

Chapter 2

Moving to the Innovation Frontier: Lessons from the OECD Review of Korean Innovation Policy

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Introduction

During 2007–2008, the OECD carried out a review of Korea's innovation policy (OECD 2009), offering a comprehensive assessment of the innovation system with a special focus on the role of government. The Korean review is one of a series of national innovation policy reviews being carried out by the OECD¹ and was intended to assess government policy in the area of science, technology and innovation (STI). The review paid particular attention to the science base, but also covered the wider innovation system, including the activities of firms and the 'framework conditions' conducive to supporting their innovation performance.

At a strategic level, the main task of Korea's innovation policy is to contribute to the country's economic convergence with the more advanced OECD economies. Historically, Korean growth can largely be attributed to the exploitation of capital and labour, driven by the highest rate of business investment in the OECD area, a growing population, long working hours and rising participation in the labour force. However, since growth of inputs of labour and capital have begun to slow, continued convergence to the OECD average through input-based growth will become more difficult. Indeed, with the lowest fertility rates in the OECD area, combined with increased competition from newly industrialising countries, particularly China, sustaining productivity growth will increasingly depend upon boosting innovation.

It should be stressed at this point that Korean government policy has long recognised the importance of innovation for development. Even the earlier technological imitation activities of firms and public technological development centres, often promoted by public policy, involved significant amounts of technological and

¹In addition to Korea, the innovation policies of the following countries had been reviewed by 2010: Luxembourg, Switzerland, South Africa, New Zealand, China, Chile, Norway, Hungary, Mexico, Greece and Russia. Further information can be found at <http://www.oecd.org/sti/innovation/reviews>

organisational innovation. However, as Korea has approached technological frontiers in several areas over the last decade or so, the scope for relying solely on adaptation and exploitation of existing technologies has diminished considerably. A different type of innovation is now required, one characterised by greater levels of high-risk exploration in addition to a more familiar exploitation.

This calls for change in the organisation and dynamics of the national innovation system, change that has been framed by government policymakers as a shift away from a “catch-up” towards a “creative” mode of development.² The catch-up mode centred upon large-scale strategic technology development with government-affiliated research institutes and large family-owned business conglomerates (*chaebol*) taking a leading role. It harboured little space for the creation of innovative start-ups, the development of technological capabilities among local independent SME suppliers, and the building of basic (fundamental) research capacity. The creative mode, by contrast, emphasises such actions and calls for greatly increased spending on R&D – by both the public and private sectors – with the aim of improving knowledge generation and diffusion across the national innovation system.

Shifting from a catch-up to a more creative mode of development requires changes in the institutions and ideas that structure the actions and interactions of national innovation system actors. In many instances, arrangements that worked well during earlier waves of catch-up need to be dismantled and reconstituted. This is far from being a straightforward task and, in today’s Korea, cannot be centrally coordinated by the government to the same extent as in the past (Mahlich and Pascha 2007). Instead, new institutional arrangements will emerge through conflict and cooperation among existing and new protagonists that seek to pursue their interests and to promote particular ideologies of development.

This chapter sets out to provide a snapshot of Korea’s progress in its transition to a more creative mode of development. It focuses on four key areas where government policy continues to play an important role in shaping the Korean innovation system, namely education and skills, SME development, public research, and international knowledge linkages. With reference to these four areas, a national innovation system conducive to creative exploration activities requires, among other things, a ready supply of advanced and adaptable skills, the participation of both large and small firms in frontier knowledge generation and utilisation, a strong basic (fundamental) research base, and strong linkages to international sources of frontier knowledge.

While Korea has made remarkable progress on all of these fronts, there is still much left to do. Structural and institutional ‘lock-ins’ along catch-up development paths and trajectories, particularly in education and public research, mean that a lot of old ideas and institutions remain, as do old habits and routines, co-existing with a lot of new initiative. Policy is trying to accelerate the shift, but is also in need of reform itself – it, too, can no longer work in a catch-up mode and must adopt a more regulatory than developmental mode of intervention, not only because of the

²For example, the 2004 Implementation Plan for the National Innovation System draws this distinction, as do more recent policy strategies.

independence and strength of other actors in the system, but also because of the very nature of the changes that must be engineered.

Policy statements have acknowledged this: for instance, as far back as 1999, the Vision 2025 initiative proposed a number of significant shifts in S&T policy, arguing for the development of a more globally open, privately-led and diffusion-oriented innovation system driven by longer-term S&T considerations. This was followed up in 2004 by the Implementation Plan for the National Innovation System, where the contrast between a catch-up and creative innovation system was first articulated in detail. The Plan paid particular attention to developing the innovation capabilities of SMEs, universities and government research institutes and to improving the linkages between them. It also emphasised various inputs, including human resources and finance, and the need for the conditions of their production and availability to be reformed. More recently, the Lee Myung-bak administration has launched its so-called “577 Initiative”, which includes several ambitious targets: to reach an R&D intensity of 5% by 2012 (it stood at an impressive 3.36% in 2008); 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 (MEST 2008).

The sections that follow focus on the aforementioned key areas for policy action, namely the development and utilisation of appropriate skills, strengthening the innovation capabilities of SMEs, increasing and realigning R&D spending, and promoting a new internationalism. The chapter is then rounded off with some concluding remarks that include an overall assessment of the strengths, weaknesses, opportunities and threats facing the Korean innovation system.

Development and Utilisation of Appropriate Skills

Throughout Korea’s industrialisation process, an adequate supply and mobilisation of qualified S&T human resources has been a cornerstone of industrial and S&T policy. In an earlier period, when Korean exports were still relatively simple, the workforce required only minimal skills. But as Korea entered new high-tech sectors of production, the education system had to expand in scope and scale to meet new demands for higher level skills. With the population almost doubling in size in the period 1960–2000, up-skilling efforts centred on young people. These efforts saw a massive expansion in tertiary education provision, with new universities and colleges springing up all over the country. Today, more than 80% of young Koreans are participating in tertiary education programmes, the highest level in the world. The proportion graduating with science and engineering (S&E) degrees is also the highest in the OECD (Fig. 2.1).

These achievements are undoubtedly impressive and are evidence of the definitive steps taken to develop the necessary skills base for a more creative mode of innovation-led development. Yet, there are also concerns. Firstly, as in many other OECD countries, the ‘massification’ of tertiary education has been accompanied by anxieties of falling standards. Furthermore, the conventional lecture-dominated

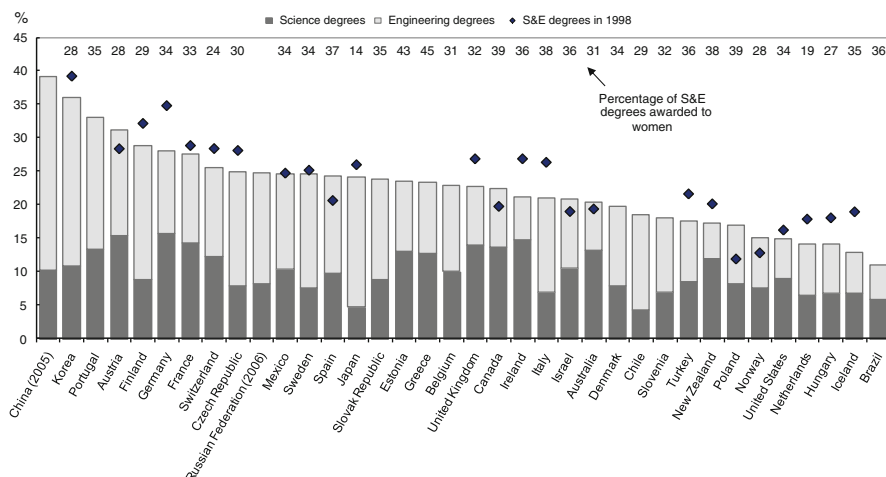


Fig. 2.1 Science and engineering degrees as a percentage of total new degrees (2007) (Source: OECD 2010)

teaching style that is common to Korean universities has been criticised for failing to nurture creative thinking. Korean firms regularly complain about the standard of graduates entering the employment market, arguing that curricula are outdated and in need of renewal. Similar complaints can be heard in most OECD countries, but they likely have some merit in the Korean context. Recent government policy has sought to tackle such problems by subjecting universities and colleges to stronger and more systematic evaluation arrangements and by promoting their specialisation in areas where they can better serve the needs of local employers (the latter applies particularly to universities and colleges outside of the Seoul metropolitan region). Stronger linkages to other innovation system actors, particularly firms, are also being actively encouraged through a variety of incentives. Such measures offer scope for quality improvements in tertiary education, though they are unable to address perhaps the most significant concern facing Korean education, which lies with secondary schools. The extensive use of rote learning and cramming, done in support of preparations for the university entrance exam, is less than conducive to the development of creative skills and continues to be a major weakness of the Korean education system.

Secondly, and perhaps more worrying, there is strong evidence of a mismatch between the skills required by the labour market and the qualifications of tertiary education graduates. Overall, there are too many people with bachelor's degrees and too few with master's or doctoral degrees in high-technology fields. Data from the Korean Educational Development Institute (KEDI) show that only two-thirds of new graduates of universities and colleges find employment within 6 months of graduating (KEDI 2006). In a further study, Grubb et al. (2006) conclude that the expansion of tertiary education seems to have outpaced the demand for jobs requiring high levels of schooling, and that the Korean system is preparing too few

technicians in colleges, while there are too many individuals with bachelor's degrees who cannot find appropriate employment. It should be said that this problem is hardly unique to Korea – in most OECD countries, there have been declines in uptake of vocational courses as more and more young people are attracted to the higher prestige of university degrees but ultimately face problems finding appropriate employment. The problem is, however, perhaps more acute in Korea given the very high university enrolment rates. Recent government policy has sought to tackle the issue by attempting to raise the prestige of vocational colleges and qualifications and to offer them as routes for obtaining degrees.

Efforts to raise the skills base must also take account of plummeting fertility rates. Korea currently has one of the lowest total fertility rates in the OECD; the flow of young people into the workforce will fall sharply over the next decade or so. The focus of skills upgrading efforts must therefore shift increasingly to the existing workforce, i.e. to lifelong learning provision. The Korean government has acknowledged this and has in recent years established important elements of a system of lifelong learning. However, these elements are insufficiently connected and inadequately linked with the employment system, and too few resources are allocated to adult learning (OECD 2005). On the supply side, the continuing emphasis upon full-time degree programmes in the Korean education system is generally ill-suited to the needs of adults already in employment (Grubb et al. 2006). But the most significant barriers are to be found on the demand side, where the dualistic structure of the Korean labour market³ offers too few incentives for employers and employees to engage in lifelong learning activities. Specifically, individuals in regular employment are paid in accordance with seniority rather than qualifications, while the lack of mobility prospects for irregular workers and workers in SMEs all mean that there is little financial incentive for many workers to invest in their own skills development. Labour market reforms are therefore a likely necessary condition for lifelong learning initiatives to be widely embraced.

If reforms of labour markets and education systems are not big enough challenges for policy makers to tackle, perhaps the biggest concern is the rather low rate of female employment, which can at least partly be ascribed to Korean societal values and tradition. Unusually, women with university level educational attainment have lower rates of participation in the labour force (57%) than those

³The Korean labour market is divided into regular and irregular/non-regular workers. Wages and fringe benefits of the latter are substantially lower than those of the former. The labour market for regular workers is characterised by lifetime employment, low risk of layoffs, good social security, trade-union representation (at least in larger manufacturing companies), and minimal intercompany mobility. By contrast, the market for irregular workers can be described as a competitive market with almost no restrictions on hiring and firing. The labour market is also segmented by company size, gender and levels of qualification. In smaller companies wages are substantially lower than in bigger ones. Furthermore, there is little opportunity for workers in small companies to move to larger ones. A far higher proportion of women than men are in irregular employment. Higher percentages of irregular workers are found among the less skilled than among the more highly skilled (OECD 2005).

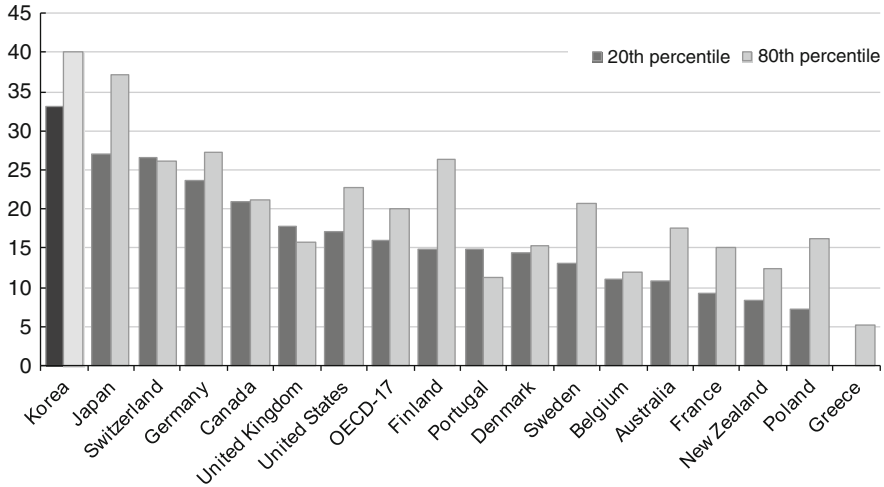


Fig. 2.2 Gender gap in full-time earnings at the top and bottom of the earnings distribution, 2003 or latest available year (Source: OECD 2006a)

who have only compulsory education (59%) (OECD 2007a).⁴ An important reason for the low activity rate among well-qualified women lies in the duality of the labour market, which manifests itself most clearly in the significant gender wage gap. As Fig. 2.2 shows, while there are still wage differentials between women and men across all OECD countries, the situation in Korea is particularly acute. Other unfavourable labour market outcomes for women include a large proportion (one-third) of women holding temporary work contracts (with few prospects for career advancement) and a working culture geared towards long hours.⁵ These are structural problems in the economy that will be difficult to solve, yet there is a clear need for greater female participation in the labour force, given the projected decline in the Korean labour force (OECD 2005).

Strengthening the Innovation Capabilities of SMEs

Korea's catch-up model has been dominated by the chaebol and has, until recently, largely neglected SMEs. The chaebol-dominated industrial structure that created economies of scale and scope and opportunities for substantial cross-subsidisation

⁴An important reason for this anomaly lies in traditional family values that expect women to remain at home. Well-qualified men can normally earn a wage that allows them to finance the traditional family model. Since highly qualified Korean women tend to marry well-qualified men, they are more likely to participate in the traditional family model (OECD 2005).

⁵Almost 90% of the male workforce spends over 40 h a week at work as compared with the OECD average of 76%. Although fewer Korean women (77%) work over 40 h a week, this is significantly higher than the OECD average of 49% (OECD 2007a).

proved ill-equipped to foster a dynamic SME sector that could provide key components and critical complementary support services to the chaebol (Ernst 2000). Taking the electronics industry as an example, this situation differs markedly from that found in Chinese Taipei and Japan, where innovative SMEs have played an active role in industrial upgrading.

The growth of a more dynamic SME sector has been strongly associated with the shift to a more creative mode of development. It is seen to offer the possibility of opening new growth paths based on radical innovations that larger firms might otherwise disregard. This is because radical innovations often make obsolete the extensive technological fixed assets of large firms and their accumulated capabilities. By contrast, SMEs are less burdened by such sunk costs and benefit from a greater flexibility to develop and exploit radical innovations. This 'New Economy' vision of the central role of SMEs in innovation has been widely adopted by OECD governments, including by Korean policy makers. Yet it tends to underplay the continuing dominant roles of large firms in innovation.⁶ It also provides only a partial account of the contributions SMEs can make to industrial dynamism and pays, in particular, too little attention to the prominent role played by linkages between large and small firms in promoting innovation, e.g. through supply chains. As implied above, these relations have, historically, failed to foster the development of strong innovation capabilities among Korean SMEs. But there are signs that this is changing, with the chaebol looking to play more supportive roles in the development of a vibrant SME sector. This is in their self-interest, of course, since their technological leadership positions increasingly require supplier companies to have substantial innovation capabilities. If these capabilities cannot be found among Korean suppliers, then the chaebol can find them elsewhere, a scenario that could see extensive industrial 'hollowing-out'. A particular case of the influence of a major chaebol in driving supplier and associated companies is provided by the rapid development of a mobile telecommunication cluster in Gumi, driven by the outsourcing strategy of Samsung Electronics (Lee 2006). Increases in telecommunications sales in the global market have driven the rapid expansion of the local agglomeration of mobile companies with most of the contract suppliers accumulating core technologies through their Samsung contracts. At the same time, recognising their vulnerability to sudden changes at Samsung, they have also sought to develop independent strategies and customers.

One of the most important public agencies promoting innovation capacities in SMEs is the Small and Medium Business Administration (SMBA). Founded in 1996, it 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 2.1. The government has

⁶The performance of some of Korea's chaebol is testimony to this, with the likes of Samsung Electronics going from strength to strength over the last decade while working at technological frontiers.

also initiated a broad array of incentive schemes targeted at promoting R&D in SMEs, including direct R&D funding, tax waivers, tariff exemption for R&D equipment, and exemption from military service for research personnel. It would seem that these efforts have met with some success. For example, R&D expenditure by SMEs grew almost fivefold from 1997, when it amounted to 12% of total firms' R&D expenditure, to 2006, when it reached 24%. Furthermore, in 1997, only 24% of researchers worked in SMEs, but by 2006 43% did so, for a fourfold increase in actual numbers of researchers to almost 75,000. This impressive growth of R&D activities in Korean SMEs can be accounted for by both the 'traditional' SME sector and the so-called 'venture firm' sector.⁷ The latter has performed particularly strongly, and now accounts for a higher proportion of business expenditure on R&D and number of researchers than the traditional SME sector.

Box 2.1: 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 involve the following:

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 USD920 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

⁷A venture firm can be generally defined as an early-stage innovative SME. However, there is a more specific legal definition for a Korean venture firm that classifies it as either an SME in which a venture capital firm has invested, or which has a relatively large R&D expenditure as a percentage of sales, or whose business stems from technology, as indicated by a patent.

is USD300,000 for 2 years for strategic tasks or USD100,000 for 1 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 (<http://www.smba.go.kr/smba/main/english/index.jsp>), accessed December 2007.

The availability of finance has naturally played an important role in these developments. As is common in most countries, SMEs have difficulties in borrowing from traditional lenders, largely on account of the information asymmetry between lending financial institutions and borrowing SMEs and a lack of tangible collateral to secure creditors' confidence. To address this market failure, the government employs loan financing and loan guarantee programmes for technological innovation in the private sector. In addition, 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 USD3 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 Korea Credit Guarantee Fund and its local offices and from the Kibo Technology Fund.⁸ Significantly, these organisations conduct technology appraisals, thereby increasing the transparency of opportunities and risks associated with new technology investments.

⁸The 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.

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. 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 KRW1trillion (for the period 2005–2009) 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 has introduced streamlined procedures for mergers and acquisitions and business transfers thereby making it easier for venture capital to exit venture businesses.

Increasing and Realigning R&D Spending

An important move towards a more creative mode of development involves increasing levels of spending on R&D. Korea has performed exceptionally well in this regard and has one of the highest R&D intensities in the OECD (Fig. 2.3). Furthermore, around three-quarters of Korean R&D is carried out by the private sector, a proportion similar to other leading manufacturing economies, such as Japan and Germany.

Increases in R&D intensity cannot alone be taken as evidence of a shift towards a more creative mode of development – the sorts of R&D performed should also have qualitatively shifted. The OECD's Frascati Manual distinguishes between basic research, applied research, and experimental development, which, while somewhat imperfect, can nonetheless be used as a proxy to estimate any qualitative shifts.⁹ To recall, a more creative mode of development translates into more exploration, which, among other things, calls for more basic research to be performed. The proportions of gross domestic expenditure on R&D (GERD) spent on basic research have indeed increased over recent years, reaching 16.1% of the total in 2008 (compared to 12.6% in 2000), which is more or less in line with the proportions seen in other advanced economies.¹⁰ More unusually, the majority of this basic

⁹The Frascati Manual defines these forms of research as follows (OECD 2002):

- *Basic research* is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.
- *Applied research* is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.
- *Experimental development* is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

¹⁰For example, the proportion of GERD devoted to basic research in 2006 in the United States was 18.7% and in Japan 14.3%.

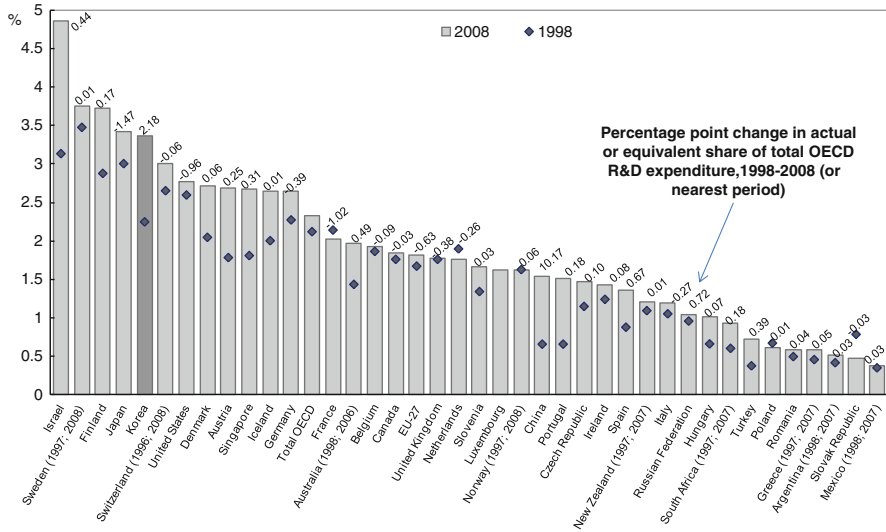


Fig. 2.3 R&D intensity (gross domestic expenditure on R&D as a percentage of GDP), 2008 or latest available year (Note: In Israel, defence R&D is not covered. Furthermore, humanities and law are only partially covered in the higher education sector. Due to the lack of a comprehensive business register for South Africa, R&D expenditure may be underestimated by 10–15%) (Source: OECD 2010)

research – around 60% in 2006 – is performed by firms. The share of business expenditure on R&D (BERD) given over to basic research has almost doubled, from 6.5% in 1998 to around 12% since 2004. Around 90% of this is performed by large firms, reflecting their concentration in high-technology manufacturing industries, particularly in the information and communication technology (ICT) and automotive sectors. The large firms in these industries are increasingly working at the technological frontier in many product areas and have had to invest in more fundamental research to support their leadership positions. The remaining 10% is performed by venture firms and traditional SMEs in roughly equal amounts. Although this proportion appears relatively low, it should be borne in mind that the level of basic research performed by SMEs has increased rapidly in recent years from a very low starting base.¹¹

As for the other Frascati Manual categories of R&D, experimental development is of particular interest. Korea has a long and fruitful tradition of performing this type of R&D in its efforts to exploit and adapt existing technologies. It still accounts for the majority of R&D performed in Korea, as it does in other advanced manufacturing economies. What is of particular interest, however, is its increasing share of GERD – up from 60.7% in 1999 to 65.0% in 2006. During this period, the

¹¹For example, between 2005 and 2006, expenditures on basic research in venture firms increased by an impressive 60% (MoST and KISTEP 2007).

share of BERD given over to experimental development has remained static, so the increase can only be accounted for by the changing composition of R&D performed in government research institutes (GRIs) and higher education institutes (HEIs). Korean R&D data confirms this, showing marked increases in the share of experimental development performed by these institutes while the share of basic research has fallen by similar amounts. Funding of GRIs' and HEIs' R&D by the business sector is not the explanation for this evolution – in fact, firms account for a diminishing proportion of funding of GRIs' and HEIs' R&D activities. This evolution must therefore reflect changing patterns in public funding.

In this regard, civil gross budget appropriations or outlays on R&D (GBAORD), a commonly used measure of government funding for R&D, shows little change in terms of its socio-economic objectives. Korea still has the largest proportion of economic development programmes within its GBAORD in the OECD area (Fig. 2.4), a pattern of support that reflects the legacy of the government's role in facilitating the country's technological 'catch-up'. Rather, the change lies in the nature of this support: public R&D programmes that historically targeted mostly large-scale industrial technology (with the intention of supporting near-immediate industrial development by the chaebol) have been largely superseded by public R&D programmes with a greater focus on generic technology development (see Box 2.2). Furthermore, greater attention is being given to support for R&D commercialisation and for technological developments in SMEs, as outlined already. These changes have implications for the GRIs and HEIs, who have come to be viewed as increasingly important players in creating and contributing to new high-tech industries. This perspective has strongly shaped policy incentives and accountability measures and appears to have shifted GRIs' and HEIs' R&D activities more 'downstream' as they seek to better commercialise their R&D results.

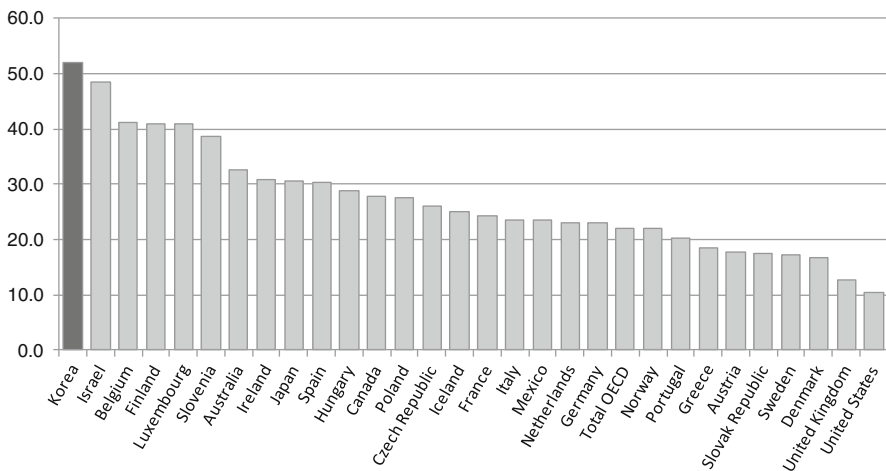


Fig. 2.4 Economic development programmes as a percentage of civil GBAORD (2009 or nearest year) (Source: OECD, Main Science and Technology Indicators, October 2010)

Box 2.2: Major Public R&D Programmes Focused on Economic Development

The high proportion of GBAORD given over to economic development programmes reflects the fact that much public R&D spending is channelled through public-private R&D collaboration programmes funded by the Ministry of Knowledge Economy (MKE), and to a lesser extent by the Ministry of Education, Science and Technology (MEST).

The MKE has the largest support measures for industrial technology development – including sectoral technology programmes to support “flagship industries”. In a more targeted manner, the 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. The programme is further supported by the MEST’s Human Resources Development Plan for Next-generation Growth Engines Sectors to ensure a supply of appropriately skilled human resources.

The MEST is also a major player in industrial technology development, though it has sought to take a longer horizon than the programmes supported by the MKE. For instance, its 2006 Total Roadmap included a foresight project that identified 90 strategic technologies with the potential for considerable impact upon Korea’s economic growth. More recently, the 577 Initiative has identified 50 “critical” technologies and 40 “candidate” technologies in seven major technology areas. The MEST is also responsible for funding several national R&D programmes that seek to improve national competitiveness. For example, the twenty-first Century Frontier R&D Programme is a medium-to-long-term funding programme to develop a selection of future technologies which could allow Korea to exploit its technological capabilities to achieve global competitiveness. The programme aims to develop these technologies within 10 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.

It could be argued that this downstream movement is, in fact, in the wrong direction and that Korean innovation policy should be encouraging the GRIs and HEIs to conduct more explorative basic research. Even if firms are conducting an increasing amount of basic research, the vast majority of this is still likely to be strategically targeted. The public sector should therefore be performing the more explorative basic research that private firms are unwilling to perform themselves. An assessment of the merits of this argument necessitates a closer examination of the history and activities of the GRIs and HEIs.

Starting first with the GRIs, these institutes played a crucial part in the technological upgrading of Korean industry during the catch-up era, working closely with the chaebol. But as the research capabilities of Korea’s largest firms deepened and reached knowledge frontiers, the role of the GRIs became less clear-cut.

Nevertheless, by budget expenditure, the GRIs remain the largest performers of research in the public sector, accounting for 53% of publicly performed R&D in 2008, although their leading position is increasingly challenged by HEIs, who accounted for 47% of publicly performed R&D in 2008.¹² Roughly speaking, around half of the GRIs' budget comes from a government core grant, while the other half comes from contract research for various organisations, including a range of central government ministries (the main purchasers of research) and local governments, plus private companies. The GRIs still conduct much of the "big science" carried out by the public sector in Korea and HEIs cannot match their facilities. This is not an unusual situation and international experience shows that such government sector labs often carry out large-scale research that would be difficult to conduct in HEIs.

Data for the types of research performed by GRIs shows that only around 20% of R&D expenditure was devoted to basic research in 2006, down from 27% in 1998. Over the same period, the share of R&D devoted to experimental development increased from 38% to 44%, while the share of applied research remained at around 35% (MoST and KISTEP 2007). There are several possible explanations for this profile and its evolution. One of these is likely to be path dependence from an earlier era of technology development, which continues to favour applied research and experimental development. But the introduction of a project-based funding system in the mid-1990s, together with the more recent deployment of a performance evaluation system skewed towards counting patents registered by GRIs, have probably also contributed to an increased outcomes-based short-termism and to the relative decline of basic research.¹³ It is important to consider how well the GRIs perform their significant role of experimental development. The number of patents registered has shown impressive increases in recent years, suggesting some success, but this should be seen in light of relatively weak patent exploitation (Lee 2007). This raises the suspicion that researchers in the GRIs are perhaps over-patenting in order to meet certain performance indicators. It also calls into question the ability of the GRIs to successfully commercialise the results of their R&D themselves, with several critics concluding that this is best done by firms.

Turning to the HEIs, the Korean government has in recent years favoured the strengthening of R&D capabilities in universities, which are considered the "natural" sites of skills development and knowledge transfer. Nevertheless, the proportion of R&D performed in the HEI sector remains small by international

¹²A decade earlier, the GRIs accounted for 62% of publicly performed R&D, the HEIs for 38%.

¹³The project-based funding system (PBS), introduced to improve R&D management and performance, has been particularly detrimental to the conduct of basic research, introducing a stronger short-termism into the GRIs, reducing the scope for knowledge deepening as GRIs compete for a wide spectrum of project funding, and reducing the capacity for GRIs to commit to long-term employment contracts (for example, in 2006, special service interns, most on temporary short-term contracts, outnumbered regular employees by almost two-to-one in one of the leading GRIs, the Korean Research Institute for Bioscience and Biotechnology). On a more positive note, the PBS has been recently reformed in an attempt to reduce these adverse effects.

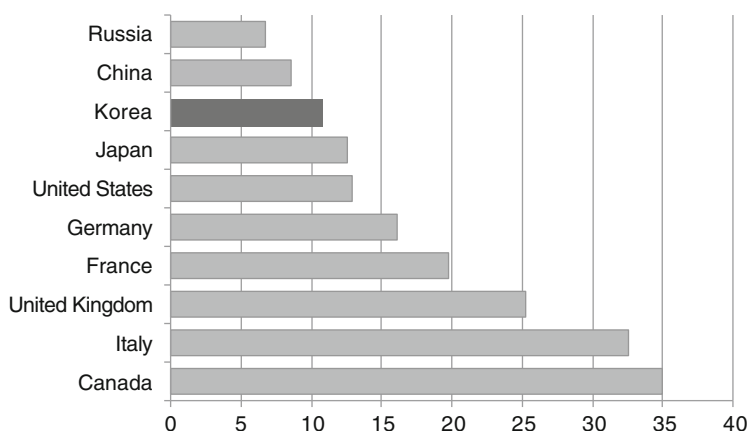


Fig. 2.5 Percentage of gross expenditure on R&D (GERD) performed by the HEI sector in selected countries (2008 or nearest year) (Source: OECD, Main Science and Technology Indicators, October 2010)

standards (Fig. 2.5) and is closest to that of China and the Russian Federation, both of which have traditionally separated research and teaching activities between national science academies and universities, respectively. This has also been the case in Korea, as the HEIs were concerned primarily with producing skilled manpower through their teaching activities during the catch-up years. In pursuing a more creative mode of development, current policy frameworks have taken a broader view of the role of HEIs (especially universities) and see them as places where new scientific and technological principles should be discovered. On paper at least, such a reorientation would seem to be well-overdue: despite performing a relatively small proportion of Korea's GERD, HEIs employ a little over one-quarter of all researchers in Korea and about four times as many researchers as the GRIs. Furthermore, they employ around 70% of all PhDs in Korea. Up until recently, much of this human resource was relatively inactive in research, having been marginalised by public funding regimes that focused on supporting large-scale, mission-oriented R&D programmes unsuited to the participation of single researchers or small research groups. In addition, the R&D facilities of most universities are less well equipped and their research teams are less well organised than those in the GRIs. Acknowledging the problems, the MEST earmarked some KRW500 billion for promoting grassroots efforts in basic research in 2009, an increase of 37% on 2008. At the same time, 7,000 individual or small-group researchers were granted research fees during 2009, and an expanded KRW255 billion was invested in the general researcher support project. The latter puts particular emphasis on facilitating basic R&D activities by young university faculty, general professors, female professors and faculty at local universities.

At the same time, the policy emphasis on promoting basic research in HEIs has been coupled to an exploitation agenda concerned with transforming discoveries into innovations. This has led to a policy focus on intellectual property rights,

patenting and technology transfer from HEIs. Against this backdrop, the top ten patenting universities have shown an almost tenfold increase in the total number of patent applications filed over the period 1997–2005. Furthermore, there has been a marked diversification in the types of universities filing patent applications: in the 1990s, applications were mostly confined to the technical universities of KAIST and POSTECH, but this is no longer the case. This policy focus on commercialisation has, as in the case of the GRIs, shifted the R&D activities of HEIs, in their aggregate, further downstream. The proportion of experimental development performed in universities has increased markedly at the expense of a relative decline in basic research in recent years. Data for the types of research performed by HEIs shows that only around 33% of R&D expenditure was devoted to basic research in 2006, down from 40% in 1998. Over the same period, the share of R&D devoted to experimental development increased from 26% to 34%, while the share of applied research remained at around 32% (MoST and KISTEP 2007).

It is likely that the government's renewed commitment to and increased investments in basic research will see some reversal in this dynamic in the coming years. Furthermore, it is important to bear in mind that these figures represent proportions of a fast-growing level of expenditure on R&D. This means that the absolute levels of basic research being performed have increased markedly, though less rapidly than the levels of experimental development and applied research. This is perhaps best indicated by the increasing number of papers in SCI publications by Korean universities, which rose from 3,765 in 1998 to 7,281 in 2005. The SCI impact factor of university lecturers and new researchers in science and technology fields also increased from 1.9 in 1999 to 2.43 in 2005 (KRF BK21-Nuri Committee 2007).

Clearly, a balance is required between the performance of different types of research in GRIs and HEIs. In a more creative mode of innovation, these institutes will need to play a variety of roles requiring a mix of activities and linkages with other actors in the innovation system. At the same time, it needs to be acknowledged that trade-offs are likely between different types of research, on account of opportunity costs and conflicting incentives.

Increased spending on basic research that the private sector is unlikely to fund itself should be a priority. 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:

- Expanding research grants for individual investigators (including small groups) from KRW368 billion in 2008 to KRW1.5 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

The reorientation to more basic research should be accompanied by appropriate expectations for the potential results. In this regard, the innovation-studies literature has demonstrated that the development of embodied skills and understanding from basic research tends to have a more significant and lasting impact than the generation of codified results. Acknowledging this has consequences for the way such 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 basic 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.

Promoting a New Internationalism

The Korean economy is often characterised as being relatively closed on account of its low levels of (1) import penetration, (2) inward foreign direct investment (FDI), and (3) foreign workers. These conditions are often viewed unfavourably by international governmental organisations that champion inward FDI and trade-openness as channels for improving productivity and competitiveness. Korean policy has seemed generally suspicious of these tenets of development, however, and has instead sought to nurture alternative channels of technological upgrading in efforts to drive economic catch-up. Significant among these have been the contracting arrangements of the *chaebol* which saw them enhance their technological capabilities via technical licensing arrangements with foreign firms, the importation of capital goods and components, and the exporting of original equipment manufacturing (OEM). In particular, OEM arrangements proved to be one of the most cost-effective channels for acquiring core capabilities in production and investment.¹⁴ Another important channel promoted by the government for acquiring foreign knowledge has been overseas education and training. Much of Korea's top talent has benefited greatly from advanced education and training in the United States and elsewhere. Crucially, most of this talent has traditionally returned to Korea after training, in contrast to the situation in many other developing economies, and has contributed to the country's successful catch-up.

Taken together, these channels demonstrate that the Korean economy was in fact well-linked to global knowledge sources during the catch-up period. They allowed for the transfer of know-how and technology that have enabled Korea's transition to a newly advanced economy. The question is whether they are sufficient or even appropriate for a more creative mode of development. Put another way, while Korean

¹⁴The often tedious and gruelling qualification process that any potential supplier has to complete successfully in order to compete for OEM contracts opens up a variety of learning possibilities with regard to business organisation and the use of technology. In addition, customers often provide technical assistance in engineering and manufacturing processes in order to ensure quality and cost efficiency (Ernst 2000).

development has been traditionally based upon the exploitation of internationally-sourced knowledge, to what extent does the shift towards a more creative mode of development change the nature of knowledge to be acquired and the channels through which it is to be sourced? The manner through which the chaebol accumulate technological capabilities certainly changes as they reach knowledge frontiers. They have become significantly more reliant on R&D to support their exploration activities, an increasing amount of which is performed outside of Korea. For example, the Korea Industrial Technology Association (KOITA) reports that Korean firms had set up around 60 overseas R&D centres by 2005. Samsung Electronics, LG and Hyundai Motors have been particularly active in establishing such centres from the mid-1990s onwards, especially in the United States, Europe, Japan and, increasingly, China. The rationales for performing R&D in overseas centres are multiple and range from the need to adapt technologies for local markets to the exploitation of knowledge held by highly-skilled researchers.

As for overseas education and training, the other knowledge accumulation catch-up channel highlighted above, this continues to be important but has also changed over time. Numerically, more Koreans than ever study abroad, increasingly so for undergraduate degrees. They tend to be self-financed rather than sponsored and, crucially, many are remaining overseas after graduating. For example, the number of doctoral students returning to Korea after graduation has dramatically declined over the last decade, leading some to declare an apparent “brain drain” crisis. The reasons for (immediate) non-return tend to be complex and have yet to be fully researched in the Korean context. But preliminary findings seem to point to higher quality research and work environments in the United States and lack of suitable post-doc positions in Korea, especially in universities. This relates to the discussion in the previous section and the need to further develop basic research capacities in HEIs.

These brain drain fears, together with the possibility that the leading chaebol could perform their most cutting-edge research work in overseas R&D centres, have prompted the Korean government to accelerate the development of the country’s science base in the same way the rate of technological learning was accelerated in earlier times, i.e. by accessing international sources of knowledge. However, some of the available channels for strengthening the science base in this way remain weakly-developed. For instance, very little R&D carried out in Korea is financed from abroad, research linkages with foreign firms and institutions are relatively weak, and few foreign researchers and students come to Korea to work or study. The language barrier and a traditional emphasis on more proprietary industrial research have probably contributed to the low level of international R&D activities; the situation appears to be similar to that of Japan. A range of policy initiatives have been subsequently launched to increase the internationalisation of the Korean 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.

The main policy actors in this regard are the MEST and MKE. Both have dedicated programmes and sub-programmes in support of S&T internationalisation. For example, international R&D collaboration is supported by the MEST’s Global

Joint R&D programme, with more than 60% of funding directed towards cooperation involving the EU, Japan or the United States. The advanced level of R&D in these regions provides a strong incentive to collaborate on account of the learning benefits. One important component of this programme is the Global Research Laboratory scheme, which provides funding for Korean laboratories to collaborate with leading research centres overseas on fundamental research. The aim is to raise national research capacities to world-class levels. In 2010, more than 30 Korean laboratories benefited from the scheme. The MKE has similar programmes to promote R&D cooperation but targeted at industrial R&D. Korea is also participating in international S&T programmes such as the EU Framework Programme, CERN and ITER.

Besides providing support to R&D collaboration with overseas research centres, Korean policy also seeks to attract foreign R&D centres to Korea. Again, both the MEST and MKE are active. The MEST established the Korea Foundation for International Co-operation of Science & Technology (KICOS) in 2004 with the aim of making Korea the Northeast Asia R&D hub by attracting prestigious foreign research institutes. There have been some successes, notably the attraction of the Institut Pasteur to establish a research centre in Korea, lured by the offer of new buildings and generous subsidies. For its part, the MKE is working to attract private firms' R&D centres and has hosted 18 new R&D centres over the period 2003–2006, including from the likes of Microsoft, Siemens and DuPont. Crucial to the continuing attraction of such R&D investments will be the establishment of a world-class science system with high-performance public research units, a highly developed infrastructure and a supply of excellent human resources (OECD 2006b).

The brain drain of Koreans to the United States and Europe would be less of an issue if Korea were more successful in attracting highly-skilled workers from overseas. The number of foreign highly skilled workers in Korea has stagnated at around 25,000 since 2000, accounting for about 6% of the total foreign labour force. In contrast, skilled labour accounts for 19% of foreign labour in Japan. The low share of highly skilled workers is largely a result of problems in the business and living environment and administrative regulations that make it difficult to work in Korea (OECD 2007b). The Korean government has begun to provide preferential treatment and incentives to attract highly skilled foreign workers. These include preferential visa programmes for foreign scientists and engineers, and attractive packages aimed at encouraging leading scientists to spend time in Korean universities. A recent MEST-funded policy measure in this regard is the World Class University programme, which is designed to attract top researchers from around the world to collaborate with Korean scientists in key fields. Announced in 2008 with a 5-year budget of around USD800 million, the programme supports universities to build new research departments around leading foreign academics and to employ Nobel Prize winners and the like to take up visiting posts.

If these schemes were not ambitious enough, the Lee Myung-bak administration has announced plans to build large-scale scientific infrastructure, including a heavy-ion accelerator, in a new city of science and culture, known currently as

the International Science and Business Belt (ISSB) initiative. Box 2.3 sets out the Korean government's vision for the Belt, which is expected 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.

Box 2.3: The Promise of the International Science and Business Belt (ISSB) Initiative

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 twenty-first 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 "twenty-first century creative network", where science, art, culture and industries converge. It will be Korea's "twenty-first 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).

As well as trying to attract 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, the 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. The 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. This is an important set of initiatives, as the Korean diaspora offers a unique resource that could be drawn upon to foster international collaboration and to provide an independent voice for domestic evaluation and assessment.

In addition to attracting established researchers, the MEST has also sought to attract more foreign students to Korean universities in order to increase the country's pool of foreign talent. 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 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. The MEST hopes these policies have a positive impact on Korea's economic and diplomatic development and expects foreign graduates to serve as a driving economic force by helping to counter low fertility rates and rapid population ageing.

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 strongly signal Korea's intent to become 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 still 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 exchanges and mobility are more likely in basic science and are often concentrated in universities. They should be boosted by better research conditions in a broad set of universities and by increases in the levels of basic research performed.

Concluding Remarks

Table 2.1 summarises some of the strengths and weaknesses of Korea's innovation system, as well as some of the opportunities and threats that are likely to be faced over the next few years. Sustaining the impressive productivity growth seen over the last four decades will increasingly depend upon boosting innovation, which in turn requires a reorientation towards more explorative search and selection, e.g. through basic research, as Korean firms reach knowledge frontiers. The transformation of the Korean innovation system – from one based almost solely on the goal of catch-up through exploitation of existing knowledge to one that extends to creative exploration – has been underway for some years now. It was accelerated by the 1998 Asian financial crisis, particularly by the government's strong intervention that followed, but also by several chaebol rapidly approaching knowledge frontiers. An innovation system geared to more creative exploration requires different skills and education, firm-level capabilities, public research, and international knowledge linkages than those required by one based almost solely on exploitation of existing technologies. These new requirements entail changes in the organisation and dynamics of the national innovation system, in particular, changes in the institutions and ideas that pattern the behaviours of and linkages between various innovation system actors (Mahlich and Pascha 2007). By their very nature, such changes are gradual, most likely uneven, and can be only partly engineered by policy intervention. The chapter has explored some of these changes in the context of four key areas where government policy continues to play an important role in shaping the Korean innovation system, i.e. education and skills, SME development, public research, and international knowledge linkages. The paragraphs that follow summarise some of the chapter's main arguments and draw a few tentative conclusions.

Table 2.1 SWOT analysis of the Korean innovation system

Strengths	Weaknesses
• 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) accounted for by significant 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 good fast followers • Strong and internationally competitive firms • Learning society with a capacity to learn from failures and international good practices	• Under-developed fundamental research capabilities and weak research capacity in universities • Weak linkages between GRIs and higher education institutes • In education, prevalence of rote learning, overemphasis upon university entrance exam, and high cost of private education • Under-utilisation of female labour • Low productivity in the services sector • Relatively weak SME sector • Uneven development across regions and sectors • Relatively small domestic market (compared to China, Japan, United States) • Policy co-ordination problems between ministries
Opportunities	Threats
• Geopolitical positioning in one of the most dynamic regions of the world • Globalisation, including of R&D • Growing Korean S&T diaspora • Developments in S&T (technological change), particularly in 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	• 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

Source: OECD (2009)

In education and skills, changes have perhaps been slower to come about than in other areas. For example, the education system is still heavily geared towards young people and their attainment of bachelor degrees and relies too heavily on rote-learning. It could be argued that Korea has been too successful in producing large numbers of bachelor degree holders, while concerns remain over the appropriateness of the skills obtained from many degree courses. Shifting education systems in

new directions is notoriously difficult, though in Korea, demographic change makes it inevitable. The government recognises the need for an urgent broadening of focus beyond young people to include greater lifelong learning provision, but HEIs and the business sector have yet to fully embrace the transition. At the same time, labour market rigidities hinder the uptake of lifelong learning opportunities, as well as the participation of more women in the workforce. Yet both will be crucial in the coming years as the population increasingly ages. These multiple considerations demonstrate well the complexity of issues around education and skills and highlight the need for sustained, coordinated action on several fronts.

Moving on to SMEs, the chapter presents some evidence of a population of smaller firms emerging with enhanced technological capabilities – a promising sign for an industrial ecosystem that has been for so long (and continues to be) dominated by a few large firms. The chaebol have supported this emergence in some instances, no doubt reflecting their self-interest in nurturing a cadre of local suppliers with strong technological capabilities. But the government has perhaps lent even greater support. Guided somewhat by New Economy thinking, it has provided incentives and funding for increased R&D activity in SMEs and has worked hard to introduce a wide variety of opportunities for innovation-friendly financing. Even though these initiatives seem to have had some success, nobody pretends that innovative SMEs will become the dominant industry players in Korea anytime soon, though to be fair, this is not the aim. Rather, the policy aim is to avoid an industrial ‘hollowing out’ scenario, driven by the chaebol sourcing increasingly from overseas suppliers, particularly from China. If Korean SME suppliers can accumulate greater technological capabilities, then the risk of this scenario being played out should, it is reasoned, be reduced.

R&D can be an important mechanism to aid exploration. Any shift to a more creative mode of development, particularly in manufacturing economies, would normally be accompanied by increases in R&D spending. The chapter has shown that growth in Korean GERD has been one of the highest in the OECD area and that an increasing share of the R&D performed is devoted to more explorative basic research. Much of the latter is, however, performed by the business sector while the proportions of basic research carried out in HEIs and GRIs have declined in relative terms over recent years. An explanation for this lies in the way government policy has assigned roles to the GRIs and HEIs as drivers of future engines of growth – again, reflecting a New Economy ideology. One outcome is a greater emphasis on commercialisation activities, even though they may not be fully congruent with a parallel focus on promoting basic research. This is because expectations around commercialisation – particularly if success is measured in terms of crude indicators, such as patent registrations – tend to place less value on many of the other, often more important, yet difficult to measure, benefits of public research, such as human resource development. Instead, they focus on the measurable and shorter-term pay-backs, an orientation that can be unhelpful to a more explorative type of research, where uncertainties are much higher and the risks are greater. There is evidence that Korean S&T policy, with a legacy of results-oriented

programmes aimed at catch-up, still needs to draw realistically upon the potential of more explorative basic research.

Accessing international sources of knowledge has always been a central part of Korean development, but the nature of the knowledge and relationships sought has changed as the Korean economy has reached knowledge frontiers in several fields. Much greater emphasis is now placed on more explorative basic research linkages with leading global research centres with a view to accessing state-of-the-art knowledge. Korea has little track record in sourcing this type of knowledge and in fostering these sorts of relationships on account of its previous R&D profile, which was dominated by proprietary R&D activities. Crucially, the ability to access such knowledge depends upon having similar centres of excellence at home that have the necessary credentials to participate in global knowledge networks and the absorptive capacity to benefit from them. While the leading chaebol have developed such centres or have acquired them overseas, the public sector still lags behind. The government has introduced various schemes to accelerate the accumulation of basic research capabilities, e.g. through schemes to attract leading international talent to universities, the International Science and Business Belt, etc. Their long-term success, however, depends ultimately on Korea developing a deeper research milieu that extends well beyond a handful of islands of excellence to encapsulate a broad set of leading-edge research centres operating across a spectrum of GRIs, HEIs and the corporate sector.

The dynamics of change outlined above have consequences for the roles to be performed by the main actors in Korea's innovation system. For example, the government still performs more than an enabling role and remains rather active in designing and implementing a directive industrial policy. The sets of ideas guiding policy intervention have changed, however, and reflect new thinking informed by a national innovation systems perspective. The levels and nature of interventions suggest a certain policy impatience, which has been typical of Korean policy over the years. While this urgency might be warranted, it also leads to demands for demonstrable effects, which might be problematic, since many benefits may take years to appear and are likely to be only partially attributable to policy interventions. As for the chaebol, their needs regarding education and research systems have changed as their work increasingly occurs at knowledge frontiers. But they also have responsibilities to the Korean innovation system if they intend to continue to draw upon its knowledge assets. This applies particularly to SME suppliers, but also to education providers who could benefit from a stronger strategic partnership with the chaebol. Finally, the public sector research performing institutes, i.e. the GRIs and HEIs, have important roles to play in increasing the amounts of more explorative research carried out in Korea. Yet, recent years have seen perhaps too much emphasis placed on certain types of commercialisation-oriented activities, e.g. patenting. Such institutes should play a variety of roles, but a better balance is required that puts greater value on the explorative search activities of the GRIs and HEIs and on their contributions to the skills base of the Korean innovation system.

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