operate mainly to support R&D that would have been performed anyway, *i.e.* there is no additionality, while tax credits also have a limited impact.

3.7.2. Improving innovation financing

Most government financial support for technological innovation in the private sector employs loan financing and loan guarantee programmes (Table 3.20). It seeks to address a market failure concerning information asymmetry and collateral problems associated with bank financing of high-technology SMEs. Such support started in the late 1970s when the government set up special-purpose banks and funds. For example, the Korean Development Bank (KDB) started a loan programme for technology development in 1976, while SMBA set up a loan programme for SMEs' technology development in 1977. As demand for indigenous technological development increased in the 1980s, financing supports for R&D investment and commercialisation were developed further, with the SME Bank (now Corporate Bank) and the Kookmin Bank starting loan programmes for the private sector.

Besides banks' loan programmes, SMEs can borrow "policy funds" from the SMBA at low interest rates to promote investment in facilities, restructuring, commercialisation of new technologies, and to assist start-up activities. The total policy funds allocated in 2005 amounted to more than USD 3 billion. For indirect financing services, the SMBA also provides a security assurance service for SMEs ineligible for bank loans owing to a lack of collateral and technology. This service allows these SMEs to borrow needed funds from the KCGF (Korea Credit Guarantee Fund) and its local offices and from the Kibo Technology Fund (see Box 3.25). Significantly, these organisations conduct technology appraisals, thereby increasing the transparency of opportunities and risks associated with new technology investments. This transparency should in turn increase the supply of new technology-based enterprises for banks and other investors (including venture capitalists) to invest in, as well as help to overcome one of the key barriers to technology transfer.

Table 3.20. Public financial support programmes for private innovation, 2005

Ministry	Supporting tool	Technology innovation stage	Project name	Expenditure in 2005 (KRW millions)
Small and Medium Business Administration (small business corporation)	Loan	Development and commercialisation	Supporting Development and Intellectual Property Technology Commercialisation	92 441
Small and Medium Business Administration (small business corporation)	Loan	Development and commercialisation	Supporting Small and Medium Venture Establishment	428 340
Small and Medium Business Administration (small business corporation)	Joint investment	Development and commercialisation	Financing Establishment Investment Association	150 000
Ministry of Commerce, Industry and Energy	Loan	Development and commercialisation	Financing Industry Technology Development	100 000
Ministry of Commerce, Industry and Energy	Joint investment	Development and commercialisation	Financing Parts and Materials Investment Association	3 000
Ministry of Information and Communication	Loan	Development and commercialisation	Applied Technology Development Supporting Project	195 000
Ministry of Science and Technology	Loan	Development and commercialisation	Research Development Financing Project	88 000
Korean Intellectual Property Office	Loan	Development and commercialisation	International Application Promotion	1 173
Korean Intellectual Property Office	Loan	Development and commercialisation	Intellectual Property Transfer Promotion	914
Ministry of Culture and Tourism	Loan	Development and commercialisation	Financing Culture Product Development	21 546
Ministry of Environment	Loan	Development and commercialisation	Financing Fostering Recycling Industry	70 000
Ministry of Gender Equality and Family	Loan	Development and commercialisation	Supporting Women Technician Establishing Firms	10 000
Sum				**1 160 414**

Source: STEPI (2006), *R&D Scoreboard*, Science and Technology Policy Institute, Seoul.

Box 3.25. The Kibo Technology Fund

The mission of the Kibo Technology Fund is to contribute to the national economy by providing credit guarantees to facilitate financing for new technology-based enterprises while promoting the growth of technologically strong SMEs and venture businesses. It has three main functions, namely technology guarantee, technology appraisal and business consultation. The first two of these are further described below.

The **technology guarantee scheme** aims to encourage financial institutions to lend to SMEs with viable projects and good prospects of success but which are unable to provide adequate collateral or which do not have a suitable record of financial transactions to prove their creditworthiness. The usual process of technology guarantee schemes is as follows. A potential borrower who cannot meet a bank's lending criteria – which usually means the borrower cannot provide satisfactory collateral – is referred by banks to Kibo. Bank branch staff carry out an independent appraisal of the loan guarantee application to investigate the borrower's creditworthiness, the use to which the loan is to be put, the borrower's prospective ability to service the debt, and above all, the quality of the technology. In most cases, the banks rely on investigation and approval by Kibo for their decision on the extension of a loan. If it is found that the case is suitable for a guarantee, the borrower returns to the bank with a letter of guarantee issued by Kibo and takes out the loan. Usually, the guarantee involves the payment of a guarantee fee, the amount of which depends on the amount being guaranteed. Since its foundation, Kibo has provided a total of more than USD 100 billion worth of guarantees to SMEs that possess prominent technology and business prospects but lack security for financing.

Meanwhile, in order to provide objective and fair evaluation on an intangible asset (technology), Kibo has operated **technology appraisal centres** (TACs). The Korean government has accredited TACs as technology evaluation institutions under the Act on Special Measures for the Promotion of Venture Businesses, the Invention Promotion Act, and the Foreign Investment Promotion Act. Each TAC has specialised teams in charge of various industries, including machinery, electrical appliances and electronics, telecommunications, materials and metals, chemical engineering, etc. The heads of each team are either appraisal experts with doctoral degrees in engineering and business administration, technical experts, or certified public accountants. Each team also includes members with expertise and practical experience in credit investigation and evaluation of business prospects. In addition to these in-house experts, TACs manage a pool of specialists which includes professors and technical experts from both private and public institutions to secure objectivity and fairness in its evaluations. In total, more than 74 000 evaluations had been made by 2006, and the TACs are evolving both in quantity and quality by continuously developing new evaluation models and acquiring advanced evaluation techniques.

Source: Kibo Technology Fund website (*http://eng.kibo.or.kr/about/about02_01.asp*), accessed August 2008.

Besides providing loan financing and loan guarantee programmes, the Korean government has sought to stimulate private venture capital markets with a view to enhancing high-technology venture firms and start-ups in Korea (see Figure 3.17 for a brief history of government initiatives). It has revised laws related to financial markets and provided funds to be injected into venture capital investment funds. For example, to build a foundation for the stable growth of venture capital, the SMBA created a Fund of Funds of around KRW 1 trillion (for the period 2005-09) for financing investment funds for early-stage venture businesses. The objective is to provide stable financing that is able to meet the needs of the capital market in the long term. Furthermore, the SMBA is revitalising markets other than KOSDAQ to provide a stable basis of growth for venture capital. Finally, to boost mergers and acquisitions (M&A) in venture businesses, the SMBA has introduced streamlined procedures for M&A and business transfers. Further to this, policy efforts are being made to facilitate M&A of venture companies with the expectation that this will facilitate strategic alliances among enterprises and encourage the flexible movement of technical services.

Figure 3.17. Development of venture capital

Initial phase (1974-86)	Growth phase (1986-98)	Overshooting phase (1998-2000)	Consolidation phase (2001-04)	Turnaround phase (2005-)
• Korea Technology Advancing Corporation (KTAC) founded by Korea Institute of Science and Technology (KIST) in 1974 • Three more new technology finance companies established under Financial Assistance to New Technology Businesses Act (1986)	• Support for Small and Medium Enterprise Establishment Act enacted in 1986 • 12 venture capital companies (VCs) founded in 1986 and the number of VCs increased to 72 in 1998 • Small and Medium Business Administration (SMBA) organised in 1996 • Act on Special Measures for the Promotion of Venture Businesses enacted in 1997	• VCs proliferated and the number of VCs peaked at 147 in 2000 • 194 venture capital funds (VC funds) were launched in 2000 • VCs invested KRW 2 trillion in 2000	• The number of VCs decreased to 105 in 2004 • The VC fund formation and VC investment significantly contracted	• Government implemented strong measures announced in December 2004 to reactivate venture ecosystem • Korea Fund of Funds with the target commitment of KRW 1 trillion was launched in 2005 • The VC fund formation and VC investment significantly increased in 2005

Source: Ilshin (2007), Venture Capital in Korea", Presentation to the OECD Country Review Unit, October 2007, Seoul.

3.7.3 Protecting intellectual property

The agency primarily responsible for protecting intellectual property is the Korean Intellectual Property Office (KIPO), though a number of other agencies, such as SMBA, provide IPR-related support programmes. As patent applications have risen rapidly in Korea, KIPO has increased the number of its examiners. Improvements in patent administration now mean that the examination period has been reduced from about 36 months in 1995 to 27 months in 2005. Co-operation with various international organisations has also been stepped up. For example, the Korean government has become a signatory of the Patent Co-operation Treaty (PCT) operated by the World Intellectual Property Organisation (WIPO), which has led to a very rapid increase in the growth of PCT patent applications. A list of policies relating to the creation, protection and application of patents is provided in Table 3.21.

Table 3.21. Classification of KIPO's IPR-related policies

	Creation	Protection	Application
Direct support	Promote common criteria Activate duty development	Provide patent conflict legal structure Operate patent attorney consulting centre Grant rewards for reporting fake products	Produce patent technology trial products Invest in Funds of Funds (venture capital)
Directly supporting infrastructure	Organise invention promotion events Encourage inventions by women	Protect international intellectual property Promote semiconductor arrangement design	Evaluate value of patented technology Operate Patent Technology Commercialisation Association
Supporting infrastructure	Promote research on intellectual property Research patented technology trends Hold the Republic of Korea Trademark Exhibition Promote creation of core semiconductor design property	Operate WIPO Korea Trust Fund Send KIPO personnel to European Patent Office Participate in free trade agreement IP negotiations Construct traditional knowledge database Manage and protect patented micro-organisms	Build and operate Patent Technology Transfer System Establish the basis for patent product distribution and sales Operate and improve patent information system Build patent information database Learn about patent administration through international co-operation

Source: STEPI (2006), *Korean R&D Scoreboard*, Science and Technology Policy Institute, Seoul.

3.7.4. Public procurement and lead markets

Demand is a major potential source of innovation, yet its critical role as a key driver of innovation has still to be recognised in government policy. Public demand, when oriented towards innovative solutions and products, has the potential to improve delivery of public policy and services, often generating improved innovative dynamics and benefits from the associated spillovers. In this context, public procurement has emerged as a potentially powerful instrument to drive research and innovation by providing "lead markets" for new technologies. Procurement competition has shifted from a sole focus on price to the provision of solutions that offer the greatest advantage to users over the whole life of the purchase. Firms are attracted to invest in research by the reduced risks associated with the presence of an informed customer waiting for the resulting innovations. Moreover, innovations developed in this way may then move on to further deployment in private-sector markets (European Commission, 2005).

In principle, the potential for using public procurement as an instrument for innovation is considerable. Public procurement accounts for significant proportions of GDP in OECD countries. It represents a key source of demand for firms in sectors such as construction, health care and transport. Nonetheless, public procurement as an innovation policy has long been neglected or downplayed (Edler and Georghiou, 2007), although this has changed in the last few years, with a number of European countries (and the European Commission) looking to develop effective demand-side innovation policies, with public procurement prominent among them.

Korea already has good examples of public and private R&D partnership programmes involving public procurement of large-scale technological outputs, such as TDX systems and CDMA commercialisation technologies. Besides these large-scale P/PPs for public procurement, there exist a few direct public procurement programmes which aim to develop technological innovation by the private sector. Prominent among these is the SMBA's New Technology Purchasing Assurance programme, which was established in 1996 to promote technological innovation in SMEs. This programme provides SMEs government procurement opportunities for their technologically innovative products. Government agencies – including the Defence Ministry, KEPCO (Korea Electric Power Corporation), KOGAS (Korea Gas Corporation) and the Korea Railroad Corporation – commission SMEs to develop new technologies with the assurance that they will purchase the product. The SMBA finances the technological development of SMEs, while public institutions purchase the products for a certain period of time. In 2006, the SMBA had supported 120 technology development projects involving 35 agencies and a procurement budget of KRW 160 billion (Table 3.22). There are plans to expand the participation of government agencies, public institutions and private business, and a target system has been introduced, which will require 10% of total procurement in 2010 to be dedicated to this programme (STEPI, 2006).

Table 3.22. Trends in the New Technology Purchasing Assurance programme

	2002	2003	2004	2005	2006
Agencies involved	1	1	8	26	35
Number of projects	13	49	40	77	120
Procurement budgets (KRW billions)	9	40	40	100	160

Source: STEPI (2006), *Korean R&D Scoreboard*, Science and Technology Policy Institute, Seoul.

3.8. Internationalisation

Indicators such as relatively low levels of FDI, low levels of foreign investment in Korean research, weak international research collaboration, and the relatively small number of foreign researchers working in Korea all suggest that the Korean innovation system is only loosely linked to international knowledge networks. Against this background, the Korean government has been enacting policy initiatives to increase the internationalisation of its research base. These include promoting international R&D collaboration, attracting foreign R&D centres to Korea and attracting human resources in the form of students and skilled researchers to study and work in Korea. Some of the measures associated with these objectives are further discussed below. The section begins with a brief description of the landscape of government intervention in this area.

3.8.1. Main players in promoting internationalisation

As might be expected, several ministries have started their own international programmes (Table 3.23). The two biggest are MEST's Internationalisation Programme of S&T and MKE's International Joint Research and Development Programme. Some of their sub-programmes share common goals, although the MKE focuses upon industrial R&D. With rising interest in international R&D collaboration in Korea, MoST established the Korea Foundation for International Co-operation of Science & Technology (KICOS) in 2004. KICOS aims at making Korea the Northeast Asia R&D hub by attracting prestigious foreign research institutes to Korea. Its role has since expanded to include the management of MEST's international S&T co-operation programmes. It also supports institutional collaboration in co-ordination with GRIs, such as KIST, which has established its own international networks over the years, particularly with Russia and China. Furthermore, as part of the 577 Initiative, an inter-ministerial committee has been established for co-ordinating international joint research policies and programmes which are carried out by each ministry.

Additionally, the government is promoting the globalisation of venture businesses through the establishment of overseas small business development centres. These are designed to help SMEs intending to enter an overseas market to locate a new market. As of 2006, 24 overseas development centres in 12 countries had helped 300 venture firms enter overseas markets. The SMBA, together with foreign investment institutions, has also set up the Global Star Fund, a specialised fund to help small and medium venture firms enter global markets, including advanced economies such as the United States, the

EU and China, as well as emerging markets in Asia. Two funds had been set up by 2006, valued at USD 100 million.

Table 3.23. Major S&T internationalisation programmes, 2006

Ministry	Main programme (starting year)	Programmes	Categories	Budget (2006) (KRW millions)
MoST	International S&T co-operation programme (1985-)	Global joint R&D programme	Bilateral/multilateral global research lab	12 500
			Global biodiversity networking	
		Inter-Korean S&T co-operation programme		650
		Global R&D networking programme	Overseas S&T co-operation centres – Multilateral co-operation networking	11 595
		Northeast Asia R&D hub programme		31 000
	ITER (2004~)			9 500
MoCIE	International Joint R&D Programme (1990-)	EUREKA		19 000
		Infrastructure of international industrial R&D		
		Hosting foreign R&D centre		
Korea Food and Drug Administration	International Co-operative Research Programme (2006-)	Safety-related OECD/WHO research		2 800
Rural Development Administration	International collaborative research programme on agriculture (1983-)	International organisation related research	Standards/regulation, developing countries, North Korea	2 785
Ministry of Education and Human Resource Development	International vaccine programme (1995-)	WHO-IVI support (30%)		3 423
	Infrastructure for basic science (2003-)	Inviting foreign researchers		3 800
		(Exchange researchers)		(10 000)

Source: MOST.

3.8.2. Promoting international R&D collaboration

Research collaboration with the EU, Japan and the United States constitutes more than 60% of the projects of MEST's Global Joint R&D programme. The advanced level of R&D in these regions provides a strong incentive to collaborate on account of the learning benefits. However, the number of projects with developing countries has risen sharply in the last few years, especially with developing Southeast Asian countries. This would seem to indicate a shift in MEST's position away from the sole objective of absorbing foreign cutting-edge research and towards a broader set of objectives that includes building collaborative links with neighbouring countries in the region. The Global Joint R&D programme also has several sub-programmes with specific objectives. These include the Global Research Laboratory programme with leading international research laboratories, funding programmes in accordance with international S&T bilateral agreements, and a programme for establishing a network for biodiversity.

In addition, several R&D centres have been set up across the world to build collaborative links with local research groups. The locating countries largely overlap with those ranked high in ICRD projects (the exception here is Japan), notably EU countries and the United States. Korea is also participating in international S&T programmes such as the EU Framework Programme (see Box 3.26), CERN and ITER.

Box 3.26. Korean participation in the European Union's Framework Programme

When compared to the active participation of other non-EU countries such as China, Singapore, Thailand and Vietnam, Korea has shown a relatively low level of engagement in the EU's Framework Programme (FP). This has been explained by a mix of factors, including a lack of awareness of the FP, insufficient support systems, and minimum exposure of Korea's S&T capacity in the EU region. To improve levels of Korean participation, MEST launched the Korea-EU Science and Technology Co-operation Advancement Programme (KESTCAP) in mid-2008. KICOS and the Germany-based Korea Institute of Science and Technology (KIST)-Europe will take the lead in developing collaborative activities with EU partners.

Source: MEST press release, 15 July 2008.

3.8.3. Attracting foreign R&D centres to Korea

By far the largest proportion of funding for international S&T in recent years has gone to a programme funded by MEST which is dedicated to the establishment of a Northeast Asia R&D Hub in Korea. The most striking characteristic of this programme is its aim to attract branches of excellent public and non-profit R&D organisations, such as the Institut Pasteur of France and RIKEN of Japan. The levels of support and presence differ. For instance, the Institut Pasteur of Korea (IP-Korea) has new buildings and large subsidies, whereas RIKEN has a relatively small office on the campus of Han-Yang University.

In parallel, MKE is working to attract private firms' R&D centres and has hosted 18 new R&D centres over the period 2003-06. These are the R&D centres of Microsoft, IBM, Intel (now exited), Motorola, Delphi, Texas Instruments, Siemens, HP, Sun, AMD, DuPont, ATI, Agilent, STMicroelectronics, National Semiconductor, Photronics, JATCO, and On-Semi. In addition to MKE's efforts, local governments, such as Gyeonggi Province, have been active in trying to attract foreign R&D centres. However, the ability of local governments to attract foreign R&D centres is weaker than in other East Asian countries, perhaps because of the smaller size of Korean regions when compared to their Chinese counterparts. As a result, such efforts depend largely on the central government.

It is important to understand why foreign firms choose to locate R&D centres overseas. Most often, they have done so to adapt technologies for local needs and markets. Although a medium-sized country of almost 50 million people, Korea is dwarfed by its neighbours, Japan and China. China in particular has benefited from such R&D investments by multinational enterprises (MNEs), which are often associated with the MNEs' overseas production facilities. In Korea (and Japan), there are relatively few foreign companies with production facilities and therefore less likelihood of foreign R&D centres being set up.

However, in recent years, there has been a shift in reasons for locating R&D facilities abroad, as technology sourcing and monitoring have become increasingly important. The availability of highly skilled (and preferably cheap) labour is an important driver for this type of investment, as is the presence of centres of excellence which can serve as outposts to monitor new technological developments. Such R&D work can be intended for regional or global markets and is determined primarily by the quality of the national innovation system (UNCTAD, 2005). Crucial to the attraction of such R&D investments is the establishment of a world-class science system with high-performance research units, a highly developed infrastructure and a supply of excellent human resources (OECD, 2006b). It is this type of investment that Korea hopes to attract through these government programmes.

3.8.4. Attracting human resources

In relation to international mobility of HRST, it is perhaps more the low utilisation of foreign expertise than the "brain drain" of domestic talent that is problematic for Korea. Since the 1960s, attracting and deploying Korean scientists and engineers who were educated and living abroad has been a strategic issue. US higher education institutions in particular have been a significant source of doctoral education. [12] Until the 1970s, substantial public financial support was provided for the repatriation of Korean scientists and engineers. However, as the expansion of education generated more well-qualified holders of doctoral degrees, the need for public intervention to attract recipients of doctorates from foreign universities has diminished.

This picture has again begun to change as the Korean government has sought to attract highly skilled researchers from aboard – not so much to make up for quantitative shortfalls, but rather to make qualitative improvements to the Korean science base. In this regard, two longstanding government subsidy programmes were put in place during the 1990s to attract foreign researchers to Korea. The first and largest is the Brain Pool programme, which provides financial and logistical support for up to two years to overseas scientists and engineers who wish to collaborate with researchers in universities and R&D institutes in Korea. From 1994 to 2006, 1 220 foreign researchers were employed at 207 institutes through this programme, although 37% of them were Korean emigrants. The Korean government has also initiated a Post-doc Fellowship Programme for researchers from developing countries, with 225 researchers from 25 countries benefiting in the ten years up to 2006.

Compared to world-class research regions, such as the United States and leading European countries, the level of inward mobility is clearly modest. The Korean government has therefore sought to attract more foreign researchers with its new World Class University programme (Box 3.27). Around USD 800 million is to be spent over five years to support universities to build new research departments around leading foreign academics and to employ Nobel Prize winners and the like to take up visiting posts. In addition, proposals for an International Science and Business Belt (see section 3.4) are intended to attract leading scientists from around the world who will want to make use of the state-of-the-art equipment on offer and to become part of a global scientific hub.

Box 3.27. World Class University programme

MEST intends to invest KRW 825 billion over the next five years to help foster research at universities under its World Class University programme announced in 2008. The programme is designed to recruit top researchers from around the world to collaborate with Korean scientists in key fields, including NBIC (nano-bio-info-cogno) fusion technology, space science, national defence, disruptive and breakthrough technologies, energy, embedded software, bio-pharmaceutics, neuroscience, financial mathematics, financial engineering, digital storytelling, and human resource and organisational development studies.

The programme will fund three types of project:

- Support will be given to universities that hire renowned scholars from abroad on a full-time basis to establish and operate new departments at the undergraduate or graduate level in collaboration with Korean professors.
- Universities have been asked to hire one or two foreign academics as full-time professors in existing departments or research institutes to lecture or conduct joint research with Korean academics.
- Support will go to universities that invite Nobel Prize winners and world-class academics as visiting professors.

For selected universities, MEST plans to offer full wages, research fees and lab establishment fees for foreign scholars. A subsidy of KRW 200 million will be granted per foreign scholar to secure office space, research facilities and lab equipment. Up to KRW 35 million will also be granted per expert staff employed by the universities to assist the foreign professors. Foreign scholars and Korean professors who participate in collaborative studies will also be provided with approximately KRW 100 million per person. For selected universities, the ministry will fund 30% of total project fees in the form of indirect and incidental expenses.

Source: MEST press release, 20 June 2008.

To facilitate the inflow of foreign scientists and engineers, Korea has three preferential visa programmes: the Science Card of MoST, the GoldCard of MoCIE and the IT Card of the MIC. Beneficiaries of the Science Card programme receive a five-year multiple-entry visa, regardless of country of origin, and those qualifying for the GoldCard and IT Card programmes obtain a three-year multiple-entry visa. From 2000 to 2006, 2 260 foreign scientists, engineers and IT professionals benefited from these preferential visa programmes.

As well as focusing upon attracting foreign researchers to Korea, the government is looking to make better use of Korean scientists and engineers working in different parts of the world. In this regard, MEST is providing funding for the Korean Scientist and Engineers Network (KOSEN), a virtual network of almost 70 000 scientists and engineers, including over 5 000 expatriate researchers. MEST has also organised societies of Korean scientists and engineers in 11 countries, which have undertaken, among other things, to collect information on Korean scientists and engineers in eight countries. This is an important set of initiatives, as the Korean diaspora offers a unique resource that could be drawn upon to foster international collaboration, provide independent evaluation and assessment, etc.

In addition to attracting established researchers, MEST has also sought to attract more foreign students to Korean universities in order to increase the pool of foreign talent in Korea. The Study Korea Project, launched in 2004, provided scholarships to 1 500 students from developing countries in 2008, a figure that is set to double by 2012. In addition, the Study Korea Project Development Plan (see Box 3.28) seeks to double the number of foreign students in Korea to 100 000 by 2012 (a previous target of 50 000 by 2010 was already exceeded by 2007) and to broaden their countries of origin. International students in S&T fields are now mainly from Southeast Asian countries. MEST also hopes for positive impacts on Korea's economic and diplomatic development, and expects foreign graduates to serve as a potential driving force, by helping counter low fertility rates and rapid population ageing.

Box 3.28. Study Korea Project Development Plan

The Study Korea Project Development Plan has the following elements:

- MEST will develop study programmes that specialise in areas of Korea's comparative strength such as information technology. The idea is to induce more foreign countries to send excellent students on their own government scholarships. At the same time, the number of Korean government scholarships available to foreign students will rise to 2 450 in 2010 and to 3 000 by 2012, up from 1 500 in 2008.
- In order to diversify the nationalities of foreign students in Korea, MEST will conclude educational arrangements with various foreign governments as a basis for facilitating student exchanges, and will ease regulations to encourage joint curricular operation between Korean and foreign universities.
- Universities will receive a subsidy of KRW 2 billion to open more English-only and Korean-language classes starting in 2008, up from KRW 400 million in 2007. Universities will also be encouraged to expand their on-campus accommodation for foreign students.
- Rules will be eased for student visa holders, so that foreign students may have more opportunity to find jobs in Korea. MEST will also encourage universities and industries to develop collaborative internship programmes for foreign students.

Source: MEST press release, 5 August 2008.

Thus, the Korean government has put in place an impressive array of initiatives to improve the internationalisation of its science and innovation base. Flagship projects, such as the International Science and Business Belt (ISBB) and the appointment of Nobel laureates to Korean universities, will send a strong signal of Korea's seriousness as a place for leading-edge science. However, the success of these and similar projects cannot be taken for granted. Indeed, a number of fundamental barriers to the internationalisation of Korean science remain. They include language and cultural barriers, which make Korea a less attractive destination for foreigners. The increasing use of English in Korean research centres and a growing international awareness of the richness of Korean arts and culture should improve the situation, but it will obviously take time to see a major impact. A further barrier concerns the education system, which is perceived negatively – an important consideration for foreign scientists with children – as evidenced by the growing tendency of Korean parents to send their children to schools outside of Korea. Finally, the vast majority of universities have weak research capacities and thus have a low international profile. This makes them relatively unattractive destinations for foreign researchers.

While these challenges in no way undermine the potential value of the flagship projects announced, they highlight the need for *systemic* solutions to the internationalisation issue. Moreover, they also point to the need for broad grassroots efforts to improve the science base rather than efforts in a few selected sites. International scientific exchange and mobility is more likely to occur in areas of fundamental science and is often concentrated in universities. By improving the conditions for research in a broad set of universities and increasing the amount of fundamental research carried out, international scientific exchange and mobility will be boosted. Acknowledging the likelihood of such effects should provide a pretext for government to 'mainstream' its internationalisation agenda across a large section of its programmes for science and innovation.

3.9. Regionalisation

Governments across the OECD are increasingly turning to innovation policy to promote development in sub-national regions. Given Korea's unbalanced regional development, the government has also looked to use science and innovation policy interventions as a means to promote economic development beyond the Seoul metropolitan area. This section first presents these efforts with respect to R&D resources, followed by a discussion of the government's regional cluster policies. Some of the intermediaries involved in promoting regional innovation, including technoparks and business incubators, are then briefly presented. Finally, an appropriate future course for Korean regional innovation policy is considered.

3.9.1. Rebalancing the regional distribution of R&D resources

The STI data presented in Chapter 1 show clearly the dominance of the Seoul metropolitan area in Korean R&D. This concentration of S&T resources has been largely taken for granted during Korea's rapid industrialisation process but has recently been questioned as the government has pushed for more balanced regional development. This is because innovation, and by extension, science and technology, are increasingly viewed by policy makers as vital to regional economic growth. Underdevelopment of innovation resources is seen as an obstacle to a region's economic development. Accordingly, the government increased the share of the public R&D budget in the provincial cities from around 27% of the total in 2003 to 40% by 2007. This has required major adjustments (and increased investments) in ministries' R&D spending portfolios.

While the increased attention to regions has been widely welcomed, some argue that it may in fact weaken national R&D capability, particularly if scientific excellence is compromised in a push to increase research funding in less developed regions. To avoid this, one solution has been to establish new national research centres or to move existing ones away from the Seoul metropolitan area to implant ready-made capabilities. The danger is that such centres may remain largely disconnected from the regional economy and thus undermine the objective of boosting economic development. To minimise this risk, there have been attempts to set up research centres that are intended to link with local industries. Much of this activity has been carried out in the context of innovation network and cluster policies.

By far the best known cluster of scientific resources outside of the Seoul metropolitan area is the Daedeok Special R&D Zone created by MoST. This project is built around an earlier initiative, Daedeok Science Town, which was created in the 1970s and modelled on similar science towns in Japan and Russia. Since then, it has expanded, with the relocation to Daedeok of KAIST, one of Korea's leading S&T universities, and several leading GRIs. By 2006, 71 research institutes from the public and private sectors (including ETRI and KARI) employing more than 14 000 staff were accommodated, and the complex housed six universities and 690 companies. By 2007, the number of companies had increased to 824, with a 2010 target of 1 500. A total of 24 000 people are employed in Daedeok, almost three-quarters of whom are graduates. Daedeok has 10% of all Korean PhDs and produces some 25 000 patents a year, 10% of the Korean total. MoST devoted KRW 25 billion to the initiative in 2006.

A recent important development is the shift towards a more innovation-led strategy, with the 2005 rebranding of the R&D Zone as the Daedeok Innopolis. Innovation is being promoted by special incentives and rules that apply only to Daedeok. These include tax incentives, special R&D programmes and earmarked venture capital funds. A question debated in Korea is whether these government interventions can catalyse the development of a Korean Silicon Valley. Detractors point to the emergence of "natural" clusters and argue that these cannot be manufactured by public policy. In response, defenders point to the contribution that policy can make to encourage the conditions for technology transfer and the formation of high-technology spin-offs. It is still too early to judge the success or otherwise of the Daedeok Innopolis, but continuing growth in the number of venture companies housed in the complex is probably cause for some optimism.

3.9.2. Beyond R&D – building innovation capabilities in regions

Simply increasing R&D activities is insufficient to enhance innovation performance in less favoured regions. A wider set of policies is required. In a survey of officials responsible for promoting innovation in the regions, Chung (2005) identified four major requirements (in order of importance) for enhancing regional innovation networks:

- Enhancing existing firms' technological capabilities.
- Initiating co-operation programmes by central government.
- Attracting new firms to the region.
- Increasing co-operation efforts of universities in the region.

On the basis of this list, Chung concludes that Korea needs various programmes to address weaknesses in regional innovation, including measures that promote partnerships among regional innovation actors, as these have been relatively weak until recently. Government policies would seem to agree, and MoST has established a five-year Comprehensive Regional Science and Technology Promotion Plan (2004) that sets out to: *i)* develop local competences in strategic technologies; *ii)* create regional centres for technological innovation; *iii)* develop local S&T human resources; *iv)* establish regional S&T information systems; *v)* nurture a culture conducive to S&T innovation; and *vi*) increase the R&D investments of local governments. This has led to a mix of policy measures to support or build regional innovation systems funded by a variety of public agencies at both national and regional levels. The most common have tended to be supply-driven, *e.g.* enhancement of the educational and research capacity. They have included the national government's relocation of public research facilities away from

Seoul, MEST's NURI Programme (focused upon the teaching specialisations of regional universities), and the regional governments' own S&T support programmes. However, while these remain important, there has been increasing attention to demand characteristics, such as the technological absorptive capacity of the region and the firms operating within it, and the variety and density of linkages between firms and between firms and researchers. This has led to the adoption of a cluster perspective (see Box 3.29) in much Korean innovation policy.

Box 3.29. Innovation clusters

The introduction of the role of innovation in regional economic development can be linked to the emergence of the concept of industry clusters. The literature on regional innovation clusters is extensive and draws upon concepts from economic geography, industry supply chains and the innovation systems approach (Nelson, 1993; Johnston, 2003). The innovation cluster concept goes beyond horizontal networks of firms operating in the same sector to emphasise vertical networks along the value chain of a product or industry. It stresses the advantages of close proximity between producers, suppliers and support services and with public knowledge institutions such as universities and research laboratories.

Clusters affect competition in three broad ways.

The first is by increasing the productivity of companies within the cluster. Being part of a cluster allows companies to operate more productively in sourcing inputs; accessing information, technology and needed institutions; co-ordinating with related companies; and measuring and motivating improvement. The productivity improvements are achieved through:

- Improved access to specialised and experienced employees and a deep, high-quality supplier base.
- Improved access to specialised market, technical and competitive information.
- Complementarities, in the form of complementary products to meet customer needs, co-ordination to optimise collective profitability, complementarities in marketing, and in the breadth and scale of the market which attracts buyers.

The second way in which clusters affect competition is by driving the pace and direction of innovation. The characteristics that enhance productivity can have an even more dramatic effect on innovation. Companies within a cluster have access to better information about changing customer needs, evolving technology, service and marketing concepts. In addition they support the flexibility to respond rapidly to these changes, through lower-cost experimentation.

The third effect of clusters is through stimulation of the formation of new businesses. This cluster itself represents a significant local market, there is an increased potential to identify new niche business opportunities, and the resources and skills to establish a new enterprise are on hand, including investment capital.

In summary, a cluster allows each member to benefit as if it had greater scale or as if it had joined with others formally, without requiring it to sacrifice its flexibility (Johnston 2003).

In general, the instruments used in cluster programmes are of three distinct types: engagement of actors, collective services and larger-scale collaborative R&D. In terms of engaging actors, key issues include: the role of facilitators, the level and type of interaction desired, the existence of a formal cluster initiative, and the spatial aspects of the cluster. For the programmes that emphasise collective services (e.g. business advice, skill development or joint marketing) a key consideration is how to target services in a way that does not substitute for private provision. Finally, collaborative R&D projects through cluster programmes tend to involve more than one research institution or university in co-operation with several firms and often tap into external R&D funding sources and programmes (OECD, 2007h).

Korea's cluster development policies have been implemented, in part, to promote scientific and technological innovation, especially in high-technology industries and SMEs, but also to promote balanced economic development through the establishment of regional innovation systems. Policies are based on the 2003 Special Law for Balanced National Development, the 2004 Second Comprehensive Plan for Promoting Regional S&T (2005-07), and the 2005 First Five-year Balanced National Development Plan. As part of these efforts, resources have been channelled towards the promotion of four so-called "strategic industries" in 16 provinces/city regions, as shown in Table 3.24.

Table 3.24. Strategic industries of 16 cities and provinces

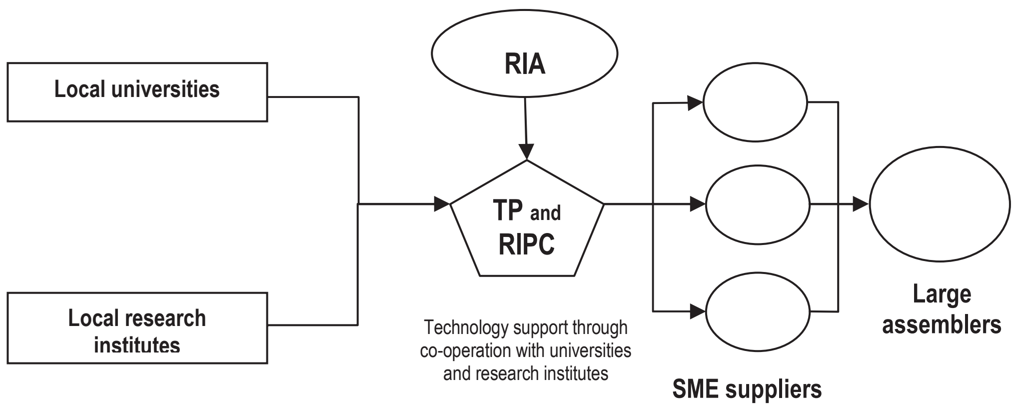
City/province	Strategic industry	City/province	Strategic industry
Busan	Harbour logistics	Jeju	Tourism
	Machinery parts		Health, beauty and BT
	Tourism and convention		Eco-friendly agriculture
	Video IT		Digital content
Ulsan	Automobile	Gyeongnam	Knowledge-based machinery
	Shipbuilding and marine eng.		Robots
	Fine chemistry		Smart homes
	Environment		Biotechnology
Jeonnam	Biotechnology	Gwangju	Optical industry
	Shipbuilding / new materials		Information home appliances
	Logistics		Automobile parts
	Culture and tourism		Design and culture
Jeonbuk	Automobile and machinery	Daejeon	Info. and communications
	Biotechnology		Biotechnology
	Alternative energy		High-technology parts and machinery
	Culture and tourism		Mechatronics
Chungnam	Electronic info. devices	Chungbuk	Biotechnology
	Automobile parts		Semiconductors
	State-of-the-art culture		Mobile communications
	Agricultural and livestock BT		Next-generation batteries
Gyeongbuk	Electronic Info. devices	Daegu	Mechatronics
	New Materials parts		Electronic info. devices
	Oriental medicine		Fibre
	Culture and tourism		Biotechnology
Gyeonggi	Info. and communications	Incheon	Logistics
	Biotechnology		Automobile
	Cultural content		Machinery and metal
	Global logistics		Info. and communications
Seoul	Digital content	Gangwon	Biotechnology
	Info. and communications		Medical devices
	Biotechnology		New materials
	Financial business support		Tourism and culture

MoCIE also launched the Innovative Cluster Cities programme in 2005, which seeks to transform seven key regional industrial complexes from manufacturing centres into more innovation-oriented regional hubs. The purpose of the innovative cluster policy has been to strengthen the industrial complexes, which mainly focus on manufacturing, through the systematic integration of R&D and the development of networking among academia, industry and research institutions. The selected cluster cities specialise in fields that are consistent with national priority industries. The programme is being carried out over four years, with a budget of KRW 46.2 billion in 2006. By mid-2006, some 2 632 organisations had participated in the programme, including 1 859 companies, 606 universities and research centres, and 167 supporting institutions (OECD, 2007h). The seven clusters chosen are: Ulsan Automotive Components, Changwon Advanced Appliances, Gwangju Photonics Industry, Gumi Digital Electronics Industry, Wonju Advanced Medical Industry, Gunsan Automobile Appliance Components, and Banwol Sihwa Advanced Component Materials.

3.9.3. Intermediaries supporting regional innovation

In addition to local universities, local research institutes and companies, several specialist intermediary organisations support innovation in regions (Figure 3.18). Among these are the technoparks which have been jointly established by MoCIE and local governments since 1997 as a means of building up technology infrastructure. The objective of the technoparks programme is to support the formation of innovative clusters by strengthening regional innovation systems. This is done by building networks between industry, academia, research institutes and government; promoting the establishment of high-technology business and strengthening technological innovation capability; creating venture businesses through innovation; prioritising the cultivation of local strategic and specific industries; and creating and fostering competitive industries. Each province has at least one technopark; Kyonggi and Kyongbuk provinces have two. Each technopark receives around KRW 5 billion annually to assist in infrastructure building and equipment purchase.

Figure 3.18. Model of "typical" regional innovation system intervention in Korea

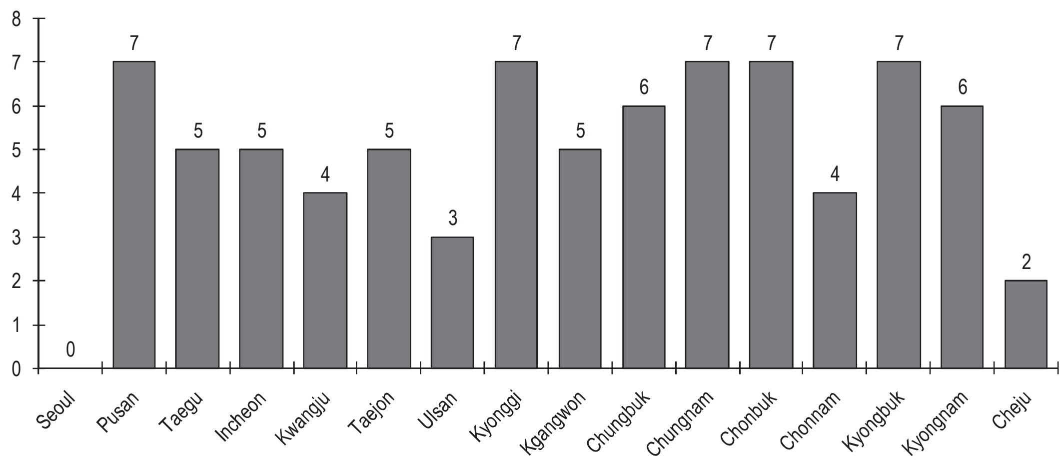


RIA: Regional innovation agency. TP: Techno-parks. RIPC: Regional industrial promotion centres.

Source: Lee and Kim (2008), "Different Evolutionary Patterns of Industrial Clusters in a Multi-Scalar Framework: Comparison of Four Industrial Clusters in Korea", paper presented at the Annual Conference of the IGU Commission, "Worlds of New Work? Multi-scalar Dynamics of New Economic Spaces", 5-8 August, Barcelona.

MoST extended its Centres of Excellence programme to incorporate a new category of research centre (in addition to SRCs, ERCs, etc.), the Regional Research Centres (RRCs). In contrast to the other types of research centres, RRCs emphasised co-operative research between regional universities and industries. In 2004, this programme was taken over by MoCIE, which combined it with its own Technology Innovation Centres (TICs) programme. While RRCs had focused on supporting research work, TICs had focused on sharing expensive experimental facilities among local universities and SMEs. The new programme, known as Regional Innovation Centres (RICs), has seen some 80 centres established. Regions such as Pusan, Kyonggi, Chungnam, Chonbuk and Kyongbuk are maintaining seven RICs, the largest number (see Figure 3.19). They are all located in local universities, and are slightly smaller in size than their MoST counterparts.

Figure 3.19. Number of regional innovation centres by region, 2005



Source: MoST (2006), *Regional Science and Technology Yearbook 2005*, MoST, Seoul

Finally, the Technology Business Incubator programme provides comprehensive business incubation support, including technology development and commercialisation funds, working space, technology and management guidance, and information services to new start-ups. Incubators are located in universities and GRIs and allow business start-ups to utilise the available research manpower and facilities.

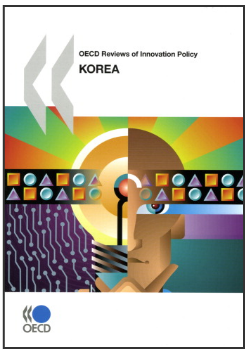
3.9.4. Getting the measure of regional innovation policy

Given that many of the current policy and programme initiatives are relatively new, it is difficult to evaluate their effectiveness. However, some problems are already apparent. Chung (2005) has examined how Korean innovation organisations co-operated during 2000-05 and found the general level of partnership in Korean regional innovation systems to be relatively low. There is also some question whether capacity building by local actors and their co-ordination and networking activities can contribute to the development of a dynamic endogenous innovation system in regions. According to Lee and Kim (2008), the legacies of a state development model still hamper the successful transformation of regions, owing to the continuing dominance of the central government in regional innovation policy planning and execution and to the lack of a balance of power between the chaebol and local suppliers. They conclude that policy interventions in support of regional innovation systems have had only limited effect in terms of capacity building and regional networking as many regional actors – including firms, universities and policy makers – do not have the capabilities needed to truly benefit from the various support programmes on offer. No doubt this is the case, but such judgement is probably somewhat premature. It should be apparent that even with government intervention, research and innovation capability building in a region will take considerable time to deliver on its promises. This is not to imply that such investments should be avoided; rather, the point is that such investments should be given due time before being judged on their merits.

Interviews conducted in support of this review also suggest there is still an overall weakness in co-ordination between the different innovation support programmes. This is because they are administered by different agencies and at different levels and therefore lead not only to overlaps but also to gaps in support. The currently separate but often entangled policies on clusters, R&D, regional innovation and education would best be melded into a comprehensive policy for regional economic development (OECD, 2005c). Moreover, responsibility for planning and implementing this comprehensive policy should be largely delegated to the regions, with accompanying accountability safeguards in place to ensure quality standards and to enable inter-regional learning.

Notes

1. Some parts of MoST have also been merged into MKE, specifically those concerned with the Daedeok Innopolis and other cluster-type programmes (see section 3.9).
2. The following points are taken from the MKE website (*www.mke.go.kr/language/eng*), accessed June 2008.
3. Staff dispatched to OSTI from other ministries returned to their previous positions after a certain period of time and were replaced by an equivalent number of new staff from the same ministry.
4. These were mostly experts in specific areas. They were expected to play a complementary role to government officials in policy making and policy co-ordination.
5. These complaints did not entirely disappear with the establishment of OSTI, as ministries and agencies still claimed special knowledge of their domains and continued to be suspicious of outside intervention.
6. The situation may have improved over time, particularly with new funding programmes designed to require inter-ministerial collaboration (for example, as in the Next-generation Growth Engines R&D Programme, in which several ministries have actively participated in many projects – see below).
7. Overall, the trend in basic research funding in OECD countries is difficult to define since only 15 countries reported data after 1996. Also, in many cases the data may be distorted since countries tend to label basic research according to the institutions in which the research is carried out, although these institutions – while originally dedicated to basic research – may also perform other types of research, *e.g.* research in universities or institutes of academies of sciences is always defined as basic research (OECD, 2003a).
8. For instance, MEST's 2009 research budget for green technologies increased by 92% from the previous year to KRW 68 billion.
9. Based upon a private communication from Prof. Hyunsoo Kim, Kookmin University.
10. These figures refer to the utilisation ratio of equipment by researchers other than those who purchased the equipment for their own research purposes. The actual number is calculated by counting the number of days when other researchers have used research equipment and is surveyed on an annual basis by MEST. On the basis of such surveys, MEST calculates a national average.
11. At least this is the case with the text available in English. More detailed plans are available in Korean and may refer to prospective developments in China and Japan.
12. Korean holders of doctorates from abroad are recommended to register with the Korea Research Foundation. In fact, most Korean universities require certificates of registration from applicants when they fill vacancies for positions requiring a doctoral degree. According to KRF statistics, 57% of registered foreign doctoral degree holders received their degrees from US higher educational institutions, followed by 16% from Japan and 8% from Germany as of 2005.


OECD Reviews of Innovation Policy
KOREA